Spitzer Space Telescope - Directors Discretionary Time Proposal #13159

Variability at the edge: highly accreting objects in Taurus

Principal Investigator: Peter Abraham
Institution: Konkoly Observatory

Technical Contact: Peter Abraham, Konkoly Observatory

Co-Investigators:
Agnes Kospal, Konkoly Observatory
Robert Szabo, Konkoly Observatory

Science Category: YSOs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.3

Abstract:
In Kepler K2, Campaign 13, we will obtain 80-days-long optical light curves of seven highly accreting T Tauri stars in the benchmark Taurus star forming region. Here we propose to monitor our sample simultaneously with Kepler and Spitzer, to be able to separate variability patterns related to different physical processes. Monitoring our targets with Spitzer during the final 11 days of the K2 campaign, we will clean the light curves from non-accretion effects (rotating stellar spots, dips due to passing dust structures), and construct, for the first time, a variability curve which reflects the time-dependent accretion only. We will then study and understand how time-dependent mass accretion affects the density and temperature structure of the protoplanetary disk, which sets the initial conditions for planet formation. The proposed work cannot be done without the unparalleled precision of Kepler and Spitzer. This unique and one-time opportunity motivated our DDT proposal.

Spitzer Space Telescope - General Observer Proposal #60167

Disk tomography and dynamics: a time-dependent study of known mid-infrared variable young stellar objects

Principal Investigator: Peter Abraham
Institution: Konkoly Observatory of the Hungarian Academy of Science

Technical Contact: Peter Abraham, Konkoly Observatory of the Hungarian Academy of Science

Co-Investigators:
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Csaba Kiss, Konkoly Observatory
Agnes Kospal, Leiden Observatory
Maria Kun, Konkoly Observatory
David Westley Miller, University of Louisville
Attila Moor, Konkoly Observatory
Aurora Sicilia-Aguilar, Max-Planck-Institut fur Astronomie

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 49.3

Abstract:
Most of our knowledge on young stars comes from snapshot observations: spectra and images taken at a single epoch, or at different epochs at different wavelengths. It is, however, known that many of the systems are variable. Variability at optical and near-infrared wavelength is mostly related to the central star itself. Mid-infrared flux changes, on the other hand, are in most cases due to varying emission of the circumstellar material, either via varying accretion rate (and thus changing thermal emission), or varying extinction along the line-of-sight (shadowing effects). If the illuminated disk area varies with time, measuring the variable integrated flux offers a tomographic analysis. Monitoring and interpreting variability provide a powerful "extra dimension" of information on the structure of the circumstellar material. The Spitzer Warm Mission is a unique opportunity for the systematic establishment of mid-infrared variability studies of young stars. Following an extensive preparatory work, we compiled a list of young stellar objects with variable mid-infrared brightness. We propose to conduct a multi-epoch survey of these carefully selected pre-main sequence stars with Spitzer. We plan to complement the Spitzer observations with simultaneous optical and near-infrared photometry from ground-based telescopes. Our aim is to document the mid-infrared brightness evolution of our targets, examine the possible reasons of the observed variability, model disk structure and dynamics for different scenarios and confront the data with model predictions.

Spitzer Space Telescope - General Observer Proposal #80165

Disk tomography during the outburst of two new young eruptive stars

Principal Investigator: Peter Abraham
Institution: Konkoly Observatory

Technical Contact: Peter Abraham, Konkoly Observatory

Co-Investigators:
Agnes Kospal, Leiden Observatory
Attila Moor, Konkoly Observatory

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.8

Abstract:
Most young stars are variable, and not only at optical, but also at infrared wavelengths. Our group had proposed a new method to interpret such light variations using a tomographic technique. It is based on analyzing the time variations of the integrated flux of a shrinking illuminated disk area during the fading. We also suggested that rearrangement in the density structure of the inner disk - mainly due to evaporation/condensation of dust particles in the outburst heat - can be seen in the multicolor light curves. The outbursts of two so-far unknown young eruptive stars in Cygnus in 2010 August offer the long-waited opportunity to perform a proof-of-concept analysis of our proposed methods to investigate disk tomography and dynamics. Here we propose to conduct a multi-epoch survey of two young eruptive star during their outburst with Spitzer/IRAC. We will obtain 3.6 and 4.5 um images at 9 epochs, and the data will be supplemented by simultaneous ground-based optical and near-infrared photometry. The flux and color variations of HBC 722 will be interpreted using the new method of disk tomography, while the corresponding data on VSX J205126.1+440523 will be interpreted in terms of the sum of variable illumination and time variable density structure of the inner disk/envelope. Our study may demonstrate that variability, in particular the wavelength dependence of flux variations over the whole infrared domain, provides an extremely powerful ?extra dimension? of information, in addition to space and wavelength.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14223

Revisiting and refining the model of TRAPPIST-1 with Spitzer

Principal Investigator: Eric Agol
Institution: University of Washington

Technical Contact: Eric Agol, University of Washington

Co-Investigators:
Emeline Bolmont, University of Geneva
Adam Burgasser, UCSD
Sean Carey, IPAC
Laetitia Delrez, University of Cambridge
Brice-Olivier Demory, University of Bern
Dan Fabrycky, University of Chicago
Michael Gillon, University of Liege
Simon Grimm, University of Bern
Jim Ingalls, IPAC
Renu Malhotra, University of Arizona
Brett Morris, University of Washington
Sean Raymond, University of Bordeaux
Amaury Triaud, University of Birmingham

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 103.0
Priority: 1

Abstract:
With the Spitzer Space Telescope, we have discovered a system of seven transiting planets about the star TRAPPIST-1, and for the first time measured the densities of three Earth-sized, temperate exoplanets using transit-timing variations (Gillon et al. 2017; Ducrot et al. 2018; Grimm et al. 2018). We propose to gather additional transits of the TRAPPIST-1 system, focusing on the outer planets in the system which have had fewer transits observed to date. The four-fold goals of this proposal are: i). to flag potential transits which might be affected by stellar variability; ii). to constrain the dynamical state of the planet system; iii). to better constrain the masses of the planets; iv). to tighten the ephemeris forecast for observations with JWST. In addition, we will search for any evidence an eighth planet, characterize the stellar variability, and forecast planet-planet overlaps during transits. The proposed observations contain measurements which are only possible in March-April 2019, and so we request a time critical review to the extent possible.

Spitzer Space Telescope - General Observer Proposal #70157

Star formation in the 4th Galactic Quadrant

Principal Investigator: Lori Allen
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Lori Allen, Smithsonian Astrophysical Observatory

Co-Investigators:
Sarah Willis, Iowa State University
Massimo Marengo, Iowa State University
Tom Megeath, University of Toledo
Rob Gutermuth, University of Massachusetts / Smith College

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 35.5

Abstract:
Empirical scaling laws relating star formation rates to gas surface density in external galaxies are widely observed, but the underlying physics of what controls the rate and efficiency of star formation is not well understood. This is especially true for distant galaxies in which individual star forming regions, much less individual stars, cannot be resolved. Massive star forming regions in the 4th quadrant of our galaxy have the highest far-infrared luminosities, and the highest apparent star formation efficiencies, in the Galactic disk. They are the local analogs of the star forming regions which dominate the integrated light from the spiral arms of external galaxies. We aim to bridge the gap between star-forming regions near the Sun and in nearby galaxies, by imaging nine infrared-luminous, massive star forming regions in the 4th quadrant of the Milky Way. These data will be combined with deep H and K band imaging to derive star formation rates and efficiencies as well as molecular cloud masses and densities, for comparison with nearby clouds and external galaxies in the context of star formation rate - gas surface density relations.

Spitzer Space Telescope - General Observer Proposal #12112

Variability of Two Young L/T Transition Brown Dwarfs

Principal Investigator: Katelyn Allers
Institution: Institute for Astronomy

Technical Contact: Katelyn Allers, Institute for Astronomy

Co-Investigators:
Beth Biller, University of Edinburgh
Jack Gallimore, Bucknell University
Ian Crossfield, Lunar and Planetary Lab, University of Arizona

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 29.7
Priority: 2

Abstract:
We propose for photometric monitoring observations of WISEP J004701.06+680352 (hereinafter W0047) and 2MASSWJ2244316+204343 (hereinafter 2M2244) using Spitzer/IRAC. Both objects are kinematically confirmed L7 members of the 150 Myr old AB Doradus moving group and show remarkable spectral similarity in both the near-IR and optical. The WoW survey found that L/T transition brown dwarfs having detected mid-IR variability are redder than the typical J - K color for their spectral type. A Cycle 11 exploration program (P.I. Metchev) is investigating the geometrical dependence of color and variability by expanding the original WoW sample. If inclination and J - K color are correlated (as predicted by Metchev et al.), then the spectral and photometric diversity seen across the L/T transition could be explained by geometry rather than diversity in atmospheric chemistry and dynamics. This would have wide ranging implications for the way we model cloud dissipation for brown dwarfs and extrasolar planets. Our proposed observations will provide an important test of the Metchev et al. prediction complementary to their Cycle 11 program. W0047 and 2M2244 are the same age, and have remarkably similar colors (J - K = 2.55 and 2.46 mags, respectively) and underlying spectra. Thus, if Metchev's prediction about the correlation of inclination and spectral morphology holds true, we would expect that W0047 and 2M2244 should have similar inclinations. However, the measured v sin(i) values for W0047 and 2M2244 are quite different. This difference in v sin(i) could be due to spin-axis inclination (with W0047 having a smaller i) or orbital period (with W0047 having a longer period), both of which we will determine from our proposed observations. This test is a unique opportunity, as there are no other free-floating L/T transition dwarfs known to be both coeval and spectrally similar. Our proposed observations will also extend the spectral type range for young objects surveyed for variability down to the L/T transition.

Spitzer Space Telescope - General Observer Proposal #13031

Wind speeds on extrasolar worlds

Principal Investigator: Katelyn Allers
Institution: Bucknell University

Technical Contact: Katelyn Allers, Bucknell University

Co-Investigators:
Beth Biller, University of Edinburgh
Johanna Vos, University of Edinburgh
Peter Williams, Harvard-CfA
Edo Berger, Harvard-CfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 16.2
Priority: 1

Abstract:
We propose for photometric monitoring observations of 2MASS J10475385+2124234 and WISE J112254.73+255021.5 using Spitzer/IRAC. 2MASS J1047+21 and WISE J1122+25 are late spectral type (T6.5 and T6) radio emitters and have measured radio periods of 1.77 hrs and 1.30 hrs, respectively. Our proposed observations will not only characterize the variability of the two coolest known radio emitters but also provide a unique opportunity to measure the first wind speeds for brown dwarfs. Spitzer is currently the only facility capable of the photometric stability, continuous observations and 4.5 micron sensitivity necessary for the success of our program.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13231

Measuring the wind speed on a radio-emitting brown dwarf

Principal Investigator: Katelyn Allers
Institution: Bucknell University

Technical Contact: Katelyn Allers, Bucknell University

Co-Investigators:
Johanna Vos, U. Edinburgh
Peter Williams, CfA
Beth Biller, U. Edinburgh

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 14.6

Abstract:
We propose for photometric monitoring observations of 2MASS J10475385+2124234 using Spitzer/IRAC. 2MASS J1047+21 is a late spectral type (T6.5) radio emitter with a measured radio period of 1.77 hrs. As a part of our successful Cycle 13 program, we detected photometric variability for 2MASS J1047+21. Our proposed observations will not only characterize this variability of the coolest known radio emitter, but also provide a unique opportunity to measure the wind speed of this brown dwarf. Spitzer is currently the only facility capable of the photometric stability, continuous observations and 4.5 micron sensitivity necessary for the success of our program.

Spitzer Space Telescope - General Observer Proposal #60071

A Comprehensive Study of Dust Formation in Type II SNe with HST, SST, and Gemini

Principal Investigator: Jennifer Andrews
Institution: Louisiana State University

Technical Contact: Jennifer Andrews, Louisiana State University

Co-Investigators:
Geoffrey Clayton, Louisiana State University
Karl Gordon, STScI
Ben Sugerman, Goucher College
Doug Welch, McMaster University
Margaret Meixner, STScI
Mike Barlow, University College London
Barbara Ercolano, Harvard CfA
Joseph Gallagher, Louisiana State University

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.3

Abstract:
Recent detections of large amounts of dust in high redshift galaxies imply that Type II supernovae (SNe) may be important dust contributors. The dust in high-z galaxies must come from young, massive stars, so Type II SNe are one of the few possible sources. We propose to continue monitoring of four nearby Type II SNe: 2004et, 2007it, 2007oc, and 2007od, in order to study dust formation in the ejecta of Type II SNe. The three observational signatures of this dust formation include, a decrease in the continuum brightness in the visible, a developing infrared excess, and asymmetric, blue-shifted emission-line profiles. With Spitzer, we will be able to carefully study the IR emission, and put strong constraints on the dust mass and how the dust changes with time. The proposed observations will be combined with previous epochs of Spitzer data and coordinated, already approved Gemini and HST observations. We may be able to double the number of Type II SNe known to have shown all three dust formation signatures. This increased sample size will help us to better understand what fraction of Type II SNe produce dust, how much dust they produce, and how conditions in the SNe ejecta affect the dust formation. These estimates will help us to deduce whether Type II SNe can be a major source of dust in young, high redshift galaxies.

Spitzer Space Telescope - General Observer Proposal #70008

Dust Formation and Light Echoes in Nearby CCSNe

Principal Investigator: Jennifer Andrews
Institution: Louisiana State University

Technical Contact: Jennifer Andrews, Louisiana State University

Co-Investigators:
Geoffrey Clayton, Louisiana State University
Mike Barlow, University College London
Barbara Ercolano, Cambridge University
Joanna Fabbri, University College London
Joseph Gallagher, Louisiana State University
Karl Gordon, STScI
Margaret Meixner, STScI
Masaaki Otsuka, STScI
Ben Sugerman, Goucher College
Doug Welch, McMaster University
Roger Wesson, University College London

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.5

Abstract:
The presence of copious amounts of dust in high redshift galaxies may be explained by core collapse supernovae (CCSNe). The dust in high-z galaxies must come from young, massive stars, so CCSNe are one of the few possible sources. We propose to begin monitoring three bright new CCSNe (SNe 2010F, 2010K, and 2010as) to look for signatures of dust formation, as well as continue the monitoring of the three dust-producing SNe 2004et, 2007it, and 2007od. The three observational signatures of this dust formation include, a decrease in the continuum brightness in the visible, a developing infrared excess, and asymmetric, blue-shifted emission-line profiles. With Spitzer, we will be able to carefully study the IR emission, and put strong constraints on the dust mass and how the dust changes with time. The proposed observations will be combined with previous epochs of Spitzer data and coordinated with other approved and proposed ground and space based observations with Magellan, Gemini, and HST. We may be able to increase the small sample of CCSNe that show all three signatures of dust formation, as well as constrain pre-existing progenitor dust creation by studying the IR echoes around the older SNe. These observations will help us to better understand what fraction of CCSNe produce dust, how much dust they produce, and how CCSNe behave at late times. These estimates will help us to deduce whether CCSNe can be a major source of dust in young, high redshift galaxies.

Spitzer Space Telescope - Directors Discretionary Time Proposal #70201

A Search for Dust Formation around the Extremely Bright Type IIn SN 2010jl

Principal Investigator: Jennifer Andrews
Institution: Louisiana State University

Technical Contact: Jennifer Andrews, LSU

Co-Investigators:
Geoffrey Clayton, LSU
Joseph Gallagher, Raymond Waters College
Ben Sugerman, Goucher College
Michael Barlow, UCL
Barbara Ercolano, Exeter
Roger Wesson, UCL
Joanna Fabbri, UCL
Margaret Meixner, STScI
Masaaki Otsuka, STScI
Douglas Welch, McMaster

Science Category: local group
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.8

Abstract:
Past studies of core-collpase supernovae (SNe) have revealed evidence of dust formation in their ejecta ~300-600 days after explosion. However, the mass of dust synthesized is several orders of magnitude less than that needed to explain observed dust quantities at high-z. Recent studies of SNe exhibiting strong circumstellar interaction (Type IIn) have found evidence of dust formation in the CSM as early as ~50 days after explosion and have suggested that the addition of this new mechanism may reconcile this inconsisitency. The very recent discovery of the brightest Type IIn SN ever observed, SN 2010jl, gives us a unique opportunity of studying this new mechanism of dust formation. We propose to obtain one observation of SN 2010jl with IRAC to search for signs of CSM-interaction and to investigate the mechanism for early dust formation in its CSM as well as understand whether early-dust-forming SNe are producing significantly more dust and are a viable explaination for the large quantities of dust observed in the early universe.

Spitzer Space Telescope - General Observer Proposal #80131

Core Collapse Supernovae: Dust Formation and CSM Interaction

Principal Investigator: Jennifer Andrews
Institution: Louisiana State University

Technical Contact: Jennifer Andrews, Louisiana State University

Co-Investigators:
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Joe Gallagher, Raymond Walters College
Joanna Fabbri, University College London
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Roger Wesson, University College London
Maasaki Otsuka, STScI

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 11.7

Abstract:
Core Collapse Supernovae (CCSNe) may explain the presence of copious amounts of dust in high redshift galaxies due to their high masses and short evolutionary timescales. We propose to continue monitoring three bright new CCSNe (SNe 2010F, 2010K, and 2010jl) and to begin monitoring SN 2010hq, to look for signatures of dust formation, as well as continue the monitoring of the three dust-producing SNe 2004et, 2007it, and 2007od to study their light echoes. Dust formation signatures include, a decrease in the continuum brightness in the visible while at the same time developing infrared excess, and asymmetric, blue-shifted emission-line profiles. With Spitzer, we will be able to carefully study the IR emission, and put strong constraints on the dust mass and how the dust changes with time. The proposed observations will be combined with previous epochs of Spitzer data and coordinated with other approved and proposed ground and space based observations with Magellan, Gemini, and HST. We may be able to increase the small sample of CCSNe that show all three signatures of dust formation, as well as constrain pre-existing progenitor dust creation by studying the IR echoes around the older SNe. These observations will help us to better understand what fraction of CCSNe produce dust, how much dust they produce, and how CCSNe behave at late times. These estimates will help us to deduce whether CCSNe can be a major source of dust in young, high redshift galaxies.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80239

Detecting Dust Around the Brightest Type IIP SN of 2011, SN 2011ja

Principal Investigator: Jennifer Andrews
Institution: University of Massachusetts

Technical Contact: Jennifer Andrews, UMass

Co-Investigators:
Geoffrey Clayton, LSU
Roger Wesson, ESO
Mike Barlow, UCL
Ben Sugerman, Goucher
Margaret Meixner, STScI
Masaaki Otsuka, ASIAA
Mikakao Matsuura, UCL
Barbara Ercolano, Univ Obs Munich
Ben Sargent, STScI
Joanna Fabbri, UCL
Nino Panagia, STScI

Science Category: evolved stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.8

Abstract:
We are proposing for DD time to observe the extremely bright Type II SN 2011ja, discovered 18 December 2011, to look for signs of early dust formation. The extreme brightness (V ~ 12.3 magnitudes and rising) and proximity (~4 Mpc) make this target an ideal candidate to look for early signs of dust formation as well as to follow for many years to come. Core Collapse Supernovae (CCSNe) may explain the presence of copious amounts of dust in high redshift galaxies due to their high masses and short evolutionary timescales. With Spitzer, we will be able to carefully study the IR emission, and put strong constraints on the dust mass and how the dust changes with time. This proposed observation will be combined with optical and near-IR observations from ground based telescopes to look for signatures of dust formation which include a decrease in the continuum brightness in the visible while at the same time developing infrared excess, and asymmetric, blue-shifted emission-line profiles. Sustained observations of young, CCSNe help us to better understand what fraction of CCSNe produce dust, how much dust they produce, and how CCSNe behave at late times. These estimates will help us to deduce whether CCSNe can be a major source of dust in young, high redshift galaxies.

Spitzer Space Telescope - General Observer Proposal #90178

Dust Formation and Light Echoes Around Core Collapse Supernovae

Principal Investigator: Jennifer Andrews
Institution: University of Massachusetts

Technical Contact: Jennifer Andrews, University of Massachusetts

Co-Investigators:
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Ben Sugerman, Goucher College
Mike Barlow, University College London
Margaret Meixner, STScI
Roger Wesson, ESO
Joseph Gallagher, University of Cinncinatti
Mikako Matsuura, University College London
Masaaki Otsuka, Academia Sinica
Barbara Ercolano, University Observatory Munich

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.3

Abstract:
The importance of core collapse supernovae (CCSNe) in the dust budget of the universe is still poorly understood. Recent discoveries of massive amounts of cool dust in SN 1987A and the Crab nebula have once again brought this debate to the forefront. We are proposing to continue observations of 7 CCSNe (SNe 1980K, 2002hh, 2008S, 2004et, 2010jl, 2011ja, and 2012aw) with Spitzer as part of our multi-wavelength campaign to both classify and quantify newly condensed dust in the SN ejecta as well as to accurately map out pre-existing circumstellar dust in light echoes. The proposed observations will be combined with previous epochs of Spitzer data and coordinated with other approved and proposed ground and space based observations with Gemini, and HST. We may be able to increase the small sample of CCSNe that show conclusive evidence of dust formation, as well as constrain pre-existing progenitor dust creation by studying the IR echoes around the older SNe. Measuring the location and mass of the dust around a SN, while the dust is still warm, is essential in deciphering the origin of the large masses of cold dust that have been discovered in nearby SN remnants, which is critical to understand the role of CCSNe as dust producers in the early universe.

Spitzer Space Telescope - General Observer Proposal #70170

Mapping Brown Dwarfs: The Evolution of Cloud Properties
Through the L-T Transition

Principal Investigator: Daniel Apai
Institution: STScI

Technical Contact: Daniel Apai, STScI

Co-Investigators:
I. Neill Reid, STScI
Adam Burrows, Princeton

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.0

Abstract:
Ultracool L and T dwarf bridge the gap between cool stars and giant planets and therefore provide an important laboratory for both probing stellar atmospheres and devising future observations of cool, large-separation giant exoplanets. A key challenge of ultracool atmospheres is the understanding of the transition from dusty L-type atmospheres to clearer T-type atmospheres, dominated by methane and water absorption bands. It is clear that understanding cloud formation and evolution is crucial to understanding the L/T transition, and hence giant exoplanet atmospheres. Numerous diverse models have been proposed to explain the atmospheric evolution, from multi-condensate clouds to growing holes and sudden collapse of the cloud layers with decresing temperature. As yet, those models remain weakly constrained by observations. We propose to use the unparalleled sensitivity and stability of WFC3 on HST to tackle this question. We will obtain time series of G141 grism spectra of six L/T dwarfs, including two resolved binaries and two unresvolved L/T dwarfs. We will measure the level of rotational variability as a function of wavelength to derive the one-dimensional spectral maps of their cloud covers. Those maps will address the following questions: How heterogenous is the cloud cloud cover as a function of spectral type? and, What are the spectral properties and diversity of clouds across the photosphere of the targets? The proposed observations will provide a unique, statistically constraining data set on cloud distribution, properties, and evolution as a function of spectral type. These new constraints will allow direct comparison to the models and will drive the development of new models with realistic treatment of the cloud layers. With typical rotation periods of 3 hours, we can cover two rotation periods within 6 HST orbits. We propose to obtain simultaneous IRAC [4.5] observations of the two unresolved T dwarfs. The Spitzer data will enhance our ability to identify absorbers in individual clouds within their complex atmospheres and will probe non-equilibrium CO chemistry and vertical mixing. Combined, these observations will provide the first spatially and spectrally resolved maps of ultracool dwarf photospheres across the L/T transition.

Spitzer Space Telescope - General Observer Proposal #90063

Extrasolar Storms: The Physics and Chemistry of Evolving Cloud Structures in Brown Dwarf Atmospheres

Principal Investigator: Daniel Apai
Institution: University of Arizona

Technical Contact: Daniel Apai, University of Arizona

Co-Investigators:
Esther Buenzli, University of Arizona
Davin Flateau, The University of Arizona
Stanimir Metchev, Stony Brook University
Mark Marley, NASA Ames
Jacqueline Radigan, University of Toronto
Patrick Lowrance, Spitzer Science Center
Adam Showman, University of Arizona
Etienne Artigau, University of Montreal
Aren Heinze, Stony Brook University
Adam Burgasser, University of California, San Diego
Subhanjoy Mohanty, Imperial College

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1143.9

Abstract:
Condensate clouds pose the most significant challenge to the understanding of ultracool atmospheres of brown dwarfs and giant exoplanets. In three ongoing Spitzer programs we have taken advantage of Spitzer's ability to obtain high-cadence uninterrupted observations to pioneer a new technique, rotational phase mapping, and successfully explored the properties of cloud covers in ~50 brown dwarfs. Among other exciting results we found that most brown dwarfs possess heterogeneous cloud cover, often with complex surface structures. Perhaps the most perplexing behavior seen in our surveys is light curve evolution on timescales as short as 5 hours and as long as a year. This unexpected behavior offers a unique opportunity to explore the dynamics of cloud layers, but requires multi-epoch data sets. We propose here to follow up a representative set of varying brown dwarfs via multi-epoch Spitzer and HST phase mapping to carry out the first quantitative exploration of cloud cover evolution. The proposed study will establish the first time-resolved multi-wavelength light curve library for brown dwarfs. Spitzer uniquely offers precise 3-5 micron photometry and continuous coverage that allow us to detect cloud structures a fraction of the size of the Great Red Spot on Jupiter in our targets. Combined with HST grism spectroscopy during a subset of the Spitzer observations, the Spitzer phase maps will allow us to disentangle the effects of cloud formation, differential rotation, large-scale rainout and dispersal of clouds. As different wavelengths probe different pressures and different rotational phases probe different latitudes we will be able to explore the two or even three-dimensional structure of the atmospheres. We will also constrain the dynamical and radiative timescales for brown dwarfs and compare these to theoretical predictions to identify the underlying atmospheric dynamics. This program will leave a unique legacy that will propel studies of ultracool atmosphere studies into a new era.

Spitzer Space Telescope - General Observer Proposal #60101

Light Echoes of Historical Galactic Supernovae

Principal Investigator: Richard Arendt
Institution: University of Maryland, Baltimore County

Technical Contact: Richard Arendt, University of Maryland, Baltimore County

Co-Investigators:
Jeonghee Rho, Spitzer Science Center
Eli Dwek, NASA/GSFC

Science Category: ISM
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 26.6

Abstract:
Spitzer's serendipitous discovery of light echoes from the supernovae (SN) that gave birth to the Cas A supernova remnant (SNR) shows that we have to opportunity to re-observe historical Galactic supernovae. Optical spectra of these echoes have shown that the Cas A SN was of Type IIb. Similarly, Tycho's SN has been spectroscopically established to be of Type Ia. The Cas A light echoes are the only ones seen by Spitzer to date. However, this is because existing observations of other young galactic SNRs have only included a single epoch of observations (insufficient to reveal the highly transitory echoes), and have only covered small fields in the immediate vicinity of the SNRs. We proposed to obtain wide field (>0.5 degree) observations of the 7 youngest Galactic SNe, having ages up to ~1000 yr. Where available, prior epoch observations will allow definitive identification of light echoes. If the Cas A echoes are representative, we can also identify echo candidates via their distinctive 4.5/3.6 micron colors. Variations (or lack thereof) in these colors as a function of SN age and SN type, will allow us to place constraints on the emission mechanism of the echoes (absorption and re-radiation vs. scattering). Low extinction at 3.6 and 4.5 microns, means that Spitzer can located echoes of distant SNe which may be too highly attenuated to observe at shorter wavelengths.

Spitzer Space Telescope - General Observer Proposal #80062

The Influence of Zodiacal Light on CIB Measurements

Principal Investigator: Richard Arendt
Institution: University of Maryland, Baltimore County

Technical Contact: Richard Arendt, University of Maryland, Baltimore County

Co-Investigators:
Alexander Kashlinsky, SSAI and GSFC
Harvey Moseley, NASA/GSFC
John Mather, NASA/GSFC

Science Category: cosmic infrared background
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 89.4

Abstract:
Analyses of the backgrounds in previous deep IRAC observations have revealed the presence of spatial structure or fluctuations in the emission. These background fluctuations are generally interpreted as being a property of the extragalactic cosmic IR background. There is some debate as to whether the fluctuations represent emission from high-z sources or whether they can arise from very faint but much more local extragalactic sources. This program addresses a more fundamental issue, and will establish with certainty whether the fluctuation are truly extragalactic, or whether they might arise extremely locally in the zodiacal light, or interplanetary dust cloud. Presently zodiacal light is excluded by extrapolation of the fluctuations measured at longer wavelengths and larger spatial scales. However, it is possible to carry out a suitable observing program with IRAC that measures the IR background fluctuations as the zodiacal light changes over time (as a function of elongation). If the observed fluctuations correlate, even weakly, with the changing zodiacal light, then their interpretation as a property of the extragalactic CIB needs significant revision. There are no existing data sets that contain both sufficient depth for measurement of the fluctuations, and sufficient variation in the zodiacal light intensity to provide a strong test for correlations. The proposed observations will provide the data set that can directly measure whether any fraction of the observed fluctuations is caused by the local interplanetary dust rather than the extragalactic CIB.

Spitzer Space Telescope - General Observer Proposal #70064

Hot Dust in ULIRGs: Completing Spitzer's Legacy

Principal Investigator: Lee Armus
Institution: Spitzer Science Center

Technical Contact: Lee Armus, Spitzer Science Center

Co-Investigators:
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Jason Surace, Spitzer Science Center
Jason Marshall, Spitzer Science Center
Hanae Inami, ISAS-JAXA
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Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.5

Abstract:
Ultraluminous Infrared Galaxies (ULIRGs) have the power output of quasars, yet they emit nearly all of their energy in the mid to far-infrared. While rare in the local Universe, ULIRGs play an increasingly important role in the evolving star formation rate density at high redshift, and they may account for a major fraction of the far-infrared background. Nearly 200 low-redshift ULIRGs have been observed with the IRS on Spitzer during the cryogenic phase of the mission. The IRS spectra of ULIRGs show a great diversity in their properties (slopes, emission line ratios, PAH strengths, extinction), and when coupled with near-infrared and far-infrared photometry, they have been used to quantify the amount of energy produced by AGN and starbursts. The 2-5 micron window is critical for measuring the contribution of hot (~1000K) AGN-heated dust to the emerging SED, yet nearly half of the ULIRGs observed with the IRS have no existing IRAC photometry to cover this wavelength range. Here we propose to complete the Spitzer observations of this important population by observing 83 ULIRGs and 23 PG QSOs (used as templates to understand the hot dust contribution in ULIRGs) with IRAC at 3.6 and 4.5 microns to fill in the missing part of their SEDs, and provide a lasting mid-infrared legacy for studies of ULIRGs and AGN at high-redshift with future generations of IR facilties.

Spitzer Space Telescope - General Observer Proposal #11092

Direct Imaging of Jupiter and Saturn-mass planets in wide orbit around nearby young stars

Principal Investigator: Etienne Artigau
Institution: Universite de Montreal

Technical Contact: Etienne Artigau, Universite de Montreal

Co-Investigators:
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Philippe Delorme, Universite Joseph Fourier
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Jonathan Gagne, Universite de Montreal
Marie-Eve Naud, Universite de Montreal
Loic Albert, Universite de Montreal

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 250.5
Priority: 1

Abstract:
The recent discovery of planetary-mass objects on very wide orbits (hundreds of AU and more) around young stars (e.g. Naud et al. 2014) demonstrates that planets can be found even with arcsecond-level resolution imaging. These massive (10MJup) companions are likely formed in-situ via hierarchical collapse and it is not yet known whether this mechanism can form lighter objects. However, dynamical modelling of young planetary systems (Veras et al. 2009) and the relatively large fraction of massive planets in eccentric orbits found by radial velocity surveys suggest that a few percent of planetary systems should host planets, comparable in mass to Jupiter and Saturn, on orbits wide enough to be imaged as isolated objects. We propose to obtain deep IRAC observations combined with J-band imaging gathered by our team to search for such planets around all known nearby young stars (< 70 pc, < 120Myr; 172 stellar systems). This survey will be sensitive to planets down to the mass of Jupiter for all systems and down to the mass of Saturn for 80 of them. Planets lighter than 2MJup are much too faint in the near-infrared to be identified from the ground; Spitzer is the only facility where such a survey can be undertaken. This survey is a unique opportunity to bring direct imaging in a new era with the detection of analogs to our own Solar System Giants, is complementary to the work done on the ground with high-contrast imagers such as GPI and Sphere, and is critical to identify new planets that will be optimally characterized with JWST.

Spitzer Space Telescope - General Observer Proposal #10088

DIBS: The Decadal IRAC Bootes Survey

Principal Investigator: Matthew Ashby
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Matthew Ashby, Harvard-Smithsonian Astrophysical Observatory

Co-Investigators:
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Peter Eisenhardt, Jet Propulsion Laboratory
Mark Brodwin, University of Missouri, Kansas City
Buell Jannuzi, University of Arizona
Christopher Kochanek, The Ohio State University
Szymon Kozlowski, University of Warsaw, Poland
Daniel Stern, Jet Propulsion Laboratory

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 88.7
Priority: 1

Abstract:
We propose the Decadal IRAC Bootes Survey (DIBS), a fifth epoch of the Spitzer Deep, Wide-Field Survey (SDWFS). The proposed observations, by covering the 10 square degree field to the same depths as during our four previous visits in 2004, 2007, and twice in 2008, will advance two main science goals. First, they will enable an unmatched study of mid-IR AGN variability (at least doubling the AGN sample size from SDWFS to 1200 objects), leading to an improved understanding of AGN physics by imposing new constraints on the mid-IR AGN structure function. Second, DIBS will enable a groundbreaking census of field brown dwarfs: the fifth epoch will increase the available timespan for proper-motion searches by a factor of 2.5 over SDWFS, to 10 years. This increase, when combined with imminent astrometric refinements, will magnify the discovery potential for field brown dwarfs far beyond what was possible with the four-epoch SDWFS. Our project will be sensitive to L and early T dwarfs out to 600 pc, sampling brown dwarf populations in different Milky Way components (thin disk, thick disk, halo). DIBS's decade-long timespan and 10 square degree survey area gives it a discovery potential far greater than any other Spitzer survey with a comparable commitment of time. DIBS brown dwarf candidates will be excellent targets for eventual spectroscopic followup by JWST.

Spitzer Space Telescope - General Observer Proposal #60121

Cadenced IRAC Monitoring of Infrared-Variable AGNs, Part III

Principal Investigator: Matthew Ashby
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Matthew Ashby, Harvard-Smithsonian Astrophysical Observatory

Co-Investigators:
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Morgan Fouesneau, University of Strasbourg
Jessica Krick, Spitzer Science Center/CalTech
Jason Surace, Spitzer Science Center/CalTech
Howard Smith, Harvard-Smithsonian CfA
Leonidas Moustakas, Jet Propulsion Laboratory

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.0

Abstract:
We have analyzed IRAC imaging data from all 109 Spitzer visits to a very well-studied field, the IRAC Dark Calibration Field (IRAC-CF) near the north ecliptic pole. With this extensive dataset, we have already identified a unique sample of 30 IR-variable galaxies for which we are now working to characterize the variability amplitudes and timescales, panchromatic SEDs, and host morphologies, among other quantities. Unfortunately, the continual change in spacecraft roll angle means that our sources are typically observed for at most six months at a time by both IRAC FOVs in succession -- in other words, the visibility windows are exactly out of phase. Thus the planned Cycle 6 IRAC calibration observations, without the additional coverage our proposal would provide, will present large, unavoidable gaps that frustrate the time-delay analysis we wish to perform on exactly the timescales known to be typical of active galaxies. Since 2007 July, we have carried out cadenced IRAC observations in synchrony with the IRAC-CF dark-calibration observations as part of our approved Cycle 4 and 5 programs. We propose to continue this unique AGN monitoring campaign into 2010. The resulting timelines (covering 2000 days thus far and expected to run ultimately to more than 2400 days), are a unique legacy of the Spitzer mission. This dataset, especially for the sizable unbiased AGN sample we now have, holds unique promise for measuring the colors and temperatures of IR-varying AGN, and will have much to say about the underlying physical models of the infrared AGN emission. Accordingly, we ask for just 8 h to gather IRAC photometry in the temporal gaps that would otherwise accrue in Cycle 6.

Spitzer Space Telescope - General Observer Proposal #10108

Resolved Mid-Infrared Imaging of Dual AGN

Principal Investigator: Roberto Assef
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Technical Contact: Roberto Assef, Universidad Diego Portales

Co-Investigators:
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Julia Comerford, CU Boulder
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Frank Masci, IPAC/Caltech
Nadia Zakamska, Johns Hopkins University

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.7
Priority: 1

Abstract:
Nuclear activity triggered by major mergers is thought to be a key component of the galaxy evolution paradigm, and, as such, kpc-scale dual active galactic nuclei (AGN) are expected to be relatively common in the universe. Measuring the frequency of dual AGN will constrain galaxy evolution models as well as increase our understanding of super-massive black hole (SMBH) growth and feeding mechanisms. While hundreds of dual AGN candidates exist, only a few have been confirmed to definitively consist of multiple accreting SMBHs existing in close proximity to one another. This is primarily due to the inherent challenges of distinguishing X-ray through optical emission from multiple nuclei from extended, dynamically resolved narrow line regions. A way to break this degeneracy is through the detection of the warm dust emission characteristic of AGN, which can only come from the innermost regions of the dust torus. To this end, we propose a 2.7 hr Warm Spitzer program to observe six bright dual AGN candidates with expected separations greater than 1.2", the size of an IRAC pixel. For every candidate we will combine 36 independent exposures in each of the [3.6] and [4.5] bands to produce a high resolution image that can confidently resolve the two nuclei if indeed present. Detecting two distinct nuclei with red [3.6]-[4.5] colors will constitute an unambiguous proof of their dual AGN nature.

Spitzer Space Telescope - Directors Discretionary Time Proposal #541

The First Exoplanet Smaller than the Earth

Principal Investigator: Sarah Ballard
Institution: Harvard University

Technical Contact: Sarah Ballard, Harvard University

Co-Investigators:
David Charbonneau, Harvard University
Jessie Christiansen, Harvard University
Drake Deming, NASA Goddard Space Flight Center
Daniel Fabrycky, Harvard University
Matthew Holman, Smithsonian Astrophysical Observatory
Heather Knutson, University of California, Berkeley
Sara Seager, Massachusetts Institute of Technology

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.0

Abstract:
Our team has collected good evidence for a planet smaller than the Earth transiting the nearby M-dwarf star GJ 436, which is already known to host a Neptune-sized planet. We first identified the signal in a 3-week-long photometric monitoring campaign by the NASA EPOXI Mission. Based on the EPOXI data, we predicted a transit event in an extant Spitzer 8-micron data set of this star. Our subsequent analysis of those Spitzer data confirmed the signal of the predicted depth and at the predicted time. However, the existing EPOXI and Spitzer data are not sufficient to support such an extraordinary claim. We propose to confirm the existence of this planet by observing the star for 18 hours spanning a predicted time of transit and at a wavelength where the signal-to-noise would provide an ironclad detection. With a radius only 75% that of the Earth, the new planet GJ 436c would be by far the smallest exoplanet yet discovered and indeed the first exoplanet akin to the terrestrial planets of the Solar system. Moreover, the star's low mass and nearby distance imply that the planetary mass could be estimated from a dedicated radial-velocity campaign. When combined with the radius estimate we will obtain from our proposed Spitzer data, this would provide the first constraint on the average density and hence bulk composition of an Earth-like exoplanet. We argue for Director's Discretionary Time based both on the compelling scientific opportunity to study an Earth-like exoplanet, and the fact that our prediction for the transit times degrades rapidly with time, making it imperative to obtain these observations in the 2010 Jan 14 - Feb 25 visibility window. If successful, our program would provide a dramatic example of the value of an extended Warm Mission during the coming years when humanity uncovers the population of rock and ice exoplanets orbiting nearby stars.

Spitzer Space Telescope - General Observer Proposal #10062

Massive White Dwarfs Host Debris Disks

Principal Investigator: Sara Barber
Institution: University of Oklahoma

Technical Contact: Sara Barber, University of Oklahoma

Co-Investigators:
Mukremin Kilic, University of Oklahoma

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.5
Priority: 1

Abstract:
For Cycle 9 of the Spitzer mission we were awarded 15 hours to observe 100 white dwarfs from the SDSS in the 4.5 micron IRAC band in order to constrain the frequency of disks at massive WDs (M>0.8Msol), and the frequency of planets at their massive progenitors (M>3.5Msol), for the first time. We currently have data on 70 of these WDs, 23 of which exhibit IRAC 4.5 micron emission in excess of that expected for their photospheres. We propose to observe these 23 targets in the 3.6 micron IRAC band to allow for robust characterization of the excess. This data will allow us to either rule out extraneous sources of 4.5 micron excess (such as brown dwarf companions) or lift the degeneracy of disk models that satisfy the observational constraints.

Spitzer Space Telescope - General Observer Proposal #90212

Do Massive Stars Have Planets?

Principal Investigator: Sara Barber
Institution: University of Oklahoma

Technical Contact: Sara Barber, University of Oklahoma

Co-Investigators:
Mukremin Kilic, University of Oklahoma
Sandy Leggett, Gemini Observatory

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.0

Abstract:
We recently conducted a near- and mid-infrared survey of a sample of 117 DA white dwarfs from the Palomar-Green (PG) survey. The white dwarfs in this sample are decedent from 1-7 solar mass stars; this survey constrained the frequency of planetary systems in the elusive intermediate-mass regime. We found that at least 4.3% of 1-7 Msol stars host planetary systems. However, the mass distribution of our sample is strongly biased toward lower mass white dwarfs, descendants of M < 3 Msol main-sequence stars. To constrain the frequency of dusty disks around massive white dwarfs, and in turn the frequency of planets around their massive progenitor main-sequence stars, we propose to observe 100 massive white dwarfs from the Sloan Digital Sky Survey in the IRAC 4.5 micron band. We restrict our sample to M > 0.8 Msol white dwarfs (> 3 Msol progenitor stars) and Teff = 9500 - 22,500 K. All but one of the known dusty white dwarfs have temperatures in this range, where dust orbiting within the tidal radius of the star will remain solid. However, no previous Spitzer survey has targeted massive WDs in this temperature range, and this unique discovery space remains unexplored. Assuming a similar disk frequency for normal and massive WDs, we are 99.5% confident that our proposed survey of 100 stars will find at least one dusty WD and it will provide stringent constraints on the frequency of planets around massive stars for the first time. This result will provide an important test for the planet formation models around sun-like and higher mass stars.

Spitzer Space Telescope - General Observer Proposal #80032

Far out: tracing the mass in M31

Principal Investigator: Pauline Barmby
Institution: University of Western Ontario

Technical Contact: Pauline Barmby, University of Western Ontario

Co-Investigators:
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Harvey Richer, University of British Columbia
Larry Widrow, Queens University
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Kristin Woodley, University of British Columbia

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 41.1

Abstract:
Recent photometric surveys have shown that the disk and halo of M31, the Andromeda galaxy, extend much further than previously thought, and contain stellar streams and arcs which indicate the complex history of this galaxy. We propose to examine the outer disk and halo of M31 from an infrared perspective. By extending the existing IRAC maps of the galaxy, we can trace the stellar mass to larger radii, better constraining mass models. An improved understading of the stellar populations in these remote areas will provide more detailed clues about the interaction history of the galaxy.

Spitzer Space Telescope - General Observer Proposal #60116

Extended Stellar Distributions in M83

Principal Investigator: Kate Barnes
Institution: Indiana University

Technical Contact: Daniel Dale, University of Wyoming

Co-Investigators:
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Daniel Dale, University of Wyoming
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Julianne Dalcanton, University of Washington
James Bullock, University of California Irvine
Rupali Chandar, University of Toledo

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30

Abstract:
The outer disks of galaxies provide a unique environment for studies of disk growth and galaxy formation. Due to the long dynamical timescales in the outer disk, stellar structures such as breaks, truncations, and tidal streams persist over billions of years. Deep imaging of these structures allows us to trace the history of the galaxy’s accretion events and evolution, thus providing essential constraints on current models of galaxy formation. Here we are proposing for deep IRAC imaging of the prototypical star-forming galaxy, M83, to conduct a pilot study for a larger survey of the outer disk of nearby galaxies. M83 has a rich set of ancillary data that will allow for a multiwavelength analysis of the stellar populations throughout the outer disk. Existing ACS data will allow for a direct calibration of the observed IR surface brightness to a stellar mass density. Comparison of deep IR and UV integrated light profiles will reveal variations in the stellar populations and provide a unique test case for models of disk growth.

Spitzer Space Telescope - General Observer Proposal #80024

CHaMP@Spitzer: The Formation and Early Evolution of Star Clusters in a Large Unbiased Sample of Dense Gas Clumps

Principal Investigator: Peter Barnes
Institution: University of Florida

Technical Contact: Peter Barnes, University of Florida

Co-Investigators:
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Nathan Smith, University of Arizona
Jonathan Tan, University of Florida
Krista Romita, University of Florida
Stefan O'Dougherty, University of Florida
Bo Ma, University of Florida
Stuart Ryder, Australian Astronomical Observatory
Andrew Hopkins, Australian Astronomical Observatory

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 73.5

Abstract:
The Galactic Census of High- and Medium-mass Protostars (CHaMP) is a large, unbiased, and panchromatic survey of the formation and early evolution of stars and star clusters covering 20 by 6 deg. of the Galactic Plane. The survey is based on a complete sample of ~300 dense (HCO+ J=1-0 emitting) gas clumps, selected by a recursive mapping of the peaks of 12CO, 13CO, and C18O emission, and then mapped by the Mopra radio telescope in a multitude of molecular transitions. Thus, for the first time we have a full census of the dense gas structures in a large volume of the Milky Way. The goal of this proposal is to use Warm Spitzer to characterize the star formation activity in this entire sample, probing the complete range of dense gas environments. We can resolve the formation of individual stars, but at the same time the full dataset will give us a measure of the global star formation activity of a large portion of the Milky Way, and the range of star formation efficiencies exhibited by molecular clouds. In particular, Spitzer data will: 1. Yield a complete census of any Young Stellar Objects in each clump down to about a solar mass, including their spatial distributions. 2. Combined with other infrared data, allow systematic measurements of the properties of any embedded clusters, including luminosity and mass functions, broad-band spectral classification, protostellar and disk fractions, outflow indicators, and how these vary with cluster mass and density. 3. Combined with mm data, permit a detailed comparison of the embedded stellar populations with their natal dense gas to derive star formation efficiencies and feedback effects.

Spitzer Space Telescope - General Observer Proposal #60063

Exoplanet HAT-P-11b Secondary Transit Observations

Principal Investigator: Richard Barry
Institution: NASA Goddard Space Flight Center

Technical Contact: Drake Deming, NASA's Godddard Space Flight Center

Co-Investigators:
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Joseph Harrington, University of Central Florida
Nikku Madhusudhan, MIT
Robert Noyes, Harvard-CfA
Sarah Seager, Massachusetts Institute of Technology

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 48.2

Abstract:
We propose to conduct secondary eclipse observations of exoplanet HAT-P-11b, recently discovered by proposal Co-Investigator G. Bakos and his colleagues. HAT-P-11b is the smallest transiting extrasolar planet yet found and one of only two known exo-Neptunes. We will observe the system at 3.6 microns for a period of 22 hours centered on the anticipated secondary eclipse time, to detect the eclipse and determine its phase. Once the secondary eclipse is located, we will make a more focused series of observations in both the 3.6 and 4.5 micron bands to fully characterize it. HAT-P-11b has a period of 4.8878 days, radius of 0.422 RJ, mass of 0.081 MJ and semi-major axis 0.053 AU. Measurements of the secondary eclipse will clarify two key issues; 1) the planetary brightness temperature and the nature of its atmosphere, and 2) the eccentricity of its orbit, with implications for its dynamical evolution. A precise determination of the orbit phase for the secondary eclipse will also be of great utility for Kepler observations of this system at visible wavelengths.

Spitzer Space Telescope - General Observer Proposal #60198

A Double Planetary Occultation By the Outer Gas Giant Neptune

Principal Investigator: James Bauer
Institution: Jet Propulsion Laboratory

Technical Contact: James Bauer, Jet Propulsion Laboratory

Science Category: planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 11.3

Abstract:
As a large number of giant exo-planets are being characterized and discovered, the need to understand how gas giants respond to the circumstances of variations in insolation is becoming apparent. The gas giants in our own solar system have not been observed in sufficient detail or over sufficiently long time scales to understand how they respond to seasonal changes. A sensitive trace of seasonally driven atmospheric global evolution is provided by observations of stellar occultation events, which yield nearly instantaneous atmospheric pressure-height profiles at critical seasonal junctures. We propose to observe two of these occultation events of the outer gas giant Neptune, which has recently undergone its summer solstice. The events are nearly consecutive, and viewable only from the SST using IRAC?s sub-array capabilities and fortuitous band-pass in the shortest wavelength channel.

Spitzer Space Telescope - General Observer Proposal #14059

Revealing Fact or Fiction in Spitzer Exoplanet Phase Curve Trends

Principal Investigator: Jacob Bean
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Technical Contact: Kevin Stevenson, STScI

Co-Investigators:
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Megan Mansfield, University of Chicago
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Eliza Kempton, Grinnell College
Jean-Michel Desert, University of Amsterdam
Mark Swain, Jet Propulsion Laboratory
Lisa Dang, McGill University
Taylor Bell, McGill University
Dylan Keating, McGill University
Robert Zellem, Jet Propulsion Laboratory
Jonathan Fortney, University of California, Santa Cruz
Michael Line, Arizona State University
Laura Kreidberg, Harvard University
Kevin Stevenson, STScI

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 620.0
Priority: 1

Abstract:
The constraints on energy transport in exoplanet atmospheres from phase curve observations is sure to be one of Spitzer's enduring legacies. However, with phase curves for 17 planets now observed we find that the previously observed trends are not coming into sharper focus. Instead, these trends in hot spot offset and day-night flux contrast vs. the fundamental planetary parameters expected to control the energy transport (e.g., irradiation and rotational period) are becoming more uncertain due to the recent discovery of outliers. At the same time, there is a growing understanding that a number of factors like magnetic fields, aerosols, and molecular chemistry could be confounding the search for these correlations. We propose a final phase curve program to advance our understanding of energy transport in transiting exoplanet atmospheres and to cement Spitzer's legacy on this topic. This program tackles the outstanding questions in this area with a comprehensive, two-pronged approach: (1) a survey of an additional 10 high signal-to-noise planets that span a broad parameter space and (2) a search for magnetic field-induced variability in the planet HAT-P-7b. The expanded survey will bring additional statistical power to the search for trends and will enable us to determine if the recently-detected outliers are indeed oddities or are instead actually representative of the intrinsic sample diversity. The variability search will test the hypothesis that the atmospheric dynamics of the partially ionized atmospheres of close-in planets are influenced by magnetic fields, which could explain the observed scatter around the existing trends. All observations will be performed at 4.5 microns, which is the consensus best channel for these measurements. The dataset from this program will provide vital context for JWST observations and will not be superseded until ARIEL flies more than a decade from now.

Spitzer Space Telescope - General Observer Proposal #11095

Phase Curve Observations of the Irradaited Transiting Brown Dwarf KELT-1b

Principal Investigator: Thomas Beatty
Institution: Pennsylvania State University

Technical Contact: Thomas Beatty, Pennsylvania State University

Co-Investigators:
Knicole Colon, Lehigh University
Jonathan Fortney, UC Santa Cruz
Scott Gaudi, Ohio State University
Mark Marley, NASA Ames
Joseph Rodriguez, Vanderbilt University
Adam Showman, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 74.5
Priority: 1

Abstract:
We propose to observe full orbit phase curves, at 3.6um and 4.5um, of the transiting brown dwarf KELT-1b. KELT-1b is a 27MJ object on a short 1.2 day (29.2 hour) orbit around a bright (V=10.8) F5V star. This system is unique, in that it contains the only known highly irradiated brown dwarf on which it is possible to perform high precision atmospheric measurements, due to KELT-1b's short orbital period and the brightness of its host star. Future work to observationally and theoretically understand the properties of irradiated brown dwarfs will, therefore, rely on our ability to measure the properties of KELT-1b and its atmosphere. Furthermore, a comparison of KELT-1b's Spitzer phase curves to those of similarly irradiated giant planets offers the best possible test of the role of surface gravity in atmospheric circulation. Besides its one-of-a-kind status as an irradiated brown dwarf, KELT-1b is one of the best possible targets for phase curve observations. There are only seven transiting extrasolar giant planets or brown dwarfs with shorter orbital periods (<1.2 days), and all but one (WASP-18b) are around stars at least a magnitude fainter (V>11.8). Our proposed observations will therefore require a relativity low amount of Spitzer time compared to other phase curve proposals (74.5 hours for both bands), and will give very high signal-to-noise ratio (SNR) detections of the phase modulation (estimated SNR of 56 to 74). Our observations will yield one of the best defined phase curve measurements conducted by Spitzer: we estimate a SNR for the phase curve of KELT-1b similar to that achieved on WASP-18b, and a SNR 4 to 5 times higher than the next highest SNR achieved, for the phase curve of HD189733b.

Spitzer Space Telescope - General Observer Proposal #12096

A Spitzer Transit of the Most Inflated Planet Known, Around an Extremely Bright Sub-giant Star

Principal Investigator: Thomas Beatty
Institution: Pennsylvania State University

Technical Contact: Thomas Beatty, Pennsylvania State University

Co-Investigators:
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Knicole Colon, Kepler/K2 Guest Observer Office
David James, CTIO
Laura Kriedberg, University of Chicago
Joshua Pepper, Lehigh University
Joseph Rodriguez, Vanderbilt University
Robert Siverd, LCOGT
Keivan Stassun, Vanderbilt University
Daniel Stevens, Ohio State University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.5
Priority: 1

Abstract:
KELT-11b is a newly discovered transiting Saturn-mass planet (Mp~0.22MJ) that promises to become a unique benchmark. KELT-11b orbits HD 93396,the second brightest star in the near-IR (K=6.122) and the third brightest star in the optical (V=8.04) to host a transiting giant planet. This makes KELT-11 comparable to the well-studied benchmarks HD 189733 and HD 209458. But unlike these other bright systems, KELT-11b's host star is a sub-giant, with log(g)~3.7. Thus KELT-11b is the first transiting giant planet known around a sub-giant star bright enough for precise follow-up observations. Furthermore, KELT-11b is the most inflated planet known, with the lowest surface gravity (log[g]~2.5) of any transiting planet. This makes it an exciting target for atmospheric characterization and studying the effect of post main-sequence evolution of a host star on a hot Jupiter. But to correctly interpret any follow-up observations, we will first need to measure accurate stellar and planetary parameters for the system via a precise transit observation. Unfortunately, this is effectively impossible to do from the ground. Spitzer's ability to provide high precision continuous photometry provides the only current way in which we may precisely observe a complete transit of KELT-11b. We therefore propose for 15.5 hours, to observe a single transit KELT-11b at 3.6um. This would reduce the uncertainties on the transit depth and stellar density by at least a factor of twenty, and will improve the model-derived stellar mass by at least a factor of ten, compared to ground-based observations. This will serve two goals. First, it will be a valuable legacy to the community, by providing a precise set of system parameters that will enable future observation and interpretation of this unique, bright, system. Second, an observation of a transit will allow us to strongly constrain the mass of KELT-11, and thus help resolve the disagreement over the true masses of the "retired A stars" radial-velocity sample.

Spitzer Space Telescope - General Observer Proposal #13055

Eclipse Observations of a Temperate Transiting Brown Dwarf

Principal Investigator: Thomas Beatty
Institution: Pennsylvania State University

Technical Contact: Thomas Beatty, Pennsylvania State University

Co-Investigators:
Jason Curtis, Pennsylvania State University
Benjamin Montet, California Institute of Technology
Andrew Vanderberg, Harvard University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.7
Priority: 1

Abstract:
We wish to use 15.7 hours of Spitzer time to observe two eclipses, one each at 3.6 um and 4.5 um of a newly discovered transiting brown dwarf, which we refer to as R147-BD. R147-BD is a 36 MJ object on a 5.3 day orbit about a K=10.666, 5800K solar analog. Uniquely, R147-BD and its host star are both members of the 3.0 Gyr old open cluster Ruprecht 147. R147-BD is thus one of the only transiting brown dwarfs for which we have a robust isochronal age that is not dependent upon brown dwarf evolutionary models. These models predict that a field object with the mass and age of R147-BD should have an effective temperature of about 800K due to internal heat. The zero-albedo blackbody equilibrium temperature for R147-BD, based only on its host star's insolation, is 1125K. This makes R147-BD the first observationally accessible sub-stellar object for which the internal and external energy fluxes are approximately equal, and it can serve as a unique laboratory to test the effect of stellar irradiation on the vertical pressure-temperature structure and clouds of giant planets. Specifically, we wish to investigate three different questions with these observations. First, how does the measured mass, radius, age and emission of R147-BD compare to brown dwarf evolution models, and how have these been altered by stellar irradiation? Second, does R147-BD's dayside atmosphere resemble its isolated field equivalent, or is it closer to hot Jupiters at similar temperatures? Third, can we constrain the cloud properties of R147-BD's dayside? Besides these particular science questions, observations of R147-BD allow us to scout-out future JWST observations of temperate giant planets, which also will have roughly equal amounts of stellar irradiation and internal heat.

Spitzer Space Telescope - General Observer Proposal #14058

Testing the Formation Pathway of a Transiting Brown Dwarf in a Middle-aged Cluster

Principal Investigator: Thomas Beatty
Institution: Pennsylvania State University

Technical Contact: Thomas Beatty, Pennsylvania State University

Co-Investigators:
Jason Curtis, Columbia University
Caroline Morley, Harvard University
Adam Burrows, Princeton University
Benjamin Montet, University of Chicago
Jason Wright, Pennsylvania State University

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.8
Priority: 2

Abstract:
We wish to use 15.7 hours of Spitzer time to observe two transits, one each at 3.6um and 4.5um, of the transiting brown dwarf CWW 89Ab (Nowak et al. 2017) to measure its nightside emission. This will allow us to either make the first positive identification of a brown dwarf that has formed through core accretion processes -- or will provide a severe challenge to brown dwarf evolution models. CWW 89Ab is a 36.5+/-0.1 MJ, 0.937+/-0.042 RJ, brown dwarf on a 5.3 day orbit about a 5800K dwarf. The brown dwarf is a member of the 3.00+/-0.25 Gyr old open cluster Ruprecht 147 (Curtis et al. 2013). CWW 89Ab is one of two transiting brown dwarfs for which we have an isochronal age -- giving us an age, a mass, and a radius that are all independent of evolutionary models. Surprisingly, Spitzer eclipse observations of CWW 89Ab (Beatty et al. 2018) show that the dayside emission requires an internal luminosity is 16 times higher than predicted by evolutionary models. In Beatty et al. (2018) we hypothesized that this is due to a stratospheric temperature inversion on CWW 89Ab's dayside. Atmospheric modeling by Molliere et al. (2015) shows that CWW 89Ab's temperature, an inversion can only happen if the atmospheric carbon-to-oxygen ratio (C/O) is close to one. Since we know that the abundances of Ruprecht 147 and CWW 89A itself (Curtis et al. 2018) are close to the Solar value of C/O~0.54, a super-stellar value of C/O~1 in CWW 89Ab would mean that the material used to form the brown dwarf was processed through CWW 89A's proto-planetary disk (Oberg et al. 2011). It would necessarily follow that CWW 89Ab formed via core accretion within the proto-planetary disk, and not through gravitational collapse. We wish to observe CWW 89Ab to determine if the dayside over-luminosity is caused by a temperature inversion. Since inversions are caused by direct stellar irradiation and impossible at night, the nightside emission should be consistent with Tint=850K if an inversion is the cause of the dayside over-luminosity.

Spitzer Space Telescope - General Observer Proposal #14077

Benchmarking Brown Dwarf Models With a Non-irradiated Transiting Brown Dwarf in Praesepe

Principal Investigator: Thomas Beatty
Institution: Pennsylvania State University

Technical Contact: Thomas Beatty, Pennsylvania State University

Co-Investigators:
Mark Marley, NASA Ames
Michael Line, Arizona State University
John Gizis, University of Delaware

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.4
Priority: 1

Abstract:
We wish to use 9.4 hours of Spitzer time to observe two eclipses, one each at 3.6um and 4.5um, of the transiting brown dwarf AD 3116b. AD 3116b is a 54.2+/-4.3 MJ, 1.08+/-0.07 RJ object on a 1.98 day orbit about a 3200K M-dwarf. Uniquely, AD 3116 and its host star are both members of Praesepe, a 690+/-60 Myr old open cluster. AD 3116b is thus one of two transiting brown dwarfs for which we have a robust isochronal age that is not dependent upon brown dwarf evolutionary models, and the youngest brown dwarf for which this is the case. Importantly, the flux AD 3116b receives from its host star is only 0.7% of its predicted internal luminosity (Saumon & Marley 2008). This makes AD 3116b the first known transiting brown dwarf that simultaneously has a well-defined age, and that receives a negligible amount of external irradiation, and a unique laboratory to test radius and luminosity predictions from brown dwarf evolutionary models. Our goal is to measure the emission from the brown dwarf. AD 3116b should have large, 25 mmag, eclipse depths in the Spitzer bandpasses, and we expect to measure them with a precision of +/-0.50 mmag at 3.6um and +/-0.54 mmag at 4.5um. This will allow us to make measure AD 3116b?s internal effective temperature to +/-40K. We will also use the upcoming Gaia DR2 parallaxes to measure AD 3116b’s absolute IRAC magnitudes and color, and hence determine the cloud properties of the atmosphere. As the only known brown dwarf with an independently measured mass, radius, and age, Spitzer measurements of AD 3116b’s luminosity and clouds will provide a critical benchmark for brown dwarf observation and theory.

Spitzer Space Telescope - General Observer Proposal #14111

A Test of the Fundamental Physics Underlying Exoplanet Climate Models

Principal Investigator: Thomas Beatty
Institution: Pennsylvania State University

Technical Contact: Thomas Beatty, Pennsylvania State University

Co-Investigators:
Dylan Keating, McGill University
Nick Cowan, McGill University
Scott Gaudi, Ohio State University
Tiffany Kataria, NASA JPL
Jonathan Fortney, UC Santa Cruz
Keivan Stassun, Vanderbilt University
Karen Collins, Harvard University
Drake Deming, University of Maryland
Taylor Bell, McGill University
Lisa Dang, McGill University
Tamara Rogers, Newcastle University
Knicole Colon, NASA Goddard

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 44.2
Priority: 2

Abstract:
A fundamental issue in how we understand exoplanet atmospheres is the assumed physical behavior underlying 3D global circulation models (GCMs). Modeling an entire 3D atmosphere is a Herculean task, and so in exoplanet GCMs we generally assume that there are no clouds, no magnetic effects, and chemical equilibrium (e.g., Kataria et al 2016). These simplifying assumptions are computationally necessary, but at the same time their exclusion allows for a large theoretical lee-way when comparing to data. Thus, though significant discrepancies exist between almost all a priori GCM predictions and their corresponding observations, these are assumed to be due to the lack of clouds, or atmospheric drag, or chemical disequilibrium, in the models (e.g., Wong et al. 2016, Stevenson et al. 2017, Lewis et al. 2017, Zhang et al. 2018). Since these effects compete with one another and have large uncertainties, this makes tests of the fundamental physics in GCMs extremely difficult. To rectify this, we propose to use 88.4 hours of Spitzer time to observe 3.6um and 4.5um phase curves of the transiting giant planet KELT-9b. KELT-9b has an observed dayside temperature of 4600K (Gaudi et al. 2017), which means that there will very likely be no clouds on the day- or nightside, and is hot enough that the atmosphere should be close to local chemical equilibrium. Additionally, we plan to leverage KELT-9b’s high temperature to make the first measurement of global wind speed on an exoplanet (Bell & Cowan 2018), giving a constraint on atmospheric drag and magnetic effects. Combined, this means KELT-9b is close to a real-world GCM, without most of the effects present on lower temperature planets. Additionally, since KELT-9b orbits an extremely bright host star these will be the highest signal-to-noise ratio phase curves taken with Spitzer by more than a factor of two. This gives us a unique opportunity to make the first precise and direct investigation into the fundamental physics that are the foundation of all exoplanet GCMs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14284

Testing the Formation Pathway of a Transiting Brown Dwarf, Take 2

Principal Investigator: Thomas Beatty
Institution: University of Arizona

Technical Contact: Thomas Beatty,University of Arizona

Co-Investigators:
Adam Burrows, Princeton University
Jason Curtis, Columbia University
Benjamin Montet, University of Chicago
Caroline Morley, UT Austin

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.8
Priority: 1

Abstract:
We wish to use 15.7 hours of Spitzer time to observe two transits, one each at 3.6um and 4.5um, of the transiting brown dwarf CWW 89Ab (Nowak et al. 2017) to measure its nightside emission. This will allow us to either make the first positive identification of a brown dwarf that has formed through core accretion processes -- or will provide a severe challenge to brown dwarf evolution models. CWW 89Ab is a 36.5+/-0.1 MJ, 0.937+/-0.042 RJ, brown dwarf on a 5.3 day orbit about a 5800K dwarf. The brown dwarf is a member of the 3.00+/-0.25 Gyr old open cluster Ruprecht 147 (Curtis et al. 2013). CWW 89Ab is one of two transiting brown dwarfs for which we have an isochronal age -- giving us an age, a mass, and a radius that are all independent of evolutionary models. Surprisingly, Spitzer eclipse observations of CWW 89Ab (Beatty et al. 2018) show that the dayside emission requires an internal luminosity is 16 times higher than predicted by evolutionary models. In Beatty et al. (2018) we hypothesized that this is due to a stratospheric temperature inversion on CWW 89Ab's dayside. Atmospheric modeling by Molliere et al. (2015) shows that CWW 89Ab's temperature, an inversion can only happen if the atmospheric carbon-to-oxygen ratio (C/O) is close to one. Since we know that the abundances of Ruprecht 147 and CWW 89A itself (Curtis et al. 2018) are close to the Solar value of C/O~0.54, a super-stellar value of C/O~1 in CWW 89Ab would mean that the material used to form the brown dwarf was processed through CWW 89A's proto-planetary disk (Oberg et al. 2011). It would necessarily follow that CWW 89Ab formed via core accretion within the proto-planetary disk, and not through gravitational collapse. We wish to observe CWW 89Ab to determine if the dayside over-luminosity is caused by a temperature inversion. Since inversions are caused by direct stellar irradiation and impossible at night, the nightside emission should be consistent with Tint=850K if an inversion is the cause of the dayside over-luminosity.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14297

Looking For Weather on a Hot Jupiter

Principal Investigator: Thomas Beatty
Institution: University of Arizona

Technical Contact: Thomas Beatty, University of Arizona

Co-Investigators:
Adam Showman, University of Arizona

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 52.6
Priority: 1

Abstract:
No hot Jupiter has ever received a repeat Spitzer/IRAC phase curve observation in the same band. As a result, the exoplanet community has to assume that the thermal emission signals seen by IRAC show us atmospheres in equilibrium, with no temporal variability. But since no hot Jupiter phase curve has been observed more than once, this assumption has only been obliquely tested by comparing repeat eclipse measurements. Given that the Spitzer phase curve data are the sole window we have into the 3D atmospheres and global climates of these planets, it is important to determine whether what we see represents the equilibrium state of an atmosphere, or if we are seeing single snapshots of time-varying weather. We therefore propose to use 52.6 hours of Spitzer time to observe two orbital phase curves of the hot Jupiter WASP-43b at 4.5um, separated by at least 20 days. Together with a previous 4.5um phase curve this will give us three epochs to sample WASP-43b's weather. We will specifically look for changes in the location of the phase curve maxima and minima, and for changes in the shape of the phase curve itself. We are asking for two new phase curve observations to provide strong evidence of variability using three total phase curves, because differences between just two observations might simply be the result of unfortunate systematic measurement uncertainties. One of the greatest legacies that Spitzer will leave to the astrophysical community is its set of exoplanet phase curve observations, and determining the possible role of weather in these data will therefore be crucial to their interpretation. Conducting these observations before the end of the Spitzer mission is the best, direct, way to accomplish this.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80263

3.6um and 4.5um Secondary Eclipse Observations of the Highly Irradiated Transiting Brown Dwarf KELT-1b

Principal Investigator: Thomas Beatty
Institution: Ohio State University

Technical Contact: Thomas Beatty, Ohio State

Co-Investigators:
Scott Gaudi, Ohio State University
Jason Eastman, LCOGT and UC Santa Barbara
Jonathan Fortney, UC Santa Cruz
Heather Knutson, Caltech
Joshua Pepper, Vanderbilt
Robert Siverd, Vanderbilt
Keivan Stassun, Vanderbilt

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.5

Abstract:
The transiting brown dwarf KELT-1b provides us with a unique opportunity to how brown dwarfs and exoplanets relate to one another, or if they are even distinct. It is a 27 Jupiter-mass object on a short 1.2 day orbit around a bright (V=10.8) F5V star. KELT-1b allows us to study a brown dwarf where we know the mass, radius and age -- in an environment similar to hot Jupiters and around a star bright enough to allow for precision follow-up observations. KELT-1b is also specifically interesting because it is substantially inflated as compared to models for brown dwarfs at the age of the KELT-1 system. This is the first instance of an inflated brown dwarf, and whether the inflation mechanism is related to that of hot Jupiters or low-mass stars is unclear. We therefore are proposing to observe two secondary eclipses: one at 3.6 um and one at 4.5 um. The information provided by the secondary eclipses will allow us to begin to characterize the atmospheric composition, dynamics, and structure of KELT-1b in such a way that we may begin to relate the observed properties of field brown dwarfs to those of hot Jupiters, and to discover how it has been inflated. Our proposed observations will also allow us to gauge the feasibility of a Spitzer GO proposal to observe orbital phase variation in the light from KELT-1, to be submitted this fall.

Spitzer Space Telescope - General Observer Proposal #12114

A transiting super-Earth around a solar twin with evidence for planet accretion?

Principal Investigator: Megan Bedell
Institution: University of Chicago

Technical Contact: Megan Bedell, University of Chicago

Co-Investigators:
Jacob Bean, University of Chicago
Jorge Melendez, Universidade de Sao Paulo
Kevin Stevenson, University of Chicago
Leonardo Santos, Universidade de Sao Paulo
DIana Dragomir, University of Chicago

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.4
Priority: 1

Abstract:
Over the last four years we have been carrying out a HARPS radial velocity planet search program aimed at solar twins. Solar twins are a class of stars uniquely suited for high-precision chemical abundance measurements, and the goal of this project is to search for correlations between stellar abundances and planet frequency at a level of sensitivity only solar twins can provide. We recently discovered a 3 Earth mass planet on a 1.8 day orbital period around one of our targets. With a 16% transit probability, this planet presents the potential to identify the first transiting planet around a solar twin star. We propose Spitzer observations to search for the transit of this super-Earth object and measure its radius, yielding a bulk density. By combining the planetary bulk density and our ultra-high-precision abundances of the host star, we will investigate the connection between planet and host star composition in an entirely new way. This will provide a powerful window into the formation process of a hot super-Earth. Furthermore, our analysis of the host star has yielded intriguing hints at a past planet accretion event. This raises the possibility that the super-Earth is actually the residual core of a hot Jupiter whose outer layers were accreted by the host star. If true, this object would be the first such remnant known. A bulk density for the planet from a transit detection would yield further insight to this interesting theory.

Spitzer Space Telescope - General Observer Proposal #60107

Investigating the Nature of Dust Disks in Weakly-Magnetic Cataclysmic Variables

Principal Investigator: Kunegunda Belle
Institution: Los Alamos National Laboratory

Technical Contact: Donald Hoard, IPAC, California Institute of Technology

Co-Investigators:
D. W. Hoard, Spitzer Science Center
Steve B. Howell, NOAO

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.4

Abstract:
We propose to obtain 4.5 micron light curves and a single 3.6 micron measurement of four intermediate polars, a class of weakly-magnetic cataclysmic variables (CVs), in order to investigate the nature of dust in CVs. This proposal is motivated by results from our Cycle 2 observations, in which we discovered the presence of circumbinary dust disks in highly-magnetic CVs, and our Cycle 4 observations, in which 4.5 and 8 micron light curves of the non-magnetic CV, WZ Sge, revealed the presence of previously undetected dust associated with the accretion disk within the binary. This dichotomy in dust properties may be the result of evolutionary differences between highly-magnetic and non-magnetic CVs, or the different accretion processes occurring within the systems. Intermediate polars present a blend of non-magnetic and highly-magnetic CV properties, and therefore, Spitzer time-series observations of these systems will help to answer many of the questions that arose after our Cycle 2 and Cycle 4 observations, and will also answer outstanding questions about intermediate polars, such as if they are evolutionarily linked to highly-magnetic systems and how the cool component of the accretion disk is affected by the truncation of the hot inner component of the disk. The proposed observations will also have great relevance for our understanding of the physics and structure of accretion disks in general, those in binary systems as well as in active galaxies.

Spitzer Space Telescope - General Observer Proposal #12023

GLIMPSE Proper: Mid-Infrared Observations of Proper Motion and Variability Towards Galactic Center

Principal Investigator: Robert Benjamin
Institution: University of Wisconsin-Whitewater

Technical Contact: Brian Babler, University of Wisconsin, Madison

Co-Investigators:
Brian Babler, University of Wisconsin Madison
Ed Churchwell, University of Wisconsin Madison
Will Clarkson, University of Michigan-Dearborn
Davy Kirkpatrick, Infrared Processing and Analysis Center
Marilyn Meade, University of Wisconsin Madison
Barbara Whitney, University of Wisconsin Madison

Science Category: stellar populations
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 97.5
Priority: 1

Abstract:
We propose to re-image 43.4 square degrees of the Galactic center to measure the proper motions of over fifteen million sources within 5 degrees of Galactic center over the last decade. This stellar sample will be over 20 times larger than the previous optical ground-based measurements and will allow us to constrain the anisotropic stellar velocity dispersion as a function of direction and distance as well as test previous claims of streaming motions associated with the near/far side of the Galactic bar, the X-shaped bar, and the vertically thin extended Long Bar. Not only will this be the largest Galactic bulge proper motion survey to date, it will also be the most uniform as mid-infrared observations are minimally affected by extinction over most of the region. We also expect to find at least 150 high proper motion stars (>100 mas/yr) which could be substellar objects and possible microlensing candidates against the crowded Galactic bulge. We will put constraints on the current production rate of hyper-velocity stars thought to be formed in binary interactions with the supermassive black hole of the Galaxy. Finally, we will be able to identify many new variable stars, particularly in the central 2x1.5 degree region of the Galaxy which has only been observed in a single epoch with Spitzer; we expect to find 1000 new sources with variability amplitudes greater than 0.2 mag.

Spitzer Space Telescope - General Observer Proposal #13117

Three Dimensional Stellar Kinematics of the Galactic Bar and Disk: Where APOGEE Meets GLIMPSE

Principal Investigator: Robert Benjamin
Institution: University of Wisconsin-Whitewater

Technical Contact: Robert Benjamin, University of Wisconsin-Whitewater

Co-Investigators:
Brian Babler, University of Wisconsin, Madison
Elena D'Onghia, University of Wisconin, Madison
Will Clarkson, University of Michigan, Dearborn
Ed Churchwell, University of Wisconsin, Madison
Davy Kirkpatrick, IPAC/Caltech
Gail Zasowski, Johns Hopkins University
Steve Majewski, University of Virginia

Science Category: galactic structure
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 198.8
Priority: 1

Abstract:
We propose to use the Spitzer Space Telescope to re-image 53 square degrees (fourteen fields) of the inner Galactic plane (galactic longitudes |L|=6-45 degrees) that have also been targeted by the APOGEE/APOGEE-2 surveys--Sloan III and IV programs to obtain high resolution H band spectroscopy for hundreds of thousands of red giants. We will combine the proposed observations (198 hours) with the original GLIMPSE observations of the Galactic plane in 2004-2005 to measure the proper motions of sources along the Galactic plane over the past decade. When combined with the 43 square degrees of Priority 1 data being obtained for Cycle 12---which cover |L|< 5 degrees and |B|<2 degrees, plus Baade's window --we will have proper motion constraints for over 25 million sources. The combination of Spitzer proper motions for millions of sources and APOGEE radial velocities for thousands of sources will be used to constrain models of stellar kinematics for the Galactic bar(s) and disk. We will also use this data to test several bar formation models that have been developed to explain the mysterious "high-velocity" Milky Way bar stars (Nidever et al 2012b), one of the first APOGEE discoveries. This program will be the most uniform and deep Galactic plane proper motion study as mid-infrared observations are minimally affected by extinction over most of the region we propose to cover. We also expect to be able to find at least 150 high proper motion stars which could be substellar objects and possible micro-lensing candidates against the crowded Galactic disk.

Spitzer Space Telescope - General Observer Proposal #12081

Probing the Compositions of Two Habitable Zone Super-Earths

Principal Investigator: Bjorn Benneke
Institution: California Institute of Technology

Technical Contact: Bjorn Benneke, California Institute of Technology

Co-Investigators:
Heather Knutson, California Institute of Technology
Ian Crossfield, University of Arizona
Katherine Deck, California Institute of Technology
Tom Greene, NASA Ames
Leslie Rogers, UC Berkeley
Andrew Vanderburg, Harvard University
Travis Barman, University of Arizona
Caroline Morley, UC Santa Cruz
Josh Lothringer, University of Arizona
Michael Werner, NASA JPL
Charles Beichman, NASA IPAC

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 61
Priority: 1

Abstract:
The recent discovery of two super-Earths orbiting in the habitable zones of nearby M stars have provided us with an unprecedented new opportunity to characterize the properties of small and potentially habitable planets outside of the solar system. Here, we propose to probe their atmospheric compositions, search for escaping hydrogen, and obtain the first bulk mass and densities estimate of a habitable zone super-Earth. The proposed observations will complement our approved HST WFC3 observations of K2-18b (15-orbits, GO13665, PI Benneke) as well as the approved HST STIS/MAMA observations of K2-18b by PI Ehrenreich. These observations will determine whether or not these two planets have primarily rocky or volatile-rich compositions, and in the volatile-rich case would enable the first studies of atmospheric chemistry in this regime. Mass loss also plays a critical role in the evolution of hydrogen-rich atmospheres on small planets, and our obsevations will provide the first constraints on the stability of these atmospheres.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14256

Thermal Emission Observations of the Keystone Exoplanet WASP-107b

Principal Investigator: Bjorn Benneke
Institution: University of Montreal

Technical Contact: Bjorn Benneke, University of Montreal

Co-Investigators:
Laura Kreidberg, Harvard Smithsonian
Michael Werner, NASA Jet Propulsion Laboratory
Caroline Piaulet, University of Montreal

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30.8
Priority: 2

Abstract:
The low temperature regime below 800~K is a yet poorly-understood region of the parameter space in exoplanetary atmospheres science. In particular, the strong emission at 3.6um combined with apparent lack of emission at 4.5um has challenged theorists. The newly detected eclipse of WASP-107b is a unique opportunity to unveil the underlying mechanisms of atmospheric dynamics and carbon chemistry. With its Neptune mass combined with a Jupiter size, it has a large atmospheric scale height which makes it the most amenable target for Spitzer secondary eclipse observations below 800~K. Our proposed repeated secondary eclipse observations at 3.6 and 4.5 um will provide the best possible measurements for a planet in the <800K yet, in that further constraint atmospheric models, and determine whether there is any flux between 4-5um that could be invested more closely by investigating substantial JWST time in the future. Currently, without any broadband detection at 4.5Î¼m in this regime, it is not clear at all what a JWST program at this wavelength could deliver for us for planets in this temperature regime (WASP-107b, GJ436b, etc.).

Spitzer Space Telescope - Directors Discretionary Time Proposal #14309

Reconnaissance of the keystone exoplanetary system around the cool dwarf LP 791-18

Principal Investigator: Bjorn Benneke
Institution: University of Montreal

Technical Contact: Bjorn Benneke, University of Montreal

Co-Investigators:
Ian Crossfield, MIT
Laura Kreidberg, Harvard University
Courtney Dressing, University of California, Berkeley
Michael Werner, NASA JPL
Merrin Peterson, University of Montreal
Diana Dragomir, MIT
Varoujan Gorjian, NASA JPL
Thomas Evans, MIT
Stephen Kane, University of California
Jessie Christansen, Caltech/IPAC

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 124.0
Priority: 1

Abstract:
The recent discovery of seven Earth-sized transiting planets orbiting the nearby cool dwarf star TRAPPIST-1 was one of the biggest discoveries in the short history of exoplanet science. These planets offer the first realistic opportunity to probe the atmospheres of potentially Earth-like, habitable-zone rocky planets outside the Solar System. Spitzer played a crucial role in their discovery because five of the seven planets including the three in the habitable-zone were discovered thanks to Spitzer's unique ability to deliver continuous high-precision IR photometry. Here, we propose for Spitzer observations of a second keystone system around the cool dwarf LP 791-18, recently discovered by TESS (Crossfield et al. 2019). LP 791-18 is similarly striking in that the initial discovery shows two planets, with potentially many Earth-sized planets lurking yet undiscovered due to TESS limited aperture size. At the same time, LP 791-18 is also different from TRAPPIST-1 in that the outer planet appears to be have been able to retain its sub-Neptune gas envelope. Here, we propose to continuously observe LP 791-18 for 124 hours to robustly detect, or eliminate the possibility of, transiting planets larger than Mars in orbital periods between LP 791-18 b and c. In addition, we will look for individual transits of longer period planets, search for TTVs, and obtain precise transit depth measurements that even enable the first reconnaissance of atmosphere of LP 791-18 c that supplements planned JWST/GTO observations. Any planets discovered and characterized around this extremely small star (0.17 R_sun) will present ideal targets for intensive JWST follow-up and therefore contribute greatly to Spitzer's long term legacy.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14215

TTV and period measurements of two planets in the bright HIP41378 system

Principal Investigator: David Berardo
Institution: MIT

Technical Contact: Ian Crossfield, MIT

Co-Investigators:
Ian Crossfield, Massachusetts Institute of Technology
Andrew Vanderburg, UT Austin
Juliette Becker, U. Michigan
Michael Werner, JPL
Kevin Hardegree-Ullman, U. Toledo
Steven Villanueva, MIT
Courtney Dressin, UC Berkeley
Stephen Kane, UC Riverside
John Livingston, U. Tokyo

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.3

Abstract:

HIP41378 is the second brightest star (V = 8.9, spectral type F8) known to host as many as five transiting exoplanets (Vanderburg et al., 2016). Previous observations with K2 and Spitzer indicate transit timing variations (TTVs) for HIP41378 c of 20-100 minutes. Additionally, the period of planet d has been narrowed down to 23 possible values. We request follow up of the system to confirm and characterize the TTV signal of planet c, while simultaneously observing possible transits of d (for which a non-transit would also provide insight to the dynamics of the system). Period variations for planet c are caused by perturbations due to other bodies in the system, and so these observations may potentially provide new information on up to three planets in the system, if planets b, e, or f are determined to be the perturber of c. Both HIP41378 c and d are too shallow to be detected from the ground, and so this opportunity with Spitzer represents the best chance to study this unique dynamical laboratory.

Spitzer Space Telescope - General Observer Proposal #80054

Probing the z>2 Mass-Metallicity Relationship with Gamma-Ray Bursts

Principal Investigator: Edo Berger
Institution: Harvard University

Technical Contact: Ranga-Ram Chary, California Institute of Technology

Co-Investigators:
Ranga-Ram Chary, California Institute of Technology
Tanmoy Laskar, Harvard University

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 77.2

Abstract:
The redshift evolution of the relationship between the stellar mass (M) of galaxies and their metallicity (Z) is a fundamental probe of the growth of galaxies, the evolution of the stellar IMF, the chemical evolution of the Universe and the importance of feedback processes in regulating the build up of mass. Although the relationship has been well studied over a range of galaxy masses in the local Universe, and luminous galaxies out to z~2.5, observing the evolution of metallicity at earlier cosmic times has been challenging due to the sensitivity limitations of ground-based spectroscopy. In the past few years, absorption line spectroscopy of long-duration gamma-ray bursts has extremely successful in yielding metallicity estimates of the host galaxy. The association of GRBs with the end stages in the evolution of a massive star implies that the hosts are actively star-forming. Our program to measure stellar masses of gamma-ray burst host galaxies using deep Spitzer imaging combined with observed metallicities yielded the first constraints on the M-Z relationship at z>3 and confirmed that GRBs probe typical, <L* star-forming galaxies with large neutral gas masses. Here, we propose deep Spitzer imaging to double the sample of GRB hosts which can be used to strengthen the current constraints on the M-Z relation at z>2. The derived stellar masses, both through direct detections and stacking will be able to extend the M-Z relation down to stellar masses of 2E9 Msun at z>2, assess the differential chemical evolution of galaxies across a wide range of stellar masses and provide a statistically robust sample to test for evolution in the environments that give rise to GRBs, as a function of cosmic time. The proposed observations, in conjunction with our previous program, will also form the Spitzer/GRB Legacy Sample by targeting all GRB hosts with known absorption metallicities during the broad overlap lifetime of NASA’s Spitzer and Swift missions.

Spitzer Space Telescope - General Observer Proposal #13103

Bright galaxies at z=9-11 from pure-parallel HST observations: Building a unique sample for JWST with Spitzer/IRAC

Principal Investigator: Stephanie Bernard
Institution: University of Melbourne

Technical Contact: Stephanie Bernard, University of Melbourne

Co-Investigators:
Michele Trenti, University of Melbourne
Rychard Bouwens, University of Leiden

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.6
Priority: 1

Abstract:
The combination of observations taken by Hubble and Spitzer revealed the unexpected presence of sources as bright as our own Milky Way as early as 400 Myr after the Big Bang, potentially highlighting a new highly efficient regime for star formation in L>L* galaxies at very early times. Yet, the sample of high-quality z>8 galaxies that have both HST and Spitzer/IRAC imaging is still very small, particularly at high luminosities. We propose here to remedy this situation and efficiently follow-up with Spitzer/IRAC the most promising z>8 sources from our Hubble Brightest of Reionizing Galaxies (BoRG) survey, which covers a footprint on the sky similar to CANDELS, provides a deeper search than ground-based surveys like UltraVISTA, and is robust against cosmic variance because of its 180 independent lines of sight. The proposed new 3.6 micron observations will continue the Spitzer cycle 12 BORG911 program and target 15 additional fields, leveraging over 300 new HST orbits (350 sqarcmin) to identify a final sample of about 5 to 10 bright galaxies at z >= 8.5. For optimal time use (just over 22 hours), our goal is to readily discriminate between z>8 sources (undetected or marginally detected in IRAC) and z~2 interlopers (strongly detected in IRAC) with just 1-2 hours per pointing. The high-quality candidates that we will identify with IRAC will be ideal targets for further studies to investigate the reionization state of the inter-galactic medium through near-IR Keck/VLT spectroscopy. They will also be uniquely suited to measurement of the redshift and stellar population properties through JWST/NIRSPEC observations, with the potential to elucidate how the first generations of stars are assembled in the earliest stages of the epoch of reionization.

Spitzer Space Telescope - Snapshot Proposal #80069

Old Stellar Populations of The VGS Void Galaxies

Principal Investigator: Burcu Beygu
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Technical Contact: Thomas Jarrett, California Institute of Technology

Co-Investigators:
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Rien van de Weygaert, Kapteyn Institute
Kathryn Kreckel, Columbia University
Thijs van der Hulst, Kapteyn Institute
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Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Hours Approved: 14.0

Abstract:
Cosmic voids form an essential ingredient of the Cosmic Web and may harbour a systematically different population of galaxies. Largely unaffected by the complex processes modifying galaxies in high-density environments, the pristine and isolated void regions must hold important clues to the intrinsic process of formation and evolution of galaxies. The Void Galaxy Survey (VGS) is a multi-wavelength program to study 60 void galaxies. Each has been selected from the deepest interior regions of identified voids in the SDSS redshift survey on the basis of a unique geometric technique, with no a prior selection of intrinsic properties of the void galaxies. The project intends to study in detail the gas content, star formation history and stellar content, as well as kinematics and dynamics of void galaxies and their companions in a broad sample of void environments. It involves the HI imaging of the gas distribution in each of the VGS galaxies. Amongst its most tantalizing findings is the possible evidence for cold gas accretion in some of the most interesting objects, amongst which are a polar ring galaxy and a filamentary configuration of void galaxies. An essential aspect for understanding the formation and evolution of void galaxies concerns their star formation history. The current IRAC proposal is meant to study the older stellar population of void galaxies to constrain their assembly history.

Spitzer Space Telescope - General Observer Proposal #80145

Stellar Mass of the Most UV Luminous Lyman Break Galaxies at z~3

Principal Investigator: Fuyan Bian
Institution: University of Arizona

Technical Contact: Fuyan Bian, University of Arizona

Co-Investigators:
Xiaohui Fan, University of Arizona
Linhua Jiang, University of Arizona
Ian McGreer, University of Arizona

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.6

Abstract:
We propose to carry out IRAC bands 1 and 2 photometry of a sample of eight extreme UV luminous Lyman Break Galaxies (LBGs) at z = 2.6-3.2 in order to measure their total stellar mass and constrain models of the formation and evolution of the most massive and most luminous galaxies at high-redshift. Studies of high-redshift LBGs in recent years have provided key insight into the history of galaxy assembly at the peak of cosmic star formation activity. However, most previous studies have been limited by small survey volume and could not select the rarest systems. We have carried out wide-field multicolor surveys of LBGs, selected from the NOAO Deep Wide Field Survey Bootes Field and the SDSS Deep Stripe, covering over 200 square degrees, increasing the survey volume by ~2 orders of magnitude. Our initial observations have revealed eight extreme UV luminous galaxies with r ~ 21-22.3, more than 2 magnitudes brighter than typical LBGs in previous studies. At L > 6 L*, they represent the rarest and most intensive star forming systems in the early Universe. Our Spitzer IRAC observations will be combined with ground-based observations in optical and near-IR wavelength to measure the total stellar mass and to constrain the AGN contribution in these galaxies, and probe the evolution history of these UV luminous galaxies. We will study whether they are dominated by young starburst activities, likely associated with major merger or major accretion event, or contain a mature stellar population with large stellar mass and extended star formation history. This will be a first step to unveil the nature of the most extreme galaxies in the early universe, providing a unique laboratory for galaxy formation theory.

Spitzer Space Telescope - General Observer Proposal #10061

A Search for Variability in a Young Planet

Principal Investigator: Beth Biller
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Technical Contact: Beth Biller, Max-Planck-Institut fuer Astronomie

Co-Investigators:
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Coryn Bailer-Jones, MPIA

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.2
Priority: 2

Abstract:
Variability attributed to cloud structure already appears to be a persistent feature for L and T type field brown dwarfs. Directly imaged planets occupy the same temperature regime as L and T type brown dwarfs and are likely to be equally variable. We propose mid-IR variability monitoring for the young free-floating planet CFHTWIR-Oph33 (<0.5 Myr, ~6 MJup). Such variability is predicted due to rotationally-modulated cloud features. These observations will probe weather conditions on a directly imaged exoplanet for the first time, providing benchmark data for ongoing development of multidimensional cloud modeling approaches. These variability monitoring observations are only possible with Spitzer and are a pilot study for future variability monitoring with JWST-MIRI of directly imaged exoplanets around young stars.

Spitzer Space Telescope - General Observer Proposal #12002

Exometeorology: Characterizing Weather on a Young Free-Floating Planet

Principal Investigator: Beth Biller
Institution: University of Edinburgh

Technical Contact: Beth Biller, University of Edinburgh

Co-Investigators:
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T. Henning, Max-Planck-Institut fur Astronomie

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 17.6
Priority: 1

Abstract:
Variability attributed to cloud structure is a persistent feature for L and T type field brown dwarfs. Directly imaged planets occupy the same temperature regime as L and T type brown dwarfs and are likely to be equally variable. As part of our ongoing NTT SOFI survey for variability in young free-floating planets and low mass brown dwarfs, we detect significant variability in a young, free-floating planetary mass object, likely due to rotational modulation of inhomogeneous cloud cover. This is the first such detection in a bonafide planetary mass object -- here we propose for HST and Spitzer followup to pinpoint the source of the observed variability and determine the rotational period of the object. Due to its low surface gravity, while this object has a late L spectral type, it has an ``early/mid T'' Teff<1200 K. We will directly test the effect of low surface gravity on observed variability. If variability matches that found in objects with similar spectral type but higher surface gravity -- i.e. high-level hazes observed in mid L dwarfs by Yang et al. 2015 -- we expect similar variability amplitudes in all bands. If variability is due to inhomogeneous clouds as found in higher gravity T dwarfs with similar Teff (Buenzli et al. 2015, Apai et al. 2013), we expect variability to be strongest in broadband J and H and have lower amplitudes within the 1.4 um water absorption feature (only observable from space). As ground-based searches for brown dwarf variability only have sensitivities to >2-3% variability, we require the proven photometric stability of HST and Spitzer (sensitivity down to <0.5% variability) to be sensitive to small differences between bands.

Spitzer Space Telescope - General Observer Proposal #12060

The First Search for Weather in a T-Type Planetary Mass Object

Principal Investigator: Beth Biller
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Technical Contact: Beth Biller, Max-Planck-Institut fuer Astronomie

Co-Investigators:
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Elena Manjavacas, IAC

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10
Priority: 1

Abstract:
With comparable temperatures but lower masses, young directly imaged exoplanets were expected to share similar atmospheric properties to brown dwarfs. However, most young directly imaged exoplanets are much redder in the near-IR than their brown dwarf counterparts at similar Teff (L-type exoplanets). Only a handful of directly imaged exoplanets possess the methane absorption feature observed in similar Teff brown dwarfs (T-type exoplanets). A key probe of cloud properties in exoplanet atmospheres is time-variability (brightness as a function of phase), which is sensitive to the spatial distribution of condensates as the planet rotates. Of the current ensemble of directly imaged planets, only Beta Pic b and HR 8799bc are bright enough for variability studies with planet-finding cameras such as SPHERE at the VLT. We can probe variability for a larger sample of similar objects and a wider range of spectral types by observing isolated young planetary mass objects (PMOs). We recently detected cloud-driven variability in the L-type free-floating planetary mass object PSO J318.5-22, a close analogue to the HR 8799 planets. This is the first such detection in either an isolated or companion PMO. PSO J318.5-22 is surprisingly variability - in fact the highest amplitude L-type variable known. This may indicate that variability properties differ between young planets and older brown dwarfs. To determine if this is the case, we must monitor a wider range of PMOs for variability, especially T spectral types. No mid-IR variability study has yet been pursued for a bonafide T-type PMO. We propose here a first search for mid-IR variability in SDSS 1110+01, the only known T-type free-floating planet bright enough to yield sufficient sensitivity to variability (down to the 0.3% level on 20 minute cadences for periods up to 20 hours). These observations are only possible with Spitzer and are a pathfinder study for future variability monitoring with JWST-MIRI of directly imaged exoplanets around young stars.

Spitzer Space Telescope - General Observer Proposal #80033

Extreme ULIRGs: Ultra-red WISE-selected Herschel Targets

Principal Investigator: Andrew Blain
Institution: University of Leicester

Technical Contact: Andrew Blain, University of Leicester

Co-Investigators:
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Dan Stern, JPL
Roberto Assef, JPL
Carol Lonsdale, NRAO/U. Virginia
Ned Wright, UCLA
Dominic Benford, GSFC
Adam Stanford, UC Davis
Roger Griffith, IPAC

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.5

Abstract:
WISE has recently completed the first all-sky infrared survey since IRAS, pushing hundreds of times deeper. This enables the search for the most extreme galaxies over fields that are hundreds of times wider than were available using the Spitzer surveys. The details of the processes in these galaxies - intense star-formation activity, the growth and fueling of AGNs, the buildup of stellar mass, and the astrophysics of their interstellar medium (ISM) - have been investigated using galaxies selected by WISE colors. The resulting sample has been targetted using large ground-based telescopes, and are approved for observations using the Herschel Space Observatory in GO-1. Herschel will yield reliable measurements of their total infrared luminosity. The targets are typically distant, ultraluminous galaxies (ULIRGs) at redshifts z~2-3. Herschel (and soon ALMA) will reveal the cooler components of their ISM; however, the transition betwen hot dust near an AGN and the stellar population of these galaxies is relatively poorly constrained from the WISE data alone, owing to very red colors from 3-22 microns. Spitzer can probe much deeper in modest exposure times, and address this important question for the astrophysics of these sources, which cannot be attacked otherwise until JWST is operating. We propose imaging of 54 WISE-selected targets that are queued for Herschel observations. 45 of these are entered in our Cycle-7 snapshot Spitzer program, and we observe any that remain unobserved by the end of Cycle-7 in Cycle-8. Nine additional Herschel targets - selected using the same criteria since the Spitzer Cycle-7 program was accepted - are also included, to ensure that the coverage and quality of the full Herschel dataset is well matched by Spitzer observations.

Spitzer Space Telescope - Snapshot Proposal #80161

A Targeted, Distant (z>0.7) Cluster Survey, Using Bent, Double-Lobed Radio Sources

Principal Investigator: Elizabeth Blanton
Institution: Boston University

Technical Contact: Elizabeth Blanton, Boston University

Co-Investigators:
Joshua Wing, Boston University
Mark Brodwin, Harvard-Smithsonian Center for Astrophysics
Matthew Ashby, Harvard-Smithsonian Center for Astrophysics

Science Category: galaxy clusters and groups(high-z)
Hours Approved: 113.1

Abstract:
We propose an efficient, targeted search for distant clusters of galaxies using bent, double-lobed radio sources as tracers. These types of radio sources have an association rate with clusters of up to 78%, higher than that of either straight-lobed or single-component radio sources. By correlating our radio sample with the SDSS, we have identified host galaxies for objects with z < 0.7. Those sources without hosts detected to the limit of the SDSS are most likely elliptical galaxies in clusters at z > 0.7, and we expect the cluster search will yield approximately 500 clusters beyond this redshift. The sample of clusters found using the radio sources in conjunction with IRAC 3.6 um observations will be used to help determine the epoch of galaxy formation, study the galaxy populations of clusters over time, examine the role that AGN feedback has on clusters as a function of redshift, and (in conjunction with X-ray observations) place constraints on cosmological models, including dark energy.

Spitzer Space Telescope - General Observer Proposal #11096

Spitzer Imaging of Massive z>1 SZ-Selected Galaxy Clusters

Principal Investigator: Lindsey Bleem
Institution: Argonne National Laboratory/KICP

Technical Contact: Mark Brodwin, U. Missour - Kansas City

Co-Investigators:
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Matt Ashby, CfA
John Carlstrom, University of Chicago
Bradford Benson, Fermilab/University of Chicago
Tom Crawford, University of Chicago
Anthony Gonzalez, University of Florida
Bill Holzapfel, University of California Berkeley
Brian Stalder, University of Hawaii
Adam Stanford, University of California Davis
Anthony Stark, CfA
Christopher Stubbs, Harvard University

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.9
Priority: 1

Abstract:
We propose a small 9.9 hour program to complete Spitzer/IRAC coverage of SZ-selected clusters at z>1 from the 2500 deg^2 SPT-SZ survey (10 clusters) as well as to image a representative sample of high-significance high-redshift SPTpol cluster candidates (20 candidates). Combined with existing optical imaging data, these IRAC data will permit us to (a) definitively confirm galaxy overdensities at the locations of these candidates, (b) estimate precise redshifts, and (c) measure stellar masses for cluster members, as well as the total stellar mass content of these extreme halos. This program will also enable the study of galaxy evolution in the richest environments for a mass-limited cluster sample over the redshift range 0 < z < 1.5 and will highlight the potential for high-z cluster science with the new generation of mm-wave surveys.

Spitzer Space Telescope - General Observer Proposal #12073

Spitzer Imaging of Distant Galaxy Clusters Discovered by the South Pole Telescope Polarimeter

Principal Investigator: Lindsey Bleem
Institution: Argonne National Laboratory/KICP

Technical Contact: Mark Brodwin, U. Missour - Kansas City

Co-Investigators:
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Brian Stalder, University of Hawaii
Adam Stanford, University of California Davis

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.1
Priority: 1

Abstract:
We propose a small program to obtain Spitzer observations of 45 massive high-redshift galaxy cluster candidates (M500 > 1e14, z >1) discovered in a deep 500-square-degree Sunyaev-Zel'dovich (SZ) survey conducted with the South Pole Telescope polarimeter (SPTpol). These IRAC data will enable us to (a) confirm galaxy over-densities at the SZ candidate locations, (b) estimate precise redshifts for these systems, and (c) measure stellar masses for the brightest (to M*+1.25 at z=1.5) cluster members. This high-redshift SZ-selected cluster sample will be a tremendous resource for understanding the changes in star formation rates, galaxy populations, and AGN activity during the critical period when massive clusters are forming and, combined with lower redshift systems, will enable the study of galaxy evolution in the richest environments for a mass-limited cluster sample from 0 < z < 1.5.

Spitzer Space Telescope - General Observer Proposal #14096

Discovering Massive z > 1 Galaxy Clusters with Spitzer and SPTpol

Principal Investigator: Lindsey Bleem
Institution: Argonne National Laboratory/KICP

Technical Contact: Mark Brodwin, U. Missouri - Kansas City

Co-Investigators:
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Matthew Ashby, CfA Harvard
Brian Stalder, LSST
Matthias Klein, Ludwig-Maximilians-Universitat
Michael Gladders, University of Chicago
Spencer Stanford, University of California Davis
Rebecca Canning, Stanford University

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10.0
Priority: 2

Abstract:
We propose to obtain Spitzer/IRAC imaging of 50 high-redshift galaxy cluster candidates derived from two new completed SZ cluster surveys by the South Pole Telescope. Clusters from the deep SPTpol 500-square-deg main survey will extend high-redshift SZ cluster science to lower masses (median M500 ~2x10^14Msun) while systems drawn from the wider 2500-sq-deg SPTpol Extended Cluster Survey are some of the rarest most massive high-z clusters in the observable universe. The proposed small 10 h program will enable (1) confirmation of these candidates as high-redshift clusters, (2) measurements of the cluster redshifts (sigma_z/(1+z)~0.03), and (3) estimates of the stellar masses of the brightest cluster members. These observations will yield exciting and timely targets for the James Webb Space Telescope---and, combined with lower-z systems---will both extend cluster tests of dark energy to z>1 as well as enable studies of galaxy evolution in the richest environments for a mass-limited cluster sample from 0<z<1.8.

Spitzer Space Telescope - General Observer Proposal #10147

The North Ecliptic Pole Extragalactic Background LIght Fluctuations Survey

Principal Investigator: James Bock
Institution: California Institute of Technology

Technical Contact: James Bock, California Institute of Technology

Co-Investigators:
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Stephen Serjeant, Open University
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Toshia Matsumoto, ASIAA
Shuji Matsuura, ISAS/JAXA
David Clements, Imperial College London
Chris Pearson, Rutherford Appleton Laboratory
Myung Shin Im, Seoul National University

Science Category: cosmic infrared background
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 157.0
Priority: 1

Abstract:
We propose to image 6 deg^2 in the North Ecliptic Pole (NEP) with IRAC to determine the origin of Extragalactic Background Light (EBL) fluctuations. These Spitzer images will be combined with CIBER data at 1.1 and 1.6 um, and Akari data at 2.4, 3.2, and 4.1 um, to probe the spectrum and band-to-band correlations of the fluctuations. The fluctuations have been reported by Spitzer and Akari, and are now positively detected in new and CIBER data, but their origin is controversial. This multi-wavelength analysis will allow us to determine if EBL fluctuations arise from epoch of reionization galaxies or diffuse intra-halo light emission both by measuring their spectral energy distribution (SED) from 1.0 to 4.5 um, and by measuring the cross-correlation between different bands. The analysis uses multiple field combinations in Spitzer, CIBER and Akari data to carry out a robust measurement with multiple data combinations for internal consistency tests. In addition, the proposed survey will be used in conjunction with Akari and Herschel data in the NEP survey that has the most comprehensive multi-band infrared coverage of any degree-scale field on the sky and the best available constraints on dust phases (e.g. PAH, silicate absorption, AGN dust tori, GMCs) in galaxies. We will use this multi-wavelength coverage to cross-identify IRAC counterparts to Herschel and Akari sources and obtain SEDs of dusty, star bursting galaxies at z ~ 1 to 3 from the UV to radio, and obtain accurate PAH luminosities of Akari 7.7 um-rest detected galaxies and AGNs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14331

Spitzer investigation of the first known active Trojan, 2019 LD2

Principal Investigator: Bryce Bolin
Institution: IPAC

Technical Contact: Bryce Bolin

Co-Investigators:
Carey Lisse, APL
Yan Fernandez, UCF
James Bauer, UMD
George Helou, IPAC

Science Category: asteroids
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.8
Priority: 1

Abstract:
We propose to investigate the recently discovered first-known active Trojan, 2019 LD2, with Spitzer/IRAC using wavelengths centered on 4.5 microns. Our observations will enable us to place constraints on the CO/CO2 gas and dust production as well as the physical properties of this object directly measured from Spitzer 4.5 micron data. As this object is the first of its kind, the detection of gas will be immensely exciting as it will provide first constraints on the volatile contents of the Trojan population measured from one of its members with implications on testing Solar System evolution models involving the capture of Trojans during the instability of the gas giants. In either case of the volatile gases being detection or not detected, we expect the results to be high-impact as it allows us to characterize the activity mechanism of this novel object that will be important for future observations of active Trojans or objects like 2019 LD2 with space/ground-based assets and the upcoming Lucy mission.

Spitzer Space Telescope - Directors Discretionary Time Proposal #550

Follow-up observations of SN 2010dn

Principal Investigator: Maria Teresa Botticella
Institution: Queens University Belfast

Technical Contact: Maria Teresa Botticella, Queens University Belfast

Co-Investigators:
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Science Category: evolved stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.6

Abstract:
A new intriguing transient, SN 2010dn in NGC 3184, was discovered ten days ago. The spectroscopic and photometric evolution make this transient similar to SN 2008S, the 2006 optical transient in M85 and the 2008 optical transient in NGC 300, members of a new class of transient events given the similar pre-explosion and post-explosion properties. The nature of these transient is still debated and our experience with SN 2008S proved that Spitzer data are invaluable to shed light on it providing a critical information in the understanding the geometry of the circumstellar environment of these transients both for the dust enshrouded progenitor stars and after their explosion. We would like to obtain a rapid follow-up of SN 2010dn with Spitzer to check if also this transient is producing an IR echo from substantial circumstellar material around the progenitor star. The modeling of the light echo will allow us to constrain the mass and physical scale of the circumstellar dust around this transient and as consequence to probe the mass loss history of the progenitor star. The proposed observations will be coordinated with an extensive optical follow up and will be of interest to the broad scientific community. To obtain prompt observations after the discovery is crucial.

Spitzer Space Telescope - General Observer Proposal #12058

The Brightest Galaxies at Cosmic Dawn: Securing the Largest Samples of z=9-11 galaxies for JWST by leveraging the HST archive with Spitzer/IRAC.

Principal Investigator: Rychard Bouwens
Institution: University of Leiden

Technical Contact: Rychard Bouwens, University of Leiden

Co-Investigators:
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Ivo Labbe, University of Leiden
Pascal Oesch, Yale University
Dan Coe, Space Telescope Science Institute
Benne Holwerda, University of Leiden
Larry Bradley, Space Telescope Science Institute
Charlotte Mason, University of California, Santa Barbara
Kasper Schmidt, University of California, Santa Barbara
Garth Illingworth, University of California, Santa Cruz

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 25.8
Priority: 1

Abstract:
Hubble's WFC3 has been a game changer for studying early galaxy formation in the first 700 Myr after the Big Bang. Reliable samples of sources up to z~10, which can be discovered only from space, are now constraining the evolution of the galaxy luminosity function into the epoch of reionization. Despite these efforts, the size of the highest redshift galaxy samples (z >9 and especially z > 10) is still very small, particularly at high luminosities (L > L*). To deliver transformational results, much larger numbers of bright z > 9 galaxies are needed both to map out the bright end of the luminosity/mass function and for spectroscopic follow-up (with JWST and otherwise). One especially efficient way of expanding current samples is (1) to leverage the huge amounts of pure-parallel data available with HST to identify large numbers of candidate z ~ 9 - 11 galaxies and (2) to follow up each candidate with shallow Spitzer/IRAC observations to distinguish the bona- fide z ~ 9 - 11 galaxies from z ~ 2 old, dusty galaxies. For this program we are requesting shallow Spitzer/IRAC follow-up of 20 candidate z ~ 9 - 11 galaxies we have identified from 130 WFC3/IR pointings obtained from more than 4 separate HST programs with no existing IRAC coverage. Based on our previous CANDELS/GOODS searches, we expect to confirm 5 to 10 sources as L > L* galaxies at z >= 9. Our results will be used to constrain the bright end of the LF at z >= 9, to provide targets for Keck spectroscopy to constrain the ionization state of the z > 8 universe, and to furnish JWST with bright targets for spectroscopic follow-up studies.

Spitzer Space Telescope - General Observer Proposal #14130

Bright galaxies at z=9-11 from pure-parallel HST observations: Building a unique sample for JWST with Spitzer/IRAC

Principal Investigator: Rychard Bouwens
Institution: University of Leiden

Technical Contact: Rychard Bouwens, University of Leiden

Co-Investigators:
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Mauro Stefanon, Yale University
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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.0
Priority: 1

Abstract:
The combination of observations taken by Hubble and Spitzer revealed the unexpected presence of sources as bright as our own Milky Way as early as 400 Myr after the Big Bang, potentially highlighting a new highly efficient regime for star formation in L>L* galaxies at very early times. Yet, the sample of high-quality z>8 galaxies with both HST and Spitzer/IRAC imaging is still small, particularly at the highest luminosities. We propose here to remedy this situation and use Spitzer/IRAC to efficiently follow up the most promising z>8 sources from our Hubble Brightest of Reionizing Galaxies (BoRG) survey, which covers a footprint on the sky similar to CANDELS, provides a deeper search than ground-based surveys like UltraVISTA, and is robust against cosmic variance because of its 210 independent lines of sight. The proposed new 3.6 micron observations will continue our Spitzer cycle 12 and 13 BORG911 programs, targeting 15 additional fields, leveraging over 200 new HST orbits to identify a final sample of about 8 bright galaxies at z >= 8.5. For optimal time use (just 20 hours), our goal is to readily discriminate between z>8 sources (undetected or marginally detected in IRAC) and z~2 interlopers (strongly detected in IRAC) with just 1-2 hours per pointing. The high-quality candidates that we will identify with IRAC will be ideal targets for further studies investigating the ionization state of the distant universe through near-IR Keck/VLT spectroscopy. They will also be uniquely suited to measurement of the redshift and stellar population properties through JWST/NIRSPEC observations, with the potential to elucidate how the first generations of stars are assembled in the earliest stages of the epoch of reionization.

Spitzer Space Telescope - General Observer Proposal #80168

ICLASH: Coherent Views of the Galaxy Formation Puzzle over z~3-10 Through the Looking Glass

Principal Investigator: Rychard Bouwens
Institution: University of Leiden

Technical Contact: Marc Postman, Space Telescope Science Institute

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 69.7

Abstract:
How galaxies build-up and evolve at early times is one of the most fundamental questions in extragalactic cosmology. While well established constraints exist on how this build-up occurs from rest-frame UV studies, an equally important part of the story - the build-up of stellar mass - is far less well understood. Although we have some results on the stellar mass at the brightest magnitudes (like the non-evolution of the specific SFR), the stellar masses of lower luminosity galaxies at high redshift remain essentially unknown. This is a major gap in our knowledge since lower luminosity galaxies dominate the SFR density, UV density, and likely provide the photons that reionize the universe. The only way of obtaining data on these faint sources at high redshift is with Spitzer, but with Spitzer one is faced with serious S/N limitations. To surmount these challenges, we propose to take advantage of gravitational lensing and a large sample of ~200 highly magnified low-luminosity galaxies expected to be found in the large 524-orbit, 25-cluster CLASH MCT program. We propose to obtain deep IRAC 3.6 and 4.5 micron observations over the full suite of CLASH clusters. Since 17 clusters from the program already have deep data, we are requesting data for the final eight. The additional data are important to ensure that these magnified samples remain sizeable after subdividing by redshift and luminosity. This ICLASH program will allow us to robustly derive stellar masses and do stellar population modelling at z>4, determine the stellar mass density at z~7-8 to faint limits, and add significance confidence to z~10 identifications in our program. We waive our right to any proprietary period for this important data set.

Spitzer Space Telescope - General Observer Proposal #90213

Quantifying the Stellar Mass Density of the Universe out to z~9-10: Ultra-Deep Spitzer Observations of Two Highly Magnified z~9-10 Galaxies

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 55

Abstract:
Measurements of the stellar mass in galaxies to increasingly high redshifts provide us one of the most powerful ways of gauging early galaxy build-up. Combining ultra- deep IRAC imaging observations with deep WFC3/IR observations have allowed astronomers both to identify and estimate masses for sources out to redshifts as high as z~8. However, it has been difficult to extend such studies to even higher redshifts due to the incredible faintness and rarity of typical z~9-10 galaxies. One method for stepping beyond the normal S/N limitations is to take advantage of gravitational lensing by massive galaxy clusters to magnify faint z>8 sources, but to do so, we must know where the magnified sources lie. Fortunately, utilizing the huge investment of HST time in the 524-orbit CLASH program, we have been able to identify 100s of z~5-8 galaxies and even 4 extremely tantalizing z~9-11 galaxy candidates. To extend our measurement of galaxy masses to the earliest possible times, we require ultra-deep Spitzer observations on these candidates to accurately measure their rest-frame optical properties. While two of the z~9-11 candidates are the subject of deep IRAC observations as a result of an approved program, the other two will not be the subject of such observations. Given the considerable galaxy-to-galaxy variations in the mass-to-light ratio, ultra-deep Spitzer observations are needed for all four z~9-11 candidates to establish the typical properties of galaxies in this epoch. We propose to obtain such observations over the two z~9 candidates lacking such observations. Not only will our proposed observations substantially improve our ability to estimate the stellar mass density at z~9-11, but it will play a pivotal role in characterizing the stellar masses and other properties of 20-30 other gravitationally lensed z~4-8 galaxies behind these clusters.

Spitzer Space Telescope - General Observer Proposal #11041

Lightcurves of the Dominant Dust Producers in Metal-poor Environments

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Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 53.6
Priority: 1

Abstract:
DUSTiNGS is a Spitzer Cycle 8 program that has provided the first complete spatially-resolved infrared census of evolved stars in a statistically significant sample of low metallicity, nearby (D<1.5 Mpc) dwarf galaxies. One of the main results of the program to date is the discovery of hundreds of dust-producing AGB stars up to ~1 dex more metal-poor than previously known examples, suggesting that dust forms efficiently at least down to [Fe/H] = -2.2 dex. This discovery not only has implications for our interpretation of the interstellar medium and star formation in nearby, resolved galaxies, but also for our understanding of the dust production and chemical evolution of galaxies in the metal-poor environment of the early Universe. Here, we propose new, multi-epoch IRAC observations of 10 DUSTiNGS galaxies to measure the amplitudes, periods, and dust excesses of the DUSTiNGS AGB stars and thereby gain insight into the basic properties of the underlying dust producing populations. These data will provide a foundation for understanding dust production by AGB stars in chemically un-evolved systems, as well as providing a target list of these enigmatic objects for James Webb Space Telescope (JWST) follow-up.

Spitzer Space Telescope - General Observer Proposal #13009

A Search for Stellar Dust Production in Leo P, a Nearby Analog of High Redshift Galaxies

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Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.2
Priority: 1

Abstract:
The origin of dust in the early Universe is a matter of debate. One of the main potential dust contributors are Asymptotic Giant Branch (AGB) stars, and several studies have been devoted to investigating whether and how AGB dust production changes in metal-poor environments. Of particular interest are the most massive AGB stars (8-10 Msun), which can in principle enter the dust-producing phase <50 Myr after they form. However, these stars cannot produce their own condensable material (unlike carbon AGB stars), so the efficiency of dust production decreases with metallicity. Evidence for dust production in massive AGB stars more metal-poor than the Magellanic Clouds is scarce due both to the rarity of chemically-unevolved, star-forming systems reachable in the infrared and to the short lifetimes of these stars. The recently discovered galaxy Leo P provides an irresistible opportunity to search for these massive AGB stars: Leo P is a gas-rich, star-forming galaxy, it is nearby enough for resolved star photometry with Spitzer, and its interstellar medium is 0.4 dex more metal-poor than any other accessible star-forming galaxy. Models predict ~3 massive AGB stars may be present in Leo P, and optical HST observations reveal 7 candidates. We propose to use Spitzer to determine whether these stars are dusty, providing valuable constraints to the dust contribution from AGB stars up to at least redshift 3.2, or 11.7 Gyr ago, when massive spheroidals and Galactic globular clusters were still forming. This is a gain of 2.8 Gyr compared to other accessible galaxies. We also request 1 orbit of joint HST time to confirm whether the AGB candidates in Leo P are indeed massive AGB stars belonging to the galaxy. These observations will provide information crucial for potential JWST followup spectroscopy.

Spitzer Space Telescope - General Observer Proposal #80063

A Complete Census of Dust Production in Local Group Dwarf Galaxies

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Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 119.4

Abstract:
Highly evolved stars (massive stars and intermediate-mass Asymptotic Giant Branch -or AGB- stars) can become heavily enshrouded in dust. This material is ejected into the interstellar medium (ISM), driving galactic chemical evolution. The dwarf galaxies of the Local Group (LG) are ideal laboratories for studying dusty evolved stars since their stellar populations are resolvable and they span a wide range in metallicity, luminosity, star formation history, ISM content, and interaction history. The majority of known resolvable LG dwarf galaxies (d < 2 Mpc) remains unobserved with IRAC or were observed with inadequate areal coverage and/or depth for detecting the dusty stellar population. We propose to complete a uniform census of LG dwarf galaxies with IRAC that is designed to detect and characterize the circumstellar dust around evolved stars, especially those obscured in optical and near-infrared surveys. The dust-producing phase is brief, so it is rare in low-luminosity dwarf galaxies. We must therefore observe a complete sample of dwarf galaxies to build equivalent statistics at each metallicity. Our immediate science goals are to (1) analyze dust content and mass loss in AGB stars, (2) generate intermediate-age star formation histories using AGB stars, (3) analyze the infrared properties of massive evolved stars, and (4) use this survey as a pathfinder for JWST science. These observations and the resulting database will leave a valuable and lasting Spitzer legacy.

Spitzer Space Telescope - General Observer Proposal #12051

Mapping the circumstellar environment of a young very low mass star

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Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10
Priority: 2

Abstract:
Young stellar objects exhibit variability due to surface features on the star, star-disk interaction, and inhomogenities in the inner disk. Over recent years, multi-band monitoring campaigns have proven to be an effective tool to map the complex environment of young stars and to investigate the physical processes associated with the formation of planets. Here we propose to use Spitzer, combined with ground-based telescopes, to monitor a young very low mass star simultaneous in the mid-infrared and optical. Our target has shown persistent high-level variability over more than a decade of optical monitoring. Our aim is to map the geometry of the inner disk and the accretion flow, for the first time for an object with a mass of only 0.1 Msol. There are clear indications that accretion and disk evolution are dependent on the mass of the central object. By targeting a very low mass star we can explore the physical processes in the inner disk in an extreme parameter regime. We plan to apply two different strategies to obtain spatial constraints. We will monitor over the rotational timescale of several days, to obtain azimuthal information about hot spots on the stellar surface and structures in the inner disk material. In addition, we will derive the inner radius of the disk by measuring the delay between optical and mid-infrared variations ('light echos') over timescales of one hour. In total, we ask for 10 hours of Spitzer/IRAC 4.5mu observing, spread over ten days. Guaranteed time at ground-based telescope will provide the simultaneous optical data. Our team combines the expertise for monitoring campaigns, radiative transfer modeling, and light echo modeling.

Spitzer Space Telescope - General Observer Proposal #12005

RELICS of the Cosmic Dawn

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 99.9
Priority: 1

Abstract:
When did galaxies start forming stars? What is the role of distant galaxies in galaxy formation models and epoch of reionization? Recent observations indicate at least two critical puzzles in these studies. First galaxies might have started forming stars earlier than previously thought (<400Myr after the Big Bang). Furthermore, it is still unclear what is their star formation history and whether these galaxies can reionize the Universe. Accurate knowledge of stellar masses, ages, and star formation rates at this epoch requires measuring both rest-frame UV and optical light, which only Spitzer and HST can probe at z>7-11 for a large enough sample of typical galaxies. To address this cosmic puzzle, we propose Spitzer imaging of the fields behind 41 powerful cosmic telescopes selected using Planck data from the RELICS program (Reionization Lensing Cluster Survey; 190 HST orbits). This proposal will be a valuable Legacy complement to the existing IRAC deep surveys, and it will open up a new parameter space by probing the ordinary yet magnified population with much improved sample variance. The program will allow us to detect early galaxies with Spitzer and directly study stellar properties of a large number, ~20 galaxies (10 at z~7, 7 at z~8, 3 at z~9, and 1 at z~10). Spitzer data will much improve photometric redshifts of the earliest galaxies and will be crucial to ascertain the nature of any z>~10 candidate galaxies uncovered in the HST data. Spitzer also allows for an efficient selection of likely line emitters (as demonstrated by our recent spectroscopic confirmation of the most distant galaxy to date at z=8.68). Finally this proposal will establish the presence (or absence) of an unusually early established stellar population, as was recently observed in MACS1149JD at z~9. If confirmed in a larger sample, this result will require a paradigm shift in our understanding of the earliest star formation.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13165

RELICS of the Cosmic Dawn

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Science Category: high-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 167.0

Abstract:
When did galaxies start forming stars? What is the role of distant galaxies in galaxy formation models and epoch of reionization? Recent observations indicate at least two critical puzzles in these studies. (1) First galaxies might have started forming stars earlier than previously thought (<400Myr after the Big Bang). (2) It is still unclear what is their star formation history and whether these galaxies can reionize the Universe. Accurate knowledge of stellar masses, ages, and star formation rates at this epoch requires measuring both rest-frame UV and optical light, which only Spitzer and HST can probe at z~6-11 for a large enough sample of typical galaxies. To address this cosmic puzzle, we propose Spitzer imaging of the fields behind 3 most powerful cosmic telescopes selected using HST, Spitzer, and Planck data from the RELICS and SRELICS programs (Reionization Lensing Cluster Survey; 41 clusters, 190 HST orbits, 390 Spitzer hours). This proposal will be a valuable Legacy complement to the existing IRAC deep surveys, and it will open up a new parameter space by probing the ordinary yet magnified population with much improved sample variance. The program will allow us to study stellar properties of a large number, ~30 galaxies at z~6-11. Deep Spitzer data will be crucial to unambiguously measure their stellar properties (age, SFR, M*). Finally this proposal will establish the presence (or absence) of an unusually early established stellar population, as was recently observed in MACS1149JD at z~9. If confirmed in a larger sample, this result will require a paradigm shift in our understanding of the earliest star formation.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13210

RELICS of the Cosmic Dawn

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 55.5

Abstract:
When did galaxies start forming stars? What is the role of distant galaxies in galaxy formation models and epoch of reionization? Recent observations indicate at least two critical puzzles in these studies. (1) First galaxies might have started forming stars earlier than previously thought (<400Myr after the Big Bang). (2) It is still unclear what is their star formation history and whether these galaxies can reionize the Universe. Accurate knowledge of stellar masses, ages, and star formation rates at this epoch requires measuring both rest-frame UV and optical light, which only Spitzer and HST can probe at z~6-11 for a large enough sample of typical galaxies. To address this cosmic puzzle, we propose Spitzer imaging of the fields behind the most powerful cosmic telescopes selected using HST, Spitzer, and Planck data from the RELICS and SRELICS programs (Reionization Lensing Cluster Survey; 41 clusters, 190 HST orbits, 550 Spitzer hours). This proposal will be a valuable Legacy complement to the existing IRAC deep surveys, and it will open up a new parameter space by probing the ordinary yet magnified population with much improved sample variance. The program will allow us to study stellar properties of a large number, ~20 galaxies at z~6-11. Deep Spitzer data will be crucial to unambiguously measure their stellar properties (age, SFR, M*). Finally this proposal is a unique opportunity to establish the presence (or absence) of an unusually early established stellar population, as was recently observed in MACS1149JD at z~9. If confirmed, this result will require a paradigm shift in our understanding of the earliest star formation.

Spitzer Space Telescope - General Observer Proposal #14017

RELICS of the Cosmic Dawn

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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 333.2
Priority: 1

Abstract:
When did galaxies start forming stars? What is the role of distant galaxies in galaxy formation models and epoch of reionization? Recent observations indicate at least two critical puzzles in these studies. (1) First galaxies might have started forming stars earlier than previously thought (<400Myr after the Big Bang). (2) It is still unclear what is their star formation history and whether these galaxies can reionize the Universe. Accurate knowledge of stellar masses, ages, and star formation rates at this epoch requires measuring both rest-frame UV and optical light, which only Spitzer and HST can probe at z~6-11 for a large enough sample of typical galaxies. To address this cosmic puzzle, we propose to complete deep Spitzer imaging of the fields behind the 10 most powerful cosmic telescopes selected using HST, Spitzer, and Planck data from the RELICS and SRELICS programs (Reionization Lensing Cluster Survey; 41 clusters, 190 HST orbits, 440 Spitzer hours). 6 clusters out of 10 are still lacking deep data. This proposal will be a valuable Legacy complement to the existing IRAC deep surveys, and it will open up a new parameter space by probing the ordinary yet magnified population with much improved sample variance. The program will allow us to study stellar properties of a large number, ~60 galaxies at z~6-11. Deep Spitzer data will be crucial to unambiguously measure their stellar properties (age, SFR, M*). Finally this proposal will establish the presence (or absence) of an unusually early established stellar population, as was recently observed in MACS1149JD at z~9. If confirmed in a larger sample, this result will require a paradigm shift in our understanding of the earliest star formation.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14281

RELICS of the Cosmic Dawn

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Science Category: High-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 166.6
Priority: 1

Abstract:
When did galaxies start forming stars? What is the role of distant galaxies in galaxy formation models and epoch of reionization? Recent observations indicate at least two critical puzzles in these studies. (1) First galaxies might have started forming stars earlier than previously thought (<400Myr after the Big Bang). (2) It is still unclear what is their star formation history and whether these galaxies can reionize the Universe. Accurate knowledge of stellar masses, ages, and star formation rates at this epoch requires measuring both rest-frame UV and optical light, which only Spitzer and HST can probe at z~6-11 for a large enough sample of typical galaxies. To address this cosmic puzzle, we propose to complete deep Spitzer imaging of the fields behind the 3 powerful cosmic telescopes selected using HST, Spitzer, and Planck data from the RELICS and SRELICS programs (Reionization Lensing Cluster Survey; 41 clusters). All three clusters are lensing extraordinary z~8 candidates and are still lacking deep data. This proposal will be a valuable Legacy complement to the existing IRAC deep surveys, and it will open up a new parameter space by probing the ordinary yet magnified population with much improved sample variance. The program will allow us to study stellar properties of a large number, ~60 galaxies at z~6-11. Deep Spitzer data will be crucial to unambiguously measure their stellar properties (age, SFR, M*). Most importantly, this proposal will establish the presence (or absence) of an unusually early established stellar population, as was recently observed in MACS1149JD at z~9. If confirmed in a larger sample, this result will require a paradigm shift in our understanding of the earliest star formation.

Spitzer Space Telescope - General Observer Proposal #90009

Spitzer UltRaFaint SUrvey (SURF'S Up): Cluster Lensing and Spitzer Extreme Imaging Reaching Out to z >~ 7

Principal Investigator: Marusa Bradac
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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 564.1

Abstract:
In spite of recent progress, the role of distant galaxies in cosmic reionization has been difficult to pin down. A powerful way to make progress is to move beyond counting high redshift sources and study the stellar properties of the population instead. Accurate knowledge of the average star formation density and its recent history in the universe at this epoch is necessary to determine whether these galaxies emit enough hard photons to reionize the Universe. This requires measuring rest frame optical light, which only Spitzer can probe at these redshifts, for a large enough sample of typical galaxies. At least 50 typical sources with Spitzer imaging are needed to determine the star formation rate (SFR) density directly from stellar mass measurement (rather than estimated from the luminosity function) to 25% accuracy. Unfortunately, the depth needed to reach typical z>~7 galaxies is impractical in a blank field survey. To address this cosmic puzzle, we will obtain ultra-deep Spitzer imaging of the fields behind 10 of the most powerful and well calibrated cosmic telescopes. Cluster-scale gravitational lenses acting as cosmic telescopes enable the study of intrinsically lower luminosity galaxies than would otherwise be possible. This will be a crucial Legacy complement to the existing IRAC deep surveys and shallower cluster studies, and will open up new parameter space parameter space by probing intrinsically fainter objects than existing cluster surveys and much improved sample variance over deep field surveys. It will allow us to study the properties (e.g. star formation rates and stellar masses) of a large number of galaxies (50 at z~7 and 10 at z~8) for the first time, thus meeting our goal of reconstructing the cosmic SFR with sufficient accuracy. Presence (or absence) of established stellar population will be measured by Spitzer for the largest sample to date. Together these findings will allow us to identify the dominant sources of the bulk of ionizing photons necessary to drive reionization.

Spitzer Space Telescope - General Observer Proposal #90038

Identifying the most distant clusters in the XXL-NORTH survey

Principal Investigator: Malcolm Bremer
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Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 124.8

Abstract:
The evolution of galaxy clusters is most sensitively probed by observational studies of the most distant systems. Clusters and cluster galaxies have undergone relatively gentle evolution at z<1, the epoch at z>1 must therefore see their strongest evolution. The best probes of cluster and cluster galaxy evolution require samples identified using a well-understood selection function, one that relies on an observable that relates directly to a key diagnostic of the system. X-ray selection does just this: The clusters are detected though the extended X-ray emission from the hot gas trapped in and tracing the clusters' gravitational wells. The XXL survey is an X-ray survey of 50 sq degrees of sky, designed to indentify galaxy clusters out to z~2 with masses of M>1e14 M_Sun. In this programme we will obtain full 3.6/4.5 micron data to a level deep enough to securly identify all z>1 clusters detected in the northern half of XXL. This IRAC data set crucially enables a variety of detailed evolutionary studies o clusters and their galaxy populations at z>1, including (1) exploring the formation of the red sequence and build-up of cluster galaxies, (2) determining the evolution of the X-ray scaling relations, key probes of the physics driving cluster evolution and (3) determining the number density and X-ray luminosity function of clusters at z>1, a vital step in using the XXL survey to eventually constrain the Dark Energy equation of state at a highly competitive level. The resulting data set, when combined with the wealth of multi-waveband coverage of the same field, will enable many other studies (by us and others) including those of obscured and very distant AGN, CMB lensing studies and even an estimation of the timescale of reionization. As a consequence it has an extremely high legacy value.

Spitzer Space Telescope - General Observer Proposal #80144

Quantifying the Infrared Variability of 10 Myr Old T Tauri Stars

Principal Investigator: Cesar Briceno
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Technical Contact: Cesar Briceno, Centro de Investigaciones de Astronomia (CIDA)

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Laura Ingleby, University of Michigan
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Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 82.1

Abstract:
We propose to carry out a combined Spitzer/ground-based program to study the multiwavelength variability of 10 Myr stars (age when planets are expected to have formed), with the goal of investigating temporal phenomena linked to the inner structure of circumstellar disks. Our target is the 25 Ori cluster, for which we already have with an extensive set of ancillary data. We will conduct IRAC mapping of ~0.7 sqr.deg. containing 87 members (13 with disks) twice a day during two 7-day blocks separated by 5-7 days, and a 7.2h long stare observation containing a subset of 9 members (4 with disks). We will be able to explore variability in the mid-IR on timescales ranging from minutes, day, weeks all the way up to a few years. Combined with shorter wavelength data our program will help open a new window into the physics of planet and star formation.

Spitzer Space Telescope - General Observer Proposal #90221

WISE Discovered Ly-alpha Blobs at High-z: AGN Feeback Caught in the Act?

Principal Investigator: Carrie Bridge
Institution: California Institute of Technology

Technical Contact: Carrie Bridge, California Institute of Technology

Co-Investigators:
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Colin Borys, Herschel Science Center / IPAC
Sara Petty, Virginia Tech
Duncan Farrah, Virginia Tech

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.5

Abstract:
Using data from the WISE mission coupled with deep optical spectroscopy, we have discovered a new population of dusty z~2 galaxies surrounded by large spatially extended Lyman-alpha emission (40-130kpc). These galaxies have redder mid-IR colors than any other population, IR luminosities of L_FIR>10^13, and are rare on the sky, implying a short-lived phase. These unique properties suggest intense AGN/supernova feedback, making them strong candidates for being one of the "missing links" in the evolution of massive ellipticals. They provide a new regime where spatially extended Ly?alpha and large amounts of dust are likely linked at the key transition from a dusty starburst to a QSO. We request 2.5hrs of Spitzer-IRAC imaging for 12 spectroscopically confirmed WISE Ly-alpha blobs, completing the mid-IR imaging of this rare population. Spitzer is the only facilty that can probe rest-frame near-IR, where the red stellar populations peak at these redshifts. These observations are required to 1) fully sample the SED and constrain the stellar mass and dust extinction, 2) model the separate contributions from star formation and AGN, 3) determine if AGN luminosity or stellar mass correlates with Lyman-alpha, 4) place this new class of extreme object in context with the other well studied z~2 dusty galaxies.

Spitzer Space Telescope - General Observer Proposal #70012

Studying planetary debris disks around isolated, hot white dwarfs

Principal Investigator: Carolyn Brinkworth
Institution: Caltech/JPL

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Co-Investigators:
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Tom Marsh, University of Warwick
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Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.5

Abstract:
While more than 440 extrasolar planets orbiting main sequence stars have been discovered, the destiny of planetary systems through the late stages of the evolution of their host stars is very uncertain. We identified metal-rich (CaII and MgII emission) gas disks around 5 relatively young, hot white dwarfs, three of which were the subject of a previous Spitzer program in Cycle-5. The Cycle-5 data revealed a large, dusty extension to the gaseous debris disks, likely originating with the tidal breakup of an asteroid left over from an ancient planetary system. Our recent intensive studies of the three original systems have now turned up variability in the line profiles of the gaseous disks, suggesting the exciting possibility that we are witnessing the real-time dynamical evolution of planetary debris around these white dwarfs. We propose to extend this study to two newly-discovered, cooler members of this small sample of objects, to determine whether dust and gas can also coexist around cooler stars. Since these stars should be too cool to produce the observed CaII emission, we suspect that there is additional mechanical heating in these systems, caused by the recent impacts of asteroids. If so, CaII emission would likely be the signature of the youngest, freshest debris disks around these stars.

Spitzer Space Telescope - General Observer Proposal #10101

The Most Massive, High Redshift Galaxy Clusters in the Universe

Principal Investigator: Mark Brodwin
Institution: U. Missour - Kansas City

Technical Contact: Mark Brodwin, U. Missour - Kansas City

Co-Investigators:
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Tom Crawford, U Chicago
Anthony Gonzalez, U Florida
Bill Holzapfel, UC Berkeley
Joe Mohr, Ludwig Maximilian University
Brian Stalder, CfA
Adam Stanford, UC Davis
Tony Stark, CfA
Chris Stubbs, Harvard

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.9
Priority: 1

Abstract:
We propose to complete the Spitzer follow-up imaging of massive, high-redshift galaxy clusters selected via the Sunyaev-Zel'dovich (SZ) effect in the South Pole Telescope (SPT) survey. The final 15 cluster candidates, selected from the full 2500 deg^2 SPT survey, have SZ significances greater than 4.8 sigma and are known from existing optical data to lie at z > 0.6. Half of this cluster sample is likely very high redshift, lying at z > 1. We propose a modest 4.9 hr program to obtain redshifts of these exciting high-redshift systems and to study their total stellar mass content. Previous Spitzer observations of SPT clusters have been extremely successful in this regard, yielding several extremely massive and distant clusters. Among these are the first SZ-selected cluster at z > 1, the two most massive z > 1 clusters found by any method, and the most distant SZ-selected cluster confirmed to date, at z = 1.48. This small program will identify the last of the most exciting, high-redshift, high-mass clusters from the entire 2500 deg^2 SPT survey.

Spitzer Space Telescope - General Observer Proposal #12101

Determining the Role of Merging in the Growth of the Galaxy Cluster Population in the Massive and Distant Clusters of WISE Survey

Principal Investigator: Mark Brodwin
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Daniel Stern, JPL
Dominika Wylezalek, JHU
Daniel Marrone, U Arizona
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Adam Mantz, Stanford
Audrey Galametz, MPE

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.5
Priority: 1

Abstract:
We propose to obtain deep Spitzer/IRAC imaging of 14 distant (z ~ 1), stellar mass-selected galaxy clusters from the Massive and Distant Clusters of WISE Survey (MaDCoWS) for which robust Sunyaev-Zel'dovich (SZ)-based masses spanning ~2-10 x 10^14 Msun have been measured. These proposed IRAC data, along with joint HST imaging, will allow us to directly test key predictions of current models of cluster formation. These models posit that galaxy-galaxy merging drives the bursts of star formation and AGN activity seen in high redshift Spitzer studies of low-mass clusters, and predict the rate of such activity should be a function of total cluster mass. As clusters grow in mass (and hence velocity dispersion), the merging efficiency drops and the growth of the galaxy population, via both mergers and star formation, should cease. By measuring the cluster stellar mass function, as a function of both mass and morphological type, we will directly confirm or refute this model. We will also identify, on the basis of IRAC colors and HST morphologies, the AGN content in these clusters. We will thus test the prediction that the incidence of AGN should be higher in the lower mass clusters. Finally, we will measure the stellar mass fraction as a function of total mass, a crucial quantity in calibrating numerical cluster simulations that are key for cluster abundance cosmology.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13214

MaDCoWS: The Most Massive Galaxy Clusters at z ~ 1

Principal Investigator: Mark Brodwin
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Technical Contact: Mark Brodwin, U. Missour - Kansas City

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Daniel Marrone, U Arizona
Emily Moravec, U Florida
Christine O'Donnell, U Arizona

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.8

Abstract:
We propose to obtain deep Spitzer/IRAC imaging of 20 of the richest -- and likely extremely massive -- stellar mass-selected galaxy clusters at z ~ 1 from the Massive and Distant Clusters of WISE Survey (MaDCoWS). The proposed IRAC data, along with allocated Gemini spectroscopy and ALMA SZ imaging, will allow us to directly test key predictions of current models of cluster formation. These models posit that galaxy-galaxy merging drives the bursts of star formation and AGN activity seen in high redshift Spitzer studies of low-mass clusters, and predict that the rate of such activity should be an inverse function of total cluster mass. As clusters grow in mass (and hence velocity dispersion), the merging efficiency drops and the growth of the galaxy population, via both mergers and star formation, should slow. By measuring the cluster stellar mass function as a function of halo mass, we will directly confirm or refute this model. We will also identify the IR-bright AGN content in these clusters, permitting a test of the prediction that the incidence of AGN, triggered by the merging activity, should be higher in the lower mass clusters. Finally, we will measure the stellar mass fraction and its scatter as a function of cluster mass, a crucial quantity in calibrating both numerical cluster simulations and scaling relations that are key for cluster abundance cosmology.

Spitzer Space Telescope - General Observer Proposal #60099

IRAC Imaging of SPT Clusters

Principal Investigator: Mark Brodwin
Institution: National Optical Astronomy Observatory (NOAO)

Technical Contact: Mark Brodwin, National Optical Astronomy Observatory (NOAO)

Co-Investigators:
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Laurie Shaw, McGill
Brian Stalder, Harvard
Adam Stanford, UC Davis
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Antony Stark, Harvard-CfA
Christopher Stubbs, Harvard
Joaquin Vieira, U Chicago
Alfredo Zenteno, University of Illinois

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 36.6

Abstract:
We propose a program to image the first sample of galaxy clusters selected at mm-wavelengths via the Sunyaev-Zeldovich Effect (SZE). We have chosen a sample of 84 robust, high-significance clusters (S/N >= 4.5) from the first 350 deg^2 of the ongoing > 1000 deg^2 South Pole Telescope (SPT) SZE survey. These clusters are selected on total mass, independently of redshift, and as such form the ideal sample for studies of massive galaxies in rich environments over a wide range of redshifts. The IRAC data will provide photometric redshifts and stellar mass estimates for both field galaxies and cluster members, allowing studies of the cluster IR luminosity and stellar mass function evolution over the last 10 Gyr in a unique, unbiased cluster sample. Finally, in concert with our ongoing, extensive multiwavelength and spectroscopic follow-up programs, the proposed data will allow empirical calibration of the relationship between SZE, X-ray, IR and dynamical measures of cluster mass, which will ultimately allow accurate constraints to be placed on the equation of state of dark energy.

Spitzer Space Telescope - General Observer Proposal #70053

The Most Massive, High Redshift Clusters in the Universe

Principal Investigator: Mark Brodwin
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Mark Brodwin, Harvard-Smithsonian Center for Astrophysics

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Joe Mohr, Ludwig-Maximilians-Universitat
Armin Rest, Harvard
Jonathan Ruel, Harvard
John Ruhl, Case Western
Laurie Shaw, Yale
Jeeseon Song, U Illinois
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Antony Stark, Harvard-Smithsonian Center for Astrophysics
Christopher Stubbs, Harvard
Keith Vanderlinde, McGill
Joaquin Vieira, Caltech
Alfredo Zenteno, Ludwig-Maximilians-Universitat

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 42.3

Abstract:
We propose to image 95 high-significance (S/N >= 4.5), high redshift galaxy clusters selected via the Sunyaev-Zel'dovich Effect (SZE) over 585 deg^2 in the South Pole Telescope SZE survey. The SZE selects clusters on total mass, nearly independently of redshift, and as such produces a valuable sample for studies of massive galaxies in rich environments over a wide range of redshifts. Combined with our existing Spitzer sample, the proposed data will yield 50 massive clusters at z>1. The IRAC data also permit accurate photometric redshifts and stellar mass estimates for both field galaxies and cluster members, allowing studies of the cluster IR luminosity and stellar mass function evolution over the last 10 Gyr in a unique, mass-limited cluster sample. Finally, in concert with our ongoing, extensive multi-wavelength and spectroscopic follow-up programs, the proposed data will allow empirical calibration of the relationship between SZE, X-ray, IR, weak lensing and dynamical measures of cluster mass, which will ultimately allow accurate constraints to be placed on the equation of state of dark energy.

Spitzer Space Telescope - General Observer Proposal #80012

The Most Massive, High Redshift Clusters in the Universe

Principal Investigator: Mark Brodwin
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Mark Brodwin, Harvard-Smithsonian Center for Astrophysics

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Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 66.5

Abstract:
We propose to image 156 high-significance (S/N >= 4.8), high redshift galaxy clusters selected via the Sunyaev-Zel'dovich Effect (SZE) over the final 1600 deg^2 of the South Pole Telescope SZE survey. The SZE selects clusters on total mass, nearly independently of redshift, and as such produces a valuable sample for constraining cosmology as well as for studies of massive galaxies in rich environments over a wide range of redshifts. Combined with our existing Spitzer sample, the proposed data will yield ~80 massive clusters (M > 5 x 10^14 Msun) at z>1. The IRAC data also permit accurate photometric redshifts and stellar mass estimates for both field galaxies and cluster members, allowing studies of the cluster IR luminosity and stellar mass function evolution over the last 10 Gyr in a unique, mass-limited cluster sample. Finally, in concert with our ongoing, extensive multi-wavelength and spectroscopic follow-up programs, the proposed data will allow empirical calibration of the relationship between SZE, X-ray, IR, weak lensing and dynamical measures of cluster mass at the highest redshifts, which will ultimately allow accurate constraints to be placed on the equation of state of dark energy and on possible non-Gaussianities in the initial perturbation spectrum.

Spitzer Space Telescope - General Observer Proposal #10031

Weather on a Room-Temperature World: A First Test of Ice Cloud Models on WD 0806-661B

Principal Investigator: Adam Burgasser
Institution: University of California, San Diego

Technical Contact: Adam Burgasser, University of California, San Diego

Co-Investigators:
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Kevin Luhman, Penn State
Mark Marley, NASA Ames
Jonathan Fortney, UC Santa Cruz

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 36.0
Priority: 1

Abstract:
Modest infrared variability has been detected from several L- and T-type brown dwarfs in recent years, interpreted to result from rotationally-modulated, heterogeneous surface coverage of mineral and sulfide condensate clouds. Newly-developed models of ice cloud formation at 300 K - in the Y dwarf regime - predict that even greater variability may be expected due to the high opacity and abundance of these clouds, particularly in Spitzer's [3.6] and [4.5] micron bands. We propose an experiment to test the predictions of this model by monitoring the coldest brown dwarf companion identified to date, the 300-350 K, widely-separated secondary WD 0806-661B. We will monitor the source in three 12-hour windows sampling both 3.6 and 4.5 micron bands to search for short-term variations associated with the rotation of cloud surface structure, long-term evolution associated with jet structures and/or cloud evolution, and color variation and phase lags associated with vertical cloud structure. This program offers the first test of variability from ice cloud atmospheres, and potentially the first detection of water-based weather beyond the Earth.

Spitzer Space Telescope - General Observer Proposal #90236

Infrared Monitoring of the Nearest Low-Mass T Tauri Binary: TWA 30AB

Principal Investigator: Adam Burgasser
Institution: University of California, San Diego

Technical Contact: Adam Burgasser, University of California, San Diego

Co-Investigators:
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Subhanjoy Mohanty, Imperial College
John Gizis, U. Delaware
Carl Melis, UC San Diego
John Bochanski, Haverford College
Andrew Drake, Caltech
Dagny Looper, NY Film Academy

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.8

Abstract:
The T Tauri phase of young stellar evolution is known to exist down to substellar masses. However, the intrinsic faintness of these objects and distances to star forming regions has limited detailed study of this critical phase. We propose monitoring observations of the nearest pair of low-mass T Tauri accretors, TWA 30A and B. Both of these 8 Myr sources exhibit spectroscopic signatures indicating actively accreting, nearly edge-on disks with jets and stellar outflows. However, their time-dependent behavior at optical and near-infrared wavelengths are distinct, suggesting differing geometries and differing sources for the observed emission. We propose to test these models through short-term (continuous over 6 hr) and medium-term (daily for 40 days) IRAC monitoring of both stars. These observations will allow us to simultaneously probe variations in the accretion on and warping of the outer disk of TWA 30A, and coherent scaleheight and opacity variations in the disk around TWA 30B in the region where planets may be forming. Combined with coincident ground-based follow-up, our program will provide the most detailed picture of disk evolution during the planet-building phase of the lowest-mass stars.

Spitzer Space Telescope - General Observer Proposal #60161

Cool, spatially resolved substellar and exoplanetary analogues at white dwarfs

Principal Investigator: Matt Burleigh
Institution: University of Leicester

Technical Contact: Jay Farihi, UCLA

Co-Investigators:
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Ted von Hippel, Siena College
Paul Steele, University of Leicester
Fergal Mullally, Princeton University
Jay Holberg, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 25.1

Abstract:
We propose to obtain second epoch IRAC 4.5 micron images of 87 nearby white dwarfs that were originally observed at the same wavelength during the first two cycles of the Spitzer mission. By combining the data at these two epochs, we will search for spatially resolved T and sub-T-type brown dwarf, and massive planetary companions via common proper motions with their primaries. These observations will comprise the deepest survey to date for wide substellar and planetary-mass companions to white dwarfs in the solar neighborhood. Owing to the known distance and age of each white dwarf, any companions identified in this program would provide a benchmark for examining evolutionary models at ages from a few 100 Myr to several Gyr. This survey will also provide the best statistical limits yet on the frequency of such objects at white dwarfs and their intermediate mass, main-sequence progenitors.

Spitzer Space Telescope - General Observer Proposal #60072

The 3.6 micron Surface Brightness Profiles of Outer Disks: NGC 4625 and M 83

Principal Investigator: Stephanie Bush
Institution: Harvard University

Technical Contact: Stephanie Bush, Harvard University

Co-Investigators:
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Matt Ashby, Harvard-CfA
Ben Johnson, Institute of Astronomy, Cambridge
Fabio Bresolin, Institute for Astronomy, Hawaii

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5.6

Abstract:
The outer regions of galactic disks have been a topic of increased interest since ultraviolet observations with the GALEX observatory demonstrated that nearly 30% of galaxies show extended UV emission and star formation, tracing to well beyond the optical radius (R25). Although young stellar populations in these disks are being studied intensively in the UV and H-alpha, very little is known about the older stellar population of outer disks. We request 16.8 hours to image the outskirts of two prototype "XUV" (extended UV emission) galaxies, with sufficient depth and field coverage to measure their 3.6 micron profiles. Using these profiles we will derive radial stellar mass profiles, UV-IR color profiles, and gas fraction profiles. These will allow us to address several critical questions about the formation and evolution of these outer disks and the host galaxies themselves.

Spitzer Space Telescope - General Observer Proposal #14040

Fundamental Properties of the SHIELD Galaxies

Principal Investigator: John Cannon
Institution: Macalester College

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Co-Investigators:
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Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 43.3
Priority: 2

Abstract:
The ALFALFA survey has significantly advanced our knowledge of the HI mass function (HIMF), particularly at the low mass end. From the ALFALFA survey, we have constructed a sample of all of the galaxies with HI masses less than 20 million solar masses. Observations of this 82 galaxy sample allow, for the first time, a characterization of the lowest HI mass galaxies at redshift zero. Specifically, this sample can be used to determine the low HI-mass ends of various fundamental scaling relations, including the critical baryonic Tully Fisher relation (BTFR) and the mass-metallicity (M-Z) relation. The M-Z relation and the BTFR are cosmologically important, but current samples leave the low-mass parameter spaces severely underpopulated. A full understanding of these relationships depends critically on accurate stellar masses of this complete sample of uniformly-selected galaxies. Here, we request imaging of the 70 galaxies in our sample that have not been observed with Spitzer. The proposed imaging will allow us to measure stellar masses and inclinations of the sample galaxies using a uniform observational approach. Comparison with (existing and in progress) interferometric HI imaging and with ground-based optical imaging and spectroscopy will enable a robust mass decomposition in each galaxy and accurate placements on the aforementioned scaling relationships. The observations proposed here will allow us to populate the mass continuum between mini-halos and bona fide dwarf galaxies, and to address a range of fundamental questions in galaxy formation and near-field cosmology.

Spitzer Space Telescope - General Observer Proposal #10042

SPLASH: Spitzer Large Area Survey with Hyper-Suprime-Cam

Principal Investigator: Peter Capak
Institution: SSC/IPAC

Technical Contact: Peter Capak, SSC/IPAC

Co-Investigators:
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Yoshiaki Ono, University of Tokyo, Japan
Massami Ouchi, University of Tokyo, Japan
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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1195.0/454.2

Priority: 1/2

Abstract:
We propose 1650h to complete SPLASH, building a foundation for comprehensive investigations of the earliest stages of galaxy, AGN and large-scale structure formation on cosmologically important scales, providing deep mid-IR imaging for two major 1.8deg^2 fields (COSMOS and SXDS). These two fields have been the target of, and are scheduled for, unparalleled deep imaging in the optical, sub-mm and radio. The Spitzer data are essential for immediate science goals and the legacy of these unique equatorial fields. The major science enabled by the proposed Spitzer observations includes: the co-evolution of cosmic large scale structure and the assembly and growth of galaxies and AGN; understanding the relative importance of smooth gas accretion vs. mergers for galaxy growth in the early universe; probing re-ionization through Infrared Background Fluctuations; constraining the Initial Mass Function at high redshift, AGN activity in the early universe, and the physics of supernova through transient studies. None of these are possible with existing Spitzer surveys. The two fields proposed here will have unique, Hyper-Suprime-Cam (HSC) imaging (to ~27-28 magAB for broad bands across the 0.4-1.0um wavelength range) and science will be immediately enabled by Spitzer using pre-existing deep X-ray to radio multi-wavelength data, including: UV (Galex), X-ray (Chandra/XMM), optical (HST), near-infrared, mid-Infrared (Spitzer/Herschel), sub-mm, and radio. The COSMOS field is the primary deep field for the Nu-Star mission and both fields have been ranked as high priority deep-field targets for Euclid. These fields also have extensive spectroscopy with Keck (>50nt), Subaru-FMOS (>30nt), VLT (>1000h), and are the primary targets for the future Subaru Prime Focus Spectrograph (PFS) surveys. The legacy impact of these data will be enormous, and will provide a treasure trove of targets for JWST. This is part 1 (SXDS) of the awarded time.

Data from this program was split into multiple PIDs. You can find the data in program IDs 10042, 10159

Spitzer Space Telescope - Frontier Legacy Proposal #13058

The Euclid/WFIRST Spitzer Legacy Survey

Principal Investigator: Peter Capak
Institution: SSC/IPAC

Technical Contact: Peter Capak, SSC/IPAC

Co-Investigators:
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H. Teplitz, IPAC
S. Toft, DARK

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5286.0
Priority: 1 (3286.0hr); 2 (2000.0hr)

Abstract:

We propose 5286h of Spitzer Legacy Science Time to carry out a precursor survey for Euclid, WFIRST, and JWST. The primary goal is to enable definitive studies of reionization, z>7 galaxy formation, and the first massive black holes. The proposed data will also enhance the cosmological constraints provided by Euclid and WFIRST. The survey will cover 20 square degrees to 2h per pointing, split between the Chandra Deep Field South (CDFS) and the North Ecliptic Pole. These are some of the darkest and most observable fields on the sky and have existing multi-wavelength data that will enable immediate science. The survey parameters are designed to enable stellar mass measurement at 3<z<10, probe the large scale structure of reionization, and find luminous quasars to the highest redshifts where they exist. The depth and area of the survey is truly unique and will not be superseded for decades. Only Spitzer can probe this region of survey space at 3-5um, a wavelength range that uniquely enables stellar mass estimates at z>3 enabling a direct probe of galaxy growth during the epoch of re-ionization.

Data from this program was split into multiple PIDs. You can find the data in program IDs 13058, 13153

Spitzer Space Telescope - General Observer Proposal #90042

SPLASH: Spitzer Large Area Survey with Hyper-Suprime-Cam

Principal Investigator: Peter Capak
Institution: SSC/IPAC

Technical Contact: Peter Capak, SSC/IPAC

Co-Investigators:
Herve Aussel, CEA
Kevin Bundy, KIPMU
Marcella Carollo, ETH Zurich
Ranga Ram-Chary, Caltech/IPAC
Francesca Civano, Harvard CfA
Jean Coupon, ASIAA
Catrina Diener, ETH Zurich
Jenifer Donley, LANL
Jim Dunlop, Eidenburgh
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Sebastien Foucaud, NTNU
Jenny Green, Princeton
Jim Gunn, Princeton
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Gunther Hassinger, University of Hawaii
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Olivier Ilbert, OAMP
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Robert Quimby, KIPMU
Tomoki Saito, KIPMU
Mara Salvato, MIPIA
Dave Sanders, University of Hawaii
Eva Schinnerer, MPIA
Nick Scoville, Caltech
Kazuhiro Shimasaku, University of Tokyo
John Silverman, KIPMU
Vernesa Smolcic, Bonn
Michael Strauss, Princeton
Jason Surace, Caltech/IPAC
Massayuki Tanaka, KIPMU
Yoshi Taniguchi, Ehime University
Harry Teplitz, Caltech/IPAC
Wei-Hao Wang, ASIAA
Yuji Urata, NCU

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1251.4

Abstract:
We propose a 2475h survey to build the foundation for comprehensive investigations of the earliest stages of galaxy, AGN and large-scale structure formation on cosmologically important scales, providing deep mid-IR imaging for two major 1.8deg^2 fields (COSMOS and SXDS). These two fields have been the target of, and are scheduled for, unparalleled deep imaging in the optical, sub-mm and radio. The Spitzer data is essential for immediate science goals and the legacy of these unique equatorial fields. The major science enabled by the

proposed Spitzer observations includes: the co-evolution of cosmic large scale structure and the assembly and growth of galaxies and AGN; understanding the relative importance of smooth gas accretion vs. mergers for galaxy growth in the early universe; probing re-ionization through Infrared Background Fluctuations; constraining the Initial Mass Function at high redshift, AGN activity in the early universe, and the physics of supernova through transient studies. None of these are possible with existing Spitzer surveys, which are limited by both insufficient contiguous area, insufficient depth of ancillary data and/or temporal cadence. The two fields proposed here will have unique, Hyper-Suprime-Cam (HSC) imaging (to ~27-28 magAB for broad bands across the 0.4?1.0um wavelength range) and science will be immediately enabled by Spitzer using pre-existing deep X-ray to radio multi-wavelength data, including: UV (Galex), X-ray (Chandra/XMM), optical (HST), near-infrared, mid-Infrared (Spitzer/Herschel), sub-mm, and radio. The COSMOS field is the primary deep field for the Nu-Star mission and both fields have been ranked as high priority deep-field targets for Euclid. These fields also have extensive spectroscopy with Keck (>50nt), Subaru-FMOS (>30nt), VLT (>1000h), and are the primary targets for the future Subaru Prime Focus Spectrograph (PFS) surveys. The legacy impact of these data will be enormous, and will provide a treasure trove of targets for JWST.

Data from this program was split into multiple PIDs. You can find the data in program IDs 90042, 10042, 10159

Spitzer Space Telescope - General Observer Proposal #11016

SMUVS: Spitzer Matching survey of the UltraVISTA ultra-deep Stripes

Principal Investigator: Karina Caputi
Institution: University of Groningen

Technical Contact: Matthew Ashby, Harvard-Smithsonian Center for Astrophysics

Co-Investigators:
Giovanni Fazio, Harvard-Smithsonian Center for Astrophysics
Jiasheng Huang, Harvard-Smithsonian Center for Astrophysics
James Dunlop, University of Edinburgh
Marijn Franx, Leiden University
Olivier Le Fevre, Laboratoire d'Astrophysique de Marseille
Johan Fynbo, Dark Cosmology Centre, University of Copenhagen
Henry McCracken, Institut d'Astrophysique de Paris
Bo Milvang-Jensen, Dark Cosmology Centre, University of Copenhagen
Adam Muzzin, Leiden University
Olivier Ilbert, Laboratoire d'Astrophysique de Marseille
Rachel Somerville, Rutgers University
Risa Wechsler, Stanford University
Peter Behroozi, Space Telescope Science Institute
Yu Lu, Stanford University

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1776.5
Priority: 1

Abstract:
We request 2026.5 hours to homogenize the matching ultra-deep IRAC data of the UltraVISTA ultra-deep stripes, producing a final area of ~0.6 square degrees with the deepest near- and mid-IR coverage existing in any such large area of the sky (H, Ks, [3.6], [4.5] ~ 25.3-26.1 AB mag; 5 sigma). The UltraVISTA ultra-deep stripes are contained within the larger COSMOS field, which has a rich collection of multi-wavelength, ancillary data, making it ideal to study different aspects of galaxy evolution with high statistical significance and excellent redshift accuracy. The UltraVISTA ultra-deep stripes are the region of the COSMOS field where these studies can be pushed to the highest redshifts, but securely identifying high-z galaxies, and determining their stellar masses, will only be possible if ultra-deep mid-IR data are available. Our IRAC observations will allow us to: 1) extend the galaxy stellar mass function at redshifts z=3 to z=5 to the intermediate mass regime (M~5x10^9-10^10 Msun), which is critical to constrain galaxy formation models; 2) gain a factor of six in the area where it is possible to effectively search for z>=6 galaxies and study their properties; 3) measure, for the first time, the large-scale structure traced by an unbiased galaxy sample at z=5 to z=7, and make the link to their host dark matter haloes. This cannot be done in any other field of the sky, as the UltraVISTA ultra-deep stripes form a quasi-contiguous, regular-shape field, which has a unique combination of large area and photometric depth. 4) provide a unique resource for the selection of secure z>5 targets for JWST and ALMA follow up. Our observations will have an enormous legacy value which amply justifies this new observing-time investment in the COSMOS field. Spitzer cannot miss this unique opportunity to open up a large 0.6 square-degree window to the early Universe.

Spitzer Space Telescope - General Observer Proposal #10146

Searching for the transit of Alpha Centauri B b

Principal Investigator: Sean Carey
Institution: SSC

Technical Contact: Sean Carey, SSC

Co-Investigators:
Jim Ingalls, Spitzer Science Center
Jessica Krick, Spitzer Science Center
Patrick Lowrance, Spitzer Science Center
Carl Grillmair, Spitzer Science Center
Stephen Kane, NExScI
Jason Surace, Spitzer Science Center

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 53.4
Priority: 1

Abstract:
We propose a novel set of observations to measure the possible transit of the recently detected exoplanet, Alpha Cen Bb. This closest exoplanet is arguably one of the most exciting detections of the previous year due to the enormous potential for followup observations as well as far-reaching public interest outside the astronomical community. The radial velocity detected planet has a minimum mass of ~1.1 MEarth and a period of 3.236 days which suggests a transit probability of ~16% with a minimum depth of ~100 ppm. If a transit is detected it will provide the planet radius and constrain the orbit inclination which will further constrain the mass and permit a determination of the density of this planet, a critical parameter for further studies. In addition, if the planet does transit, it increases the probability that other potential planets in this system will transit which would be a result of considerable interest. As Alpha Cen B saturates the IRAC detectors for even the shortest frametime, we cannot employ the now standard high photometric precision techniques. Instead, we will rely on the stability of the PSF and use the high signal to noise wings to achieve ~30 ppm photometry for a potential transit. As described in the text, we have demonstrated the viability of this method with an engineering observation of Canopus. 53.4 hours are requested to make an initial transit observation and observe a detected transit a second time as confirmation.

Spitzer Space Telescope - General Observer Proposal #14121

Spitzer Parallax Observations of Long Duration Gaia Microlensing Events

Principal Investigator: Sean Carey
Institution: SSC

Technical Contact: Sean Carey, SSC

Co-Investigators:
Sebastiano Calchi-Novati, Caltech/IPAC
Lukasz Wyrzykowski, Warsaw University
Katarzyna Kruszynska, Warsaw University
Mariusz Gromadzki, Warsaw University
Krzysztof Rybicki, Warsaw University

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 17.1
Priority: 1

Abstract:
We proposed to observe of order ten long duration (>100 day) microlensing events identified in Gaia survey data with the Spitzer Space Telescope. The long duration events are likely due to massive lenses, hence they could be isolated black holes. These observations could make defintive mass measurements for the first time of isolated stellar remanant black holes in our Galaxy. The Spitzer data provide a key component to making an umabiguous mass measurement by providing the microlensing parallax (as has been done for >500 event by Spitzer so far). The Gaia data is used for the detection of the events and measurement of the astrometric motion caused by the microlensing event. From the astrometric microlensing signature, the Einstein radius of the lens can be measured and combined with the microlensing parallax yields the lens mass and distance.

Spitzer Space Telescope - General Observer Proposal #11112

North Polar Surfaces of the Uranian Moons: Coated with CO2 Frost?

Principal Investigator: Richard Cartwright
Institution: University of Tennessee

Technical Contact: Richard Cartwright, University of Tennessee

Co-Investigators:
Joshua Emery, University of Tennessee
Andy Rivkin, Johns Hopkins University Applied Physics Laborator
David Trilling, Northern Arizona University
Noemi Pinilla-Alonso, University of Tennessee

Science Category: satellites
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5.1
Priority: 1

Abstract:
We propose to investigate the near-surface composition of the Uranian moons Ariel, Umbriel, Titania, and Oberon by using the Infrared Array Camera (IRAC) onboard the Spitzer Space Telescope. Previous IRAC observations of these objects in Program 71 (2003 - 2005) indicate that the surfaces of their southern hemispheres are dominated by pure water ice (sub-observer latitudes 7 - 18 degree S). The observations we propose here are of these objects' now observable northern hemispheres (sub-observer latitudes 25 - 33 degree N). Unlike the Program 71 observations, which collected data near the end of southern summer when any seasonal CO2 frost would have migrated to the winter hemisphere, we are proposing to observe these moons at the beginning of northern summer when seasonal CO2 frost should still be present. Therefore, the 2015 - 2016 Cycle 11 opportunity window represents an ideal time frame to search for seasonal CO2 frost on these objects.

Spitzer Space Telescope - General Observer Proposal #60130

Rapid variability of jets in X-ray binaries: a new tool.

Principal Investigator: Piergiorgio Casella
Institution: University of Amsterdam

Technical Contact: Piergiorgio Casella, University of Amsterdam

Co-Investigators:
Simone Migliari, ESA - Madrid
Tom Maccarone, University of Southampton
Dave Russell, University of Amsterdam

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.1

Abstract:
We propose to observe Cyg X-1, an accreting black hole, and Sco X-1, an accreting neutron star, with a 2-hour long uninterrupted exposure each with IRAC in high time resolution modes. Their rapidly variable IR components are likely to come from relativistic jets, and these data will provide important insights into how these jets are powered by the systems' accretion disks. While jets appear as a byproduct of the accretion process, there is as yet no standard model for their underlying physics. Several key issues are be solved, including the geometry of jets, their energetic power and their coupling with the disk. Multwavelength fast variability is an exciting new tool, which will provide new informations. For the first time, we will study the fast jet variability in great detail, opening a new promising window on the Physics of accretion. These explorative observations will provide a measure of the size of the emitting region, thus constraining the jet geometry. By studying the correlated variability in mid-IR and X-rays, we will put important constraints to the jet-disk connection. Finally, by comparing these results between the two sources, we will cast light on the jet energetic budget, which is thought to be different in black holes and in neutron stars.

Spitzer Space Telescope - General Observer Proposal #70078

The nature of the unseen companion to WD0837+185

Principal Investigator: Sarah Casewell
Institution: University of Leicester

Technical Contact: Sarah Casewell, University of Leicester

Co-Investigators:
Matt Burleigh, University of Leicester
Paul Dobbie, AAO
Richard Jameson, University of Leicester
Ralf Napiwotzki, University of Hertfordshire

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.7

Abstract:
WD0837+185 is a radial velocity (RV) variable, white dwarf (WD) member of the Praesepe open star cluster. Using high precision RV measurements we estimate the binary period as 4.2 hr, with a velocity semi amplitude of ~11 km/s, but other periods are possible. Photometry obtained from UKIRT indicates that there is no near-IR excess (in J, H or K), making the secondary either a cool T (>T5) dwarf with mass ~30 MJup, the lowest mass companion to a WD known, or a massive (>1.2MSun) WD. In this latter case the system has a super-Chandrasekhar mass and is a candidate Type 1a Supernova progenitor and, will converge within a Hubble time. If the period is considerably longer (> 12hrs), the companion is certainly another WD, but will not converge within a Hubble time. We have applied for time to obtain high resolution radial velocity measurements to confirm our estimate of the period. We therefore request IRAC 3.6 and 4.5 micron observations of this system to determine whether the companion is a low mass T dwarf, or a more massive WD.

Spitzer Space Telescope - General Observer Proposal #90153

Time resolved observations of irrdaiated brown dwarfs

Principal Investigator: Sarah Casewell
Institution: University of Leicester

Technical Contact: Sarah Casewell, University of Leicester

Co-Investigators:
Matt Burleigh, University of Leicester
Paul Steele, MPE
Katherine Lawrie, University of Leicester

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.6

Abstract:
Irradiation of substellar brown dwarfs and hot Jupiters in close binaries can increase their surface temperatures by an order of magnitude, alter their radii and atmospheric structure, and lead to moderate mass loss. In these tidally locked systems, temperature diffences between the 'day' and 'night' sides could lead to strong winds and jet streams transporting heat to the 'night' side. We have discovered two new close white dwarf+brown dwarf binaries. Optical photometry suggests that in both systems the brown dwarfs are being irradiated by their hotter white dwarf companions. We have obtained observations of a similar system, WD0137-349, and determined that the level of irradiation in the IRAC [4.5] micron band is 40% suggesting that the irradiation is significantly affecting the atmosphere. We will obtain time-resolved IRAC photometry for each both targets over an entire orbital period. We will use both IRAC bands for the brighter WD+L dwarf binary, and only [3.6] for the fainter target, which has a longer orbital period. We will use these data to make a detailed investigation of the heating effects on the brown dwarfs' atmosphere. These observations will help us to understand how irradiation affects the atmospheric structure and evolution of very cool, low mass objects, and to develop and test new atmospheric models for irradiated brown dwarfs and hot Jupiters.

Spitzer Space Telescope - General Observer Proposal #12074

Stellar masses for thousands of z>1 resolved, dusty starbursts

Principal Investigator: Caitlin Casey
Institution: University of Texas, Austin

Technical Contact: Caitlin Casey, University of Texas, Austin

Co-Investigators:
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Scott Chapman, Dalhousie University
Chao-Ling Hung, University of Texas, Austin
Sinclaire Manning, University of Texas, Austin
Richard Battye, University of Manchester
Filipe Abdalla, University College London
Mark Birkinshaw, University of Bristol
Christopher Hales, NRAO
Steve Myers, NRAO
Tom Muxlow, University of Manchester
Neal Jackson, University of Manchester
David Bacon, University of Portsmouth
Michael Brown, University of Manchester
Ian Browne, University of Manchester
Rob Beswick, University of Manchester
Simon Garrington, University of Manchester
Scott Kay, University of Manchester
Paddy Leahy, University of Manchester
Bob Nichol, University of Portsmouth
Anita Richards, University of Manchester
Peter Wilkinson, University of Manchester
David Sanders, University of Hawai'i

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.7
Priority: 1

Abstract:
Dusty star-forming galaxies, with individual star formation rates ~>100Msun/yr, formed most of the stars in the Universe at early epochs (z~1-2), yet their physical origins and triggering, whether it be from major mergers or secular disk-bound star-formation, is still unsolved. In assessing the role of major galaxy mergers (amongst dusty galaxies) to cosmic star formation, the measurement of galaxies' stellar masses is critical. Starbursts' stellar masses tell us about their past average star formation rate and whether or not the current high-SFR phase is indeed rare (short-lived) or in line with expectation. Can we definitively measure whether the occurrence of major mergers at a given star-formation rate varies with stellar mass, as predicted? Or are high star formation rates simply always indicative of short-lived bursts? Here we propose deep infrared imaging of a new 1.77deg^2 extragalactic legacy field which has very unique, deep, high-resolution radio interferometric coverage from the $e-$MERLIN SuperCLASS survey; the dataset's radio continuum mapping will allow a unique morphological measurement of obscured star formation in ~5000 starbursts, probing the merger fraction of dusty galaxies (which are too dusty for HST morphology). Critically, Spitzer IRAC 3.6um and 4.5um will allow calculation of galaxies' stellar masses and allow us to directly test if higher mass starbursts are less likely to exhibit clumpy, merging morphologies than their lower mass counterparts (a key corollary to the galaxies 'main sequence' framework). In addition, IRAC coverage provides an independent AGN indicator (steep mid-IR powerlaw), will improve the quality of photometric redshifts in the field, and will provide crucial near-IR positional counterparts for future submillimeter coverage.

Spitzer Space Telescope - General Observer Proposal #80008

Metallicity mapping of the Milky Way

Principal Investigator: Vicky Scowcroft
Institution: Carnegie Institution of Washington

Technical Contact: Vicky Scowcroft, Carnegie Institution of Washington

Co-Investigators:
Barry Madore, Carnegie Observatories
Wendy Freedman, Carnegie Observatories
Andy Monson, Carnegie Observatories
Eric Persson, Carnegie Observatories
Mark Seibert, Carnegie Observatories
Jane Rigby, NASA Goddard
David Bersier, Liverpool John Moores University
Peter Stetson, Dominion Astrophysical Observatory
Laura Sturch, Boston University

Science Category: stellar populations
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 220.5

Abstract:
We have discovered that the mid-infrared [3.6]-[4.5] colors of long-period Cepeids are dominated by a metallicity and temperature sensitive carbon monoxide feature that is squarely situated inside of the 4.5mu bandpass. The [3.6] photometry is unaffected by the CO and its PL relation can deliver distances to Cepheids that are individually good to ±4%. We will use the time-averaged 3.6um photometry of the 120 longest -period Galactic Cepheids to map the spiral structure of the Milky Way out to a radius 6 kpc around the solar neighborhood, and we will then use the [3.6]-[4.5] colors to derive spectroscopic-quality metallicities for each of these Cepheids. This will alow us to measure the radial gradient of metals in the galaxy and to explore its variance at fixed radius. For Cepheids with phased radial-velocity coverage we will for the first time apply the Baade-Wesselink methodology in the mid-infrared for determining the absolute luminosities (and distances) of these Cepheids. These determinations will greatly enhance the precision calibration of the slope, zero point and width of the Cepheid Period-Luminosity relation, well in advance of GAIA (whose nominal mission end is 2017). However, once GAIA has determined direct parallaxes to these same long-period Cepheids we will immediately be in a position to make the necessary intercomparisons and explore the physical consequences.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13224

Characterizing Massive Galaxy Protoclusters at z > 4 with IRAC

Principal Investigator: Scott Chapman
Institution: Dalhousie University

Technical Contact: Matthew Ashby, Harvard-Smithsonian Astrophysical Observatory

Co-Investigators:
Matthew Ashby, Harvard-Smithsonian Center for Astrophysics

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 33.4

Abstract:
We ask for time to obtain two-band IRAC imaging of three uniquely dense high-redshift SPT-detected protoclusters now known, based on our recent ALMA spectroscopy, to be among the most massive protoclusters ever found. They lie at extreme but well-measured redshifts (4.2, 4.3 and 5.7), and unlike most SPT-detected galaxies, are NOT lensed. One such target, SPT2349-56, has just been revealed by ALMA to consist of 13 ULIRGs/SMGs detected in dust-continuum and 9 detected in CO emission within 20" (total integrated SFR of ~10^4 Msun/yr). Because it was found in a blind 1.4-mm survey of 2500 deg^2, it is unlikely there are many other systems like these in the entire sky. Thus our targets are intrinsically very luminous and massive, and pose serious challenges for our understanding of galaxy and cluster formation at the earliest times. With the present proposal we seek to photometer the 50% or more of cluster members known to exist but not yet reliably detected by IRAC, to measure the masses of these systems, and to fully characterize the environments in which they form.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14216

Characterizing A Massive z=4.3 Protocluster with IRAC

Principal Investigator: Scott Chapman
Institution: Dalhousie University

Technical Contact: Matthew Ashby, Harvard & Smithsonian CfA

Co-Investigators:

Science Category: Galaxy clusters
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.0
Priority: 2

Abstract:
We ask for time to obtain deep two-band IRAC imaging of an extreme submm-bright and dense high-redshift SPT-detected protocluster. Based on our ALMA spectroscopy, it is one of the most massive protoclusters ever found, and it is the most dense structure known. It lies at an extreme but well-measured redshift (z=4.3), and unlike most SPT-detected galaxies, it is NOT lensed. Our ALMA and LABOCA observations have revealed that it consists of dozens of ULIRGs/SMGs detected in the thermal dust continuum and CO line emission within 20" (of which 14 are brighter than L*!). Because it was found in a blind 1.4-mm survey of 2500 deg^2, it is unlikely there are many other systems like these in the entire sky. Thus this system is intrinsically very luminous and massive, and poses serious challenges for our understanding of galaxy and cluster formation at the earliest times. With the present proposal we seek to photometer the majority of cluster members known to exist, but not yet reliably detected by IRAC, and thereby measure their stellar masses in combination with our deep Gemini K-band imaging so as to gain a better understanding of this unique structure and its implications for galaxy formation and evolution.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14316

The Highest-Redshift Proto-Cluster, SPT0311

Principal Investigator: Scott Chapman
Institution: Dalhousie

Technical Contact: Matt Ashby, CfA Harvard

Co-Investigators:
Joaquin Vieira, Illinois

Science Category: High-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.0
Priority: 1

Abstract:
The rarest, highest redshift massive proto-cluster found from our South Pole Telescope survey is SPT0311-58, at z=6.9, likely representing the progenitor of an extremely massive cluster at the present epoch. The proto-cluster is confirmed to have at least 4 robust ALMA identified members, and a network of satellite galaxies identified by LABOCA and SPIRE at 850um to 250um wavelengths, which are being followed up in a high priority ALMA Cy7 program. We propose deep IRAC, two-band imagery in 2 offset pointings from our original central pointing, to provide a mosaic of uniform depth over the full extent of the proto-cluster. These observations will detect the ALMA-identified members, constrain the rest R,B-band luminosities, constrain stellar mass with extinction estimated from the IRAC colours, and help with identification of other candidate proto-cluster galaxies. The redshift implies that the Halpha and [OIII] lines fall in the IRAC bands and these will be ideal targets for JWST followup in Cycle1. The IRAC measurements, deep enough for significant detections, are a crucial precursor to analysing the sources and planning JWST observations.

Spitzer Space Telescope - General Observer Proposal #60028

Confirmation and Characterization of Kepler Mission Exoplanets: The Era of Rock and Ice Exoplanets

Principal Investigator: David Charbonneau
Institution: Harvard University

Technical Contact: David Charbonneau, Harvard University

Co-Investigators:
William Borucki, NASA Ames Research Center
Timothy Brown, Las Cumbres Observatory Global Telescope
Drake Deming, NASA Goddard Space Flight Center
Eric Ford, University of Florida
Jonathan Fortney, UC Santa Cruz
Ronald Gilliland, Space Telescope Science Institute
Heather Knutson, Harvard University
David Latham, Smithsonian Astrophysical Observatory
Sara Seager, Massachusetts Institute of Technology

Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Approved: 800.0

Abstract:
In the past 4 years, the combination of ground-based transit surveys and the remarkable stability of the Spitzer Space Telescope permitted the direct investigation of the atmospheres of one specific class of exoplanet, namely the Hot Jupiters. The power of the NASA Kepler Mission will be to discover dozens of transiting exoplanets that are not detectable from the ground either due to the shallow transit depth or the low transit frequency resulting from their longer orbital periods. Kepler will find large numbers of transiting hot Neptunes and hot SuperEarth exoplanets, as well as cooler Jupiters, each of which are nonetheless amenable to direct study of their infrared emission. We propose to use Spitzer to observe Kepler-detected exoplanets and candidates to pursue two goals. First, we will measure the two-color planetary emission for 20 representative members of these previously inaccessible cexoplanets. Such observations will permit the first opportunity to directly test theoretical models of exoplanetary atmospheres of varying compositions (notably SuperEarths and Neptunes) and under differing levels of irradiation (cooler Jovian companions). The same data will permit an estimate of the orbital eccentricities, thus providing a test of models of the orbital migration, and tidal dissipation for these various types of exoplanets. Second, we will use Spitzer to follow up Kepler-identified candidate terrestrial exoplanets to prove that these signals are indeed planetary in origin. By gathering single color time series spanning times of primary transit, we will exclude a significant source of astrophysical false positives (resulting from blends of triple stars systems containing an eclipsing binary) that will precisely mimic an exoplanetary signature in the Kepler data. These infrared data will provide a crucial step in confirming the planetary nature of many of the most exciting candidates, namely the planets with the smallest radii that are likely rocky in composition.

Data from this program was split into multiple PIDs.
You can find the data in program IDs 60028, 80117

Spitzer Space Telescope - General Observer Proposal #80117

Validating the First Habitable-Zone Planet Candidates Identified by the NASA Kepler Mission

Principal Investigator: David Charbonneau
Institution: Harvard

Technical Contact: David Charbonneau, Harvard

Co-Investigators:
Jean-Michel Desert, Harvard University
Francois Fressin, Harvard University
Sarah Ballard, Harvard University
William Borucki, NASA Ames Research Center
David Latham, Smithsonian Astrophysical Observatory
Ronald Gilliland, Space Telescope Science Institute
Sara Seager, Masssachusetts Institute of Technology
Heather Knutson, University of California Berkeley
Jonathan Fortney, University of California Santa Cruz
Timothy Brown, Las Cumbres Observatory Global Telescope
Eric Ford, University of Florida
Drake Deming, NASA Goddard Space Flight Center
Guillermo Torres, Smithsonian Astrophysical Observatory

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 600.0

Abstract:
At the beginning of Cycle 8, the NASA Kepler Mission will have completed two years of science observations, the minimum baseline sufficient to identify candidate transiting exoplanets orbiting within the habitable-zones of Sun-like stars. The principal task that lies ahead is to reject from this sample the false positives (blends of eclipsing binaries that precisely mimic the signal of a transiting exoplanet), and to confirm the planetary nature of the remaining candidates. For planets more massive than Neptune, the direct confirmation of their planetary status can be accomplished by radial-velocity measurements. However, such planets possess primordial envelopes of hydrogen and helium that make them unsuitable to life as we know it. The most exciting candidates -- and the ones that Kepler is specifically tasked with finding -- are super-Earth and Earth-sized planets orbiting within their stellar habitable zones. Kepler has just begun to identify such planet candidates, and it will identify many more as its baseline increases throughout the coming year. While the Kepler team has developed powerful tools to weed out the impostors, Spitzer possesses the unique ability to provide the final validation of these candidates as planets, namely by measuring the depth of the transit at infrared wavelengths. By combining the infrared and optical measurements of the transit depth with models of hypothetical stellar blends, we can definitively test the stellar-blend hypothesis. We propose to observe the transits of 20 candidate habitable-zone super-Earths to be identified by the Kepler Mission. The results from this Exploration Science Program will be twofold: First, we will definitively validate the first potentially habitable planets ever identified. Second, we will determine the rate of occurrence of impostors. This rate of false positives can then be applied to the much larger sample of candidates identified by Kepler, to deduce the true rate of planetary companions.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14269

Placing New Observational Constraints on the Structure of the Zodiacal Dust with the Spitzer/IRAC Shutter

Principal Investigator: Ranga-Ram Chary
Institution: Caltech/IPAC

Technical Contact: Ranga-Ram Chary, Caltech/IPAC

Co-Investigators:
Sean Carey, Caltech/IPAC
Joe Hora, SAO/Harvard
Matthew Ashby, SAO/Harvard
Giovanni Fazio, SAO/Harvard
Steven Willner, SAO/Harvard
Patrick Lowrance, Caltech/IPAC
Jessica Krick, Caltech/IPAC
Bill Glaccum, Caltech/IPAC
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Shuji Matsuura, Kwansei Gakuin University
Aoi Takahashi, ABC/Mitaka
Takafumi Ootsubo, ISAS/JAXA
Michael Zemcov, RIT
Asantha Cooray, UC Irvine
Jim Ingalls, Caltech/IPAC
Ryan Lau, ISAS/JAXA
Kohji Tsumura, Tokyo City University
Kei Sano, Kanazawa University
Varoujan Gorjian, NASA/JPL

Science Category: Zodiacal dust
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 44.0
Priority: 1

Abstract:
There are significant uncertainties associated with our understanding of the dust distribution in the zodiacal dust cloud (zody). Results from COBE, Spitzer/NEP and Akari seem to be in conflict with each other with the latter two arguing for a more compact zodiacal cloud with higher intensity at high ecliptic latitudes and a temporally varying local dust overdensity. Observations with the Spitzer/IRAC shutter during the final hours of the mission from a vantage point outside the local dust overdensity, in conjunction with Palomar/Doublespec Fraunhofer line spectroscopy, provides a once-in-a-generation opportunity to reduce the uncertainty between the different zodiacal dust models. The observations will constrain the zodiacal light models which in turn will improve our understanding of the contribution of Oort cloud comets to the zody, result in a better estimation of the extragalactic background light and provide a legacy dataset to allow for absolute calibration of all archival Spitzer Warm mission data.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14222

Probing the nature of long lasting supernova SN2018evt

Principal Investigator: Sijie Chen
Institution: Texas A&M University

Technical Contact: Sijie Chen, Texas A&M University

Co-Investigators:
Lifan Wang, Texas A&M University

Science Category: Nearby galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.6
Priority: 1

Abstract:
SN2018evt was first discovered in Aug 11th 2018 and was confirmed as a SN Ia. However, its spectrum shows a prominent Hydrogen emission line, a rare feature among SNe Ia and a signature of strong interaction between ejecta and circumstellar medium, resembling a SN2002ic-like event. The object was discovered again in Dec 2018 by ZTF as well as in Jan 2019 by SWIFT, and its brightness has remained at M_V=-19.1, close to a Type Ia supernova at maximum light. We have been allocated VLT DDT time (PI: L. Wang) to acquire spectropolarimetry data, as well as accumulating spectrosopcic and UBVRIJHK photometric data and monitoring the evolution of the system closely. We propose to use Spitzer to measure the emission from warm dust at late time and reveal the physical nature of this peculiar event.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14273

First proof of dust formation in superluminous supernovae

Principal Investigator: Ting-Wan Chen
Institution: Max Planck Institute for Extraterrestrial Physics

Technical Contact: Ting-Wan Chen, Max Planck Institute for Extraterrestrial Physics

Co-Investigators:
Cosimo Inserra, Cardiff University
Mikako Matsuura, Cardiff University
Lifan Wang, Texas A&M University
Sijie Chen, Texas A&M University
Morgan Fraser, College Dublin
Eric Y. Hsiao, Florida State University
Tassilo Schweyer, Max Planck Institute for Extraterrestrial Physics
Giorgos Leloudas, Technical University of Denmark
Rupak Roy, Inter-University Centre for Astronomy and Astrophysics

Science Category: Evolved Stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.1
Priority: 1

Abstract:
This Spitzer DDT proposal aims to detect the thermal emission from dust associated with the closest superluminous supernova ever discovered, SN 2018bsz. It is the first superluminous supernova showing a K-band excess suggesting a thermal dust emission. With 4 epochs of Spitzer observations at 3.6 and 4.5 micron, we will be able to determine whether the infrared emission is from newly formed dust inside the supernova ejecta or from pre-existing circumstellar envelope heated by the radiation from the superluminous supernova. Superluminous supernovae are suspected to be related to the first generations of stars in the Universe and they are bright enough to be detectable at redshifts above 4. SN 2018bsz could potentially provide an analogue of dust formation in the early Universe. DDT is requested due to the rapid time variability of the associated infrared radiation.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13253

Extending and Characterizing an Exoplanet System in a Pristine Chain of Resonances

Principal Investigator: Jessie Christiansen
Institution: Caltech/IPAC

Technical Contact: Jessie Christiansen, Caltech/IPAC

Co-Investigators:
Varoujan Gorjian, Caltech/JPL
Kevin Hardegree-Ullman, University of Toledo
John Livingston, University of Tokyo
Courtney Dressing, University of California Berkeley
Thomas Barclay, NASA Goddard Space Flight Center
Chris Lintott, University of Oxford
David Ciardi, Caltech/IPAC
Geert Barentson, NASA Ames Research Center/BAERI
Martti Kristiansen, Danmarks Tekniske Universitet
Ian Crossfield, MIT
Bjorn Benneke, University of Montreal
Andrew Howard, Caltech

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.0

Abstract:
The K2-138 (EPIC 245950175; 2MASS J23154776-1050590) exoplanet system was recently identified in the K2 mission campaign 12 data (Christiansen et al. 2018). The moderately bright (K=10.3) K1V star hosts at least five sub-Neptune planets (1.6-3.3 Re) in a compact configuration, all with periods shorter than 13 days. The five confirmed planets in the system form an unbroken chain of near first-order mean motion resonances, with each successive pair of planets having close to a 3:2 commensurability; this is the longest such chain as yet discovered. The K2 data contain two additional transits which, if confirmed as due to a sixth planet, could extend the chain even further. Due to the proximity of the K2-138 planets to mean motion resonances, it is an ideal target to search for transit timing variations (TTVs). In order to further both of these time-critical and important science cases, we propose for DDT time to capture a third transit of the candidate sixth planet, and also observe a chance nearby cluster of three transits of planets b, c, and d.
(12.0hrs were approved to observe the 6th planet.)

Spitzer Space Telescope - General Observer Proposal #12047

Continuation of Deep Extinction Mapping in Molecular Cores

Principal Investigator: Laurie Chu
Institution: Institute for Astronomy, University of Hawaii

Technical Contact: Laurie Chu, Institute for Astronomy, University of Hawaii

Co-Investigators:
Klaus Hodapp, Institute for Astronomy, University of Hawaii

Science Category: ISM
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 7.6
Priority: 2

Abstract:
This proposal is a continuation for preparatory observations of the targets selected for a future James Webb Space Telescope (JWST) Near-Infrared Camera (NIRCam) guaranteed time project, as well as for a more general preparation for the science of this project. Our JWST project with NIRCam, NIRSpec, and MIRI is aimed at obtaining the deepest, and therefore best sampled, extinction maps of a sample of molecular cores, selected to contain quiescent, collapsing, and star-forming cores. We will also obtain spectroscopy of suitable, selected background stars for a detailed study of both the continuum extinction law and the ice feature absorption. The proposed Spitzer IRAC observations are aimed at identifying specific background stars for these future spectroscopic observations with JWST NIRSpec or NIRCam (grism), and with MIRI. For detailed planning of the JWST observations, we need to know how many suitable background stars are available, how many NIRSpec multi-slit pointing will be required, or whether slitless NIRCam grism spectroscopy is feasible. In addition to their role in preparing future JWST observations, the proposed Spitzer observations will immediately be used, together with UKIRT data we have already obtained and together with archival imaging data from other ground-based telescopes, to compute column density maps of the target objects and compare those with JCMT continuum and CO line emission maps to study the temperature distribution and gas freeze-out effects in those dense molecular cores. Three of our six molecular clouds were observed in Cycle 11, this is a continuation to complete our target list and observe the remaining three targets. This work will form the main part of my Ph.D. thesis project.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10172

Simultaneous Spitzer and K2 monitoring of young accreting stars in Upper Scorpius

Principal Investigator: Ann Marie Cody
Institution: IPAC

Technical Contact: Luisa Rebull, SSC

Co-Investigators:
John R. Stauffer, SSC
Luisa Rebull, SSC
Lynne A. Hillenbrand, Caltech
Sean J. Carey, SSC
Neal J. Turner, JPL
John M. Carpenter, Caltech

Science Category: YSOs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10

Abstract:
We propose to obtain 24 days of Spitzer/IRAC monitoring on disk-bearing members of the 5-10 Myr Upper Scorpius region, simultaneous with the K2 optical campaign on the same objects during fall 2014. Young stars in this age range are dynamic objects, with highly variable emission at many wavelengths from X-ray to infrared. Variability on day to month timescales originates from the stellar surface, accretion columns, and the inner disk (r~0.1-1 AU), and provides a way to infer structural features that are inaccessible to direct imaging. We aim to monitor a set of 15 young, low mass stars in the optical and infrared at continuous sub-day cadence and 1% or better precision-- a set-up that is only possible with space telescopes. Despite similarity to the Young Stellar Object Variability Project (YSOVAR; cycle 6) and Coordinated Synoptic Investigation of NGC 2264 (CSI 2264; cycle 8), this program is the only one to obtain high quality light curves on objects older than 5 Myr. At these epochs, inner disks have evolved substantially and accretion rates are lower. We will use the acquired data to determine how variability processes-- and hence inner disk structure-- vary with age. In addition, we will have high quality ancillary data (e.g., disk inclinations) from ALMA and other facilities that will be used in combination with the Spitzer monitoring to test models of variability mechanisms and dust properties that are crucial to terrestrial planet formation.

Spitzer Space Telescope - General Observer Proposal #12113

Simultaneous Spitzer and K2 monitoring of young stars in the Lagoon Nebula

Principal Investigator: Ann Marie Cody
Institution: NASA Ames Research Center

Technical Contact: Ann Marie Cody, NASA Ames Research Center

Co-Investigators:
John Stauffer, IPAC/SSC
Luisa Rebull, IPAC/SSC
Steve Howell, NASA Ames Research Center
Geert Barentsen, NASA Ames Research Center
Stephanie Douglas, Columbia University

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 33
Priority: 1

Abstract:
We propose to obtain 17 days of Spitzer/IRAC monitoring on disk-bearing members of the 1--2 Myr Lagoon Nebula star cluster (M8), simultaneous with the K2 optical campaign 9 on the same objects June/July 2016. Young stars in this age range are dynamic objects, with highly variable emission at many wavelengths from X-ray to infrared. Variability on day to month timescales originates from the stellar surface, accretion columns, and the inner disk (r~0.1-1 AU), and provides a way to infer structural features that are inaccessible to direct imaging. We aim to monitor a set of several hundred young stars in the optical and infrared at continuous sub-day cadence and 1% or better precision-- a set-up that is only possible with space telescopes. Despite similarity to the Young Stellar Object Variability Project (YSOVAR; cycle 6) and Coordinated Synoptic Investigation of NGC 2264 (CSI 2264; cycle 8), this program is the only one to obtain high quality light curves on higher mass Herbig AeBe stars. In this mass regime, the inner disk and its relationship to the star may be substantially different from the lower mass T Tauri stars previously monitored with Spitzer. We will use the acquired data to determine how variability processes-- and hence inner disk structure-- vary with mass. With the required 2x/day cadence, we request a total of 33.0 hours for this program.

Spitzer Space Telescope - General Observer Proposal #60169

Search for Pulsation in Young Brown Dwarfs

Principal Investigator: Ann Marie Cody
Institution: California Institute of Technology

Technical Contact: Ann Marie Cody, California Institute of Technology

Co-Investigators:
Lynne Hillenbrand, California Institute of Technology

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.0

Abstract:
Brown dwarfs are a ubiquitous yet poorly understood product of the processes that take place in star formation regions. To date, observational methods to determine important properties such as mass and age are lacking. But better understanding of the physical characteristics of young brown dwarfs and very low mass stars is now within reach through the signature of variable lightcurves. In particular, pulsation in these objects is a newly suggested phenomenon that offers unprecedented opportunities to probe their interiors and evolution. We propose to use Spitzer IRAC to improve upon ground-based studies which suggest low-amplitude, short-period variability indicative of pulsation just below the statistical detection threshold. We will acquire precise time-series photometry on a sample of confirmed brown dwarfs in the young Sigma Orionis cluster. With estimated masses and ages appropriate to the deuterium-burning stage, these objects are some of the most promising candidates in a potential new class of pulsators. We aim to fully characterize light-curve periodicities down to millimagnitude amplitudes, and ultimately use the results to provide fundamental constraints on the interiors and properties of brown dwarfs.

Spitzer Space Telescope - General Observer Proposal #10140

Age, Stellar Mass, and Rest-Frame UV Slope of a z ~ 11 Galaxy

Principal Investigator: Dan Coe
Institution: Space Telescope Science Institute

Technical Contact: Ranga-Ram Chary, California Institute of Technology

Co-Investigators:
Leonidas Moustakas, JPL
Ranga-Ram Chary, Caltech
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Marc Postman, STScI
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Adi Zitrin, Caltech
Mauricio Carrasco, AIUC-PUCC
Holland Ford, JHU
Megan Donahue, MSU
Piero Rosati, ESO
Dan Kelson, OCIW
Mario Nonino, INAF
Tom Broadhurst, U Basque / IKERBASQUE

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 112.0
Priority: 1

Abstract:
The first galaxies are the frontier of extragalactic astronomy. Hubble and Spitzer have measured the buildup of stellar mass and specific star formation rates from z ~ 8 to 4. Extending this to z > 9 with the handful of candidates discovered in the Hubble Ultra Deep Field has not been possible due to their faint observed fluxes (~10 nJy). We expect the upcoming Frontier Fields to deliver another ~35 - 120 candidates at z ~ 9 - 12. It is imperative that we learn more about their physical properties, but many will still be too faint for follow-up. Fortunately, CLASH, a shallower survey of gravitational lensing clusters, has yielded 4 much brighter z > 9 candidates, including the most distant: MACS0647-JD at z ~ 10.8 (observed 420 Myr after the Big Bang). Our primary target, lensed image MACS0647-JD2, is magnified by a factor of 7 to 170 nJy in the rest-frame UV. With an intrinsic (unlensed) flux of ~25 nJy, it is a near-analog of z > 9 candidates discovered in "blank" (unlensed) Hubble deep fields. The existing Spitzer IRAC imaging (5 hours in each of ch1 3.6um and ch2 4.5um, PI Egami) yields no detection in ch1 but a possible (3-sigma) intriguing detection of a Balmer break / [OII] 3727A emission in ch2. Here we propose imaging 10 times deeper (50 hours in each band) to detect the object significantly in both channels and obtain the first constraints on the age, stellar mass, and rest-frame UV slope of a galaxy observed in the heart of the epoch of reionization. This imaging will also enable study of a large sample of ~30 lensed z ~ 6 - 8 candidates (far more than revealed by most other cluster lenses) with delensed intrinsic fluxes down to ~1 nJy. This study, now possible before JWST, will contribute to measurements of scatter about the "main sequence of star formation," constraining SFR duty cycles at these early times.

Spitzer Space Telescope - General Observer Proposal #10041

Mass Assembly In The WFC3 Infrared Spectroscopic Parallels Survey

Principal Investigator: James Colbert
Institution: Spitzer Science Center

Technical Contact: James Colbert, Spitzer Science Center

Co-Investigators:
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Brian Siana, UC Riverside
Matt Malkan, UCLA
Patrick McCarthy, Carnegie
Alaina Henry, GSFC
Hakim Atek, SSC
Robert Fosbury, ESO
Nathanial Ross, UCLA
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Carrie Bridge, Caltech
Andrew Bunker, Oxford
Alan Dressler, Carnegie
Hyunjin Shim, SSC
Alejandro Bedregal, University of Minnesota
Alberto Dominguez, UC Riverside
Marc Rafelski, SSC
Dan Masters, Carnegie
Crystal Martin, UC Santa Barbara

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.4
Priority: 1

Abstract:
The WFC3 Infrared Spectroscopic Parallel (WISP) Survey uses over 1300 HST orbits to study galaxy evolution over a majority of cosmic history. Its slitless grism spectroscopy over a wide, continuous spectral range (0.8-1.7 micron) provides an unbiased selection of thousands of emission line galaxies over 0.5 < z < 2.5. Hundreds of these galaxies are detected in multiple emission lines, allowing for important diagnostics of metallicity and dust extinction. We propose deep 3.6 micron imaging (5 sigma, 0.9 micro-Jy) of 40 of the deepest WISP fields observed with the combination of G102+G141 grisms, in order to detect emission-line galaxies down to 0.1 L*. Combined with our HST optical and near-IR photometry, these IRAC data will be critical to determining accurate stellar masses for both passive and active galaxies in our survey. We will determine the evolution of the faint end slope of the stellar mass function and the mass-metallicity relation down to low-mass galaxies, including measurement of a possible mass-metallicity-SFR fundamental plane. The addition of the IRAC photometry will also provide much stronger constraints on dust extinction and star formation history, especially when combined with information available from the emission lines themselves.

Spitzer Space Telescope - General Observer Proposal #12093

Measuring Low Mass Galaxies In The WFC3 Infrared Spectroscopic Parallels Survey

Principal Investigator: James Colbert
Institution: Spitzer Science Center

Technical Contact: James Colbert, Spitzer Science Center

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Nathanial Ross, UCLA
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Carrie Bridge, Caltech
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Alan Dressler, Carnegie
Hyunjin Shim, SSC
Alejandro Bedregal, University of Minnesota
Alberto Dominguez, UC Riverside
Marc Rafelski, GSFC
Dan Masters, Carnegie
Crystal Martin, UC Santa Barbara
Sophia Dai, SSC

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 36.9
Priority: 2

Abstract:
The WFC3 Infrared Spectroscopic Parallel (WISP) Survey uses over 1800 HST orbits to study galaxy evolution over a majority of cosmic history. Its slitless grism spectroscopy over a wide, continuous spectral range (0.8-1.7 micron) provides an unbiased selection of thousands of emission line galaxies over 0.5 < z < 2.5. Hundreds of these galaxies are detected in multiple emission lines, allowing for important diagnostics of metallicity and dust extinction. We propose deep 3.6 micron imaging (5 sigma, 0.9 micro-Jy) of 60 of the deepest WISP fields observed with the combination of G102+G141 grisms, in order to detect emission-line galaxies down to 0.1 L* and masses below 10^8 Mo. Combined with our HST optical and near-IR photometry, these IRAC data will be critical to determining accurate stellar masses for both passive and active galaxies in our survey. We will determine the evolution of the faint end slope of the stellar mass function and the mass-metallicity relation down to low-mass galaxies. The addition of the IRAC photometry will also provide much stronger constraints on dust extinction and star formation history, especially when combined with information available from the emission lines themselves.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13207

Low Mass AGN: Combining IRAC With Near-IR Grism Spectroscopy

Principal Investigator: James Colbert
Institution: Spitzer Science Center

Technical Contact: James Colbert, Spitzer Science Center

Co-Investigators:
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Matt Malkan, UCLA
Claudia Scarlata, University of Minnesota
Micaela Bagley, University of Minnesota
Ivano Baronchelli, IPAC/Caltech
Connor Hayden-Pawson, UCLA
Marc Rafelski, STScI

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.0

Abstract:
Low mass AGN are critical to understanding the evolution of AGNs and stars in galaxies, marking the time periods of highest accretion efficiency and greatest likely deviations from the black hole mass - sigma correlation. Using the WFC3 Infrared Spectroscopic Parallels (WISP), we have just recently identified 68 candidate z > 1 AGN in 27 fields from their near-infrared emission line ratios. The WISP survey selects emission line galaxies without any pre-selection bias and is exquisitely sensitive to low mass (down to 10^7 solar masses), high-equivalent width galaxies that are missed by most other surveys. We propose to take IRAC 4.5 micron imaging of these AGN candidate fields in order to confirm 68 low mass AGN candidates, identify additional low mass IR-AGN missed by emission line selection, and produce the SED fits that can separate hot dust from star light, allowing comparison of stellar mass to AGN bolometric luminosity. The upcoming Euclid and WFIRST missions will generate hundreds of thousands of near-infrared spectra over a similar redshift range to WISP. For most of these objects, near-infrared emission line ratios will be the only viable AGN diagnostic. The Spitzer IRAC color AGN selection is one of the most robust AGN identifiers available. We wish to test these near-infrared emission line selection methods against the IRAC selection in order to evaluate the reliability of the AGN these future missions are likely to produce.

Spitzer Space Telescope - General Observer Proposal #80134

Measuring Mass In The WFC3 Infrared Spectroscopic Parallels Survey

Principal Investigator: James Colbert
Institution: Spitzer Science Center

Technical Contact: James Colbert, Spitzer Science Center

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Hakim Atek, SSC
Robert Fosbury, ESO
Nathanial Ross, UCLA
Nimish Hathi, Carnegie
Carrie Bridge, Caltech
Andrew Bunker, Oxford
Alan Dressler, Carnegie
Hyunjin Shim, SSC

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 39.4

Abstract:
The WFC3 Infrared Spectroscopic Parallel (WISP) Survey is using 500 HST orbits to study the epoch of peak star formation. Its slitless grism spectroscopy over a wide, continuous spectral range (0.8-1.7 micron) provides an unbiased selection of thousands of emission?line galaxies over 0.5 < z < 2.5. Hundreds of these galaxies are detected in multiple emission lines, allowing for important diagnostics of metallicity and dust extinction. We propose deep 3.6 micron imaging (5 sigma, 0.9 micro-Jy) of all 62 of the WISP fields observed with the combination of G102+G141 grisms, in order to detect emission-line galaxies down to 0.1 L*. Combined with our optical and near?IR photometry, these IRAC data will be critical to determining accurate stellar masses for both passive and active galaxies in our survey. We will determine the evolution of the faint end slope of the stellar mass function and the mass-metallicity relation down to low-mass galaxies, including measurement of a possible mass-metallicity-SFR fundamental plane. The addition of the IRAC photometry will also provide much stronger constraints on dust extinction and star formation history, especially when combined with information available from the emission lines themselves. Finally, it will also allow us to constrain the properties of stellar populations in luminous z>6 Lyman alpha-emitters.

Spitzer Space Telescope - General Observer Proposal #90230

Low Mass Galaxy Evolution In The WFC3 Infrared Spectroscopic Parallels Survey

Principal Investigator: James Colbert
Institution: Spitzer Science Center

Technical Contact: James Colbert, Spitzer Science Center

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Patrick McCarthy, Carnegie
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Hyunjin Shim, SSC
Alejandro Bedregal, University of Minnesota
Alberto Dominguez, UC Riverside
Marc Rafelski, SSC
Dan Masters, Carnegie

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 23.5

Abstract:
The WFC3 Infrared Spectroscopic Parallel (WISP) Survey uses nearly 1000 HST orbits to study the epoch of peak star formation. Its slitless grism spectroscopy over a wide, continuous spectral range (0.8-1.7 micron) provides an unbiased selection of thousands of emission line galaxies over 0.5 < z < 2.5. Hundreds of these galaxies are detected in multiple emission lines, allowing for important diagnostics of metallicity and dust extinction. We propose deep 3.6 micron imaging (5 sigma, 0.9 micro-Jy) of 39 of the deepest WISP fields observed with the combination of G102+G141 grisms, in order to detect emission-line galaxies down to 0.1 L*. Combined with our HST optical and near-IR photometry, these IRAC data will be critical to determining accurate stellar masses for both passive and active galaxies in our survey. We will determine the evolution of the faint end slope of the stellar mass function and the mass-metallicity relation down to low-mass galaxies, including measurement of a possible mass-metallicity-SFR fundamental plane. The addition of the IRAC photometry will also provide much stronger constraints on dust extinction and star formation history, especially when combined with information available from the emission lines themselves.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13229

The Great Exoplanet Eclipse: Spitzer Observations of the Benchmark Sub-Saturn-Mass Planet KELT-11b

Principal Investigator: Knicole Colon
Institution: NASA Goddard Space Flight Center

Technical Contact: Knicole Colon, NASA Goddard Space Flight Center

Co-Investigators:
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Michael Line, Arizona State University
Laura Kreidberg, Harvard University
Eric Lopez, NASA GSFC
Keivan Stassun, Vanderbilt University
Joseph Rodriguez, Harvard University
Joshua Pepper, Lehigh University
David James, University of Washington

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.0

Abstract:
KELT-11b is a unique sub-Saturn-mass planet with a super-Jupiter radius that is in orbit around a bright, metal-rich, sub-giant star. We propose to observe a single eclipse of KELT-11b with Spitzer in IRAC Channel 2, which will allow us to precisely constrain the orbital eccentricity of the planet, study atmospheric circulation in an as yet unexplored regime of planetary surface gravity and temperature, and perform comparative science with other exoplanets in order to explore the correlation between surface gravity and thermal structure. Spitzer is the only active facility capable of providing the high precision, continuous infrared eclipse photometry of KELT-11b that is required to reach these objectives. The Spitzer infrared eclipse combined with near-infrared transmission spectroscopy that we will obtain with WFC3 on the Hubble Space Telescope will ultimately enable a detailed investigation of the atmospheric properties of KELT-11b and will provide a benchmark for planning thermal observations of exoplanets with the James Webb Space Telescope.

Spitzer Space Telescope - General Observer Proposal #90175

Imaging the most extreme starbursts in the early Universe

Principal Investigator: Alexander Conley
Institution: University of Colorado

Technical Contact: Alexander Conley, University of Colorado

Co-Investigators:
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Asantha Cooray, University of California, Irvine
Dave Clements, Imperial College London
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Dominik Riechers, Cornell University
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Mattia Vaccari, University of the Western Cape, South Africa
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Alain Omont, Institut d'Astrophysique de Paris
Elisabetta Valiente, University of Cardiff
Helmut Dannerbauer, University of Vienna

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 27.2

Abstract:
The HerMES and H-ATLAS projects, using Herschel/SPIRE data, have discovered a population of ultra-red (hence high-z), faint (hence unlensed), dusty extreme star forming galaxies, which are likely among the most distant, luminous and massive known. Follow up of the first few sources has confirmed that they predominantly lie above z > 4, including one souce at z=6.3. However, current observations of these sources can only probe their young, starbursting stellar populations. In order to form a complete picture of their stellar content, as well as place the starburst within the context of the history of these systems, we request Spitzer observations of 20 such sources. In addition, this data will be sensitive to un-obscured starbursts (LBGs) associated with the same overdensity, allowing us to test whether our targets serve as signposts to high-z protoclusters as suggested by structure formation models.

Spitzer Space Telescope - Directors Discretionary Time Proposal #548

Spitzer Followup and of Key Discoveries in Herschel-ATLAS Science Demonstration Phase Field

Principal Investigator: Asantha Cooray
Institution: UC Irvine

Technical Contact: Asantha Cooray, UC Irvine

Co-Investigators:
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Loretta Dunne, U. of Nottingham
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David Clements, Imperial
Gianfranco De Zotti, Padova
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Paolo Serra, UC Irvine
Mark Thompson, Herts
Julie Wardlow, UC Irvine

Science Category: High-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.7

Abstract:
We propose to obtain followup IRAC imaging data for four key targets from the 14 sq. deg. Science Demonstration Phase field of the Herschel- ATLAS survey. This will provide a vital component in validating and confirming the discoveries we have made with Herschel observations. H-ATLAS is the largest Open-Time Key Program of Herschel both in terms of time awarded (600 hours) and the total survey area (550 sq. degrees). The targets of this proposed DDT program are (a) a proto-cluster of sub-mm galaxies at a redshift between 2 and 2.5 selected based on sub-mm colors; (b) 2 gravitationally lensed sources at redshift of 3.04 and 2.06; and (c) an optically dark compact core, possibly a Bok globule with a unique origin given the location in the Galactic plane. Spitzer IRAC data will allow us to find counterparts to sub-mm sources in the high redshift proto-galaxy cluster and improve photometric redshift estimates of member galaxies. IRAC data of lensed sources will establish the spectral energy distribution of high-redshift sources and guide us for future followup of the 100 lensed sources expected in all of H-ATLAS 550 sq. degrees. IRAC data of the Galactic will allow us to look for the embedded Class 0 object in the sub-mm compact core.

Spitzer Space Telescope - Snapshot Proposal #13042

IRAC Snapshot Imaging of Red Herschel Galaxies

Principal Investigator: Asantha Cooray
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Technical Contact: Asantha Cooray, University of California Irvine

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Julie Wardlow, Durham University
Rob Ivison, University of Edinburgh
Ismael Perez-Fournon, IAC, Spain
Dominik Riechers, Cornell University
David Clements, Imperial College
Seb Oliver, University of Sussex
Ivan Oteo, University of Edinburgh

Science Category: high-z galaxies (z>0.5)
Hours Approved: 247.9
Priority: 2

Abstract:
Wide-field submillimeter surveys with Herschel have produced large samples of rare populations, which provide some of the most stringent constraints on galaxy formation theories. In this proposal we request IRAC observations of "red" Herschel sources, which are the most extreme DSFGs at z>4. The proposed snapshot IRAC 3.6 and 4.5um data will probe the stellar emission from these systems - complementary data to the far-infrared dust emission that led to their identification. We will use these data to extend the SEDs into the near-IR regime and measure more reliable stellar masses than otherwise available. They will be combined with existing survey data and dedicated follow-up programs to map the evolution of DSFGs as a function of redshift, stellar mass and far-IR luminosity.

Spitzer Space Telescope - General Observer Proposal #14088

Spitzer Imaging of Planck-Herschel Dusty Proto-Clusters at z=2-3

Principal Investigator: Asantha Cooray
Institution: University of California Irvine

Technical Contact: Asantha Cooray, University of California Irvine

Co-Investigators:
Jingzhe Ma, University of California at Irvine
Joshua Greenslade, Imperial College London
Mariko Kubo, NAOJ
Hooshang Nayyeri, University of California at Irvine
David Clements, Imperial College London
Tai-An Cheng, Imperial College London

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.4
Priority: 1

Abstract:
We have recently introduced a new proto-cluster selection technique by combing Herschel/SPIRE imaging data and Planck/HFIk all-sky survey point source catalog. These sources are identified as Planck point sources with clumps of Herschel source over-densities with far-IR colors comparable to z=0 ULIRGS redshifted to z=2 to 3. The selection is sensitive to dusty starbursts and obscured QSOs and we have recovered couple of the known proto-clusters and close to 30 new proto-clusters. The candidate proto-clusters selected from this technique have far-IR flux densities several times higher than those that are optically selected, such as using LBG selection, implying that the member galaxies are in a special phase of heightened dusty starburst and dusty QSO activity. This far-IR luminous phase may be short but likely to be necessary piece to understand the whole stellar mass assembly history of clusters. Moreover, our photo-clusters are missed in optical selections, suggesting that optically selected proto-clusters alone do not provide adequate statistics and a comparison of the far-IR and optical selected clusters may reveal the importance of the dusty stellar mass assembly. Here, we propose IRAC observations of six of the highest priority new proto-clusters, to establish the validity of the technique and to determine the total stellar mass through SED models. For a modest observing time the science program will have a substantial impact on an upcoming science topic in cosmology with implications for observations with JWST and WFIRST to understand the mass assembly in the universe.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14203

Spitzer Imaging of Planck-Herschel Dusty Proto-Clusters at z = 2-3: Completing the Full Sample

Principal Investigator: Asantha Cooray
Institution: UC Irvine

Technical Contact: Jingzhe Ma, UC Irvine

Co-Investigators:
Jingzhe Ma, UCI
Joshua Greenslade, Imperial College
Mariko Kubo, NAOJ
Hooshang Nayyeri, UCI
David Clements, Imperial College
Tai-An Cheng, Imperial College

Science Category: galaxy clusters
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 55.8

Abstract:
We have recently introduced a new proto-cluster selection technique by combing Herschel/SPIRE imaging data and Planck/HFIk all-sky survey point source catalog. These sources are identified as Planck point sources with clumps of Herschel source over-densities with far-IR colors comparable to z=0 ULIRGS redshifted to z=2 to 3. The selection is sensitive to dusty starbursts and obscured QSOs and we have recovered couple of the known proto-clusters and 31 new proto-clusters. These photo-clusters are missed in optical selections, suggesting that optically selected proto-clusters alone do not provide adequate statistics and a comparison of the far-IR and optical selected clusters may reveal the importance of the dusty stellar mass assembly. During Cycle 14 requested time for the top 6 proto-clusters that had substantial ancillary data at the time of the proposal deadline. Those 6 targets were granted Priority I observing time in Cycle 14. Due to the Legacy Value - as highlighted by the Cycle 14 review panel - we request Priority II observing time for rest 25 proto-clusters. These represent the complete sample of proto-clusters in overlapping Herschel and Planck areas in all of Herschel extragalactic surveys. They are all likely to be at z of 2-3. For an additional modest observing time with IRAC the science program will have a substantial impact on an upcoming science topic in cosmology with implications for observations with JWST and WFIRST to understand the mass assembly in the universe.

Spitzer Space Telescope - General Observer Proposal #80156

Spitzer Imaging of Herschel Lensed Sub-mm Galaxies

Principal Investigator: Asantha Cooray
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Technical Contact: Asantha Cooray, University of California Irvine

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Jeff Cooke, Caltech
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David Frayer, NOAO
Jonathan Gardner, NASA Goddard
Hai Fu, Caltech
Shane Bussmann, Harvard/CfA
Mark Gurwell, Harvard/CfA
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Alex Conley, Colorado
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Carrie Bridge, Caltech
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Michael Zemcov, Caltech
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David Shupe, IPAC
Ros Hopwood, Imperial
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Paola Andreani, ESO
David Clements, Imperial
Helmut Dannerbauer, CEA, France
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Loretta Dunne, U. of Nottingham
James Dunlop, Edinburgh
Steve Eales, Cardiff University
Duncan Farrah, Sussex
Rob Ivison, Edinburgh
Matt Jarvis, Herts
Steve Maddox, Nottingham
Michal Michalowski, Edinburgh
Alain Omont, IAP, France
Ismael Perez-Fournon, IAC, Spain
Dimitra Rigopoulou, Oxford
Stephen Serjeant, Open U
Ian Smail, Durham
Mark Thompson, Herts
Mattia Vaccari, Padova
Aprajita Verma, Oxford
Kirsten Coppin, McGill
Seb Oliver, Sussex
Lingyu Wang, Sussex

Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 93.6

Abstract:
Sub-millimeter surveys have, in the last decade, revealed an unexpected

population of high-redshift dust-obscured sub-mm galaxies (SMGs) which are forming stars at a tremendous rate. Due to steep number counts and the negative k-correction at sub-mm wavelengths sub-mm surveys are effective at finding intrinsically faint, gravitationally lensed galaxies. We have now produced a reliable list of about 150 bright lensed SMGs in 200 sq. deg of the Herschel-ATLAS and HerMES (the GTO program of the SPIRE Instrument team) surveys with Herschel-SPIRE. We propose Spitzer IRAC 3.6 and 4.5 micron imaging of 122 of these gravitationally lensed SMGs. The target SMGs are selected to maximally overlap with existing and planned multi-wavelength followup programs, without duplicating existing deep IRAC data. Using the proposed Spitzer data we will: (a) Extend the SEDs of z~ 1 to 5 lensed SMGs into the near-IR regime, where derived stellar masses are more reliable than those estimated at other wavelengths alone; (b) Combine with lens models from existing and planned high-resolution sub-mm imaging (SMA, CARMA, PdBI) to map the evolution of stellar mass as a function of redshift and star-formation rate (SFR); (c) Combine with existing and planned CO and CII molecular line measurements to map the evolution of dust-to-gas and stellar-to-gas mass ratios as a function of redshift and SFR; (d) Obtain snapshot statistics on the sub-mm galaxy evolution from z of 1 to 5 as a function of stellar, dust, and gas mass to study the role of mergers and AGN contribution that may regulate the starburst phenomenon; (e) Compare our results to those from numerical simulations of high-redshift starburst galaxies to investigate the physical conditions in SMGs, and their evolutionary pathways.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80236

Spitzer-IRAC imaging of a Planck-selected Herschel-resolved candidate sub-mm galaxy proto-cluster at z = 3.25

Principal Investigator: Asantha Cooray
Institution: UC Irvine

Technical Contact: Asantha Cooray, UC Irvine

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Sam Kim, UC Irvine
Julie Wardlow, UC Irvine
Rob Ivison, Edinburgh
Dave Clements, Imperial
Guilia Rodighiero, Trieste
Paul van der Werf, Leiden
Alain Omont, IAP
Gianfranco De Zotti, Trieste
Michal Michalowski, Edinburgh
Shane Bussmann, CfA

Science Category: cosmology
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.0

Abstract:
Planck Early Release Compact Source Catalog (ERCSC) captures radio/sub-mm emission from Galactic cirrus structure to distant galaxy over densities. A joint study of Planck ERCSC and Herschel-SPIRE imaging overlapping in the GAMA survey fields of Herschel-ATLAS has led to the identification of one candidate proto-cluster of sub-millimeter galaxies. While ERCSC has this source detected with a flux of about 1 Jy, it is resolved into multiple sources in Herschel maps with an excess of about 20 submillimeter-bright galaxies over a region of 20 sq. arcmins. The brightest source of this clump is gravitationally lensed and its redshift of 3.259 is now well determined from multiple CO lines. Most of the nearby sub-mm galaxies within Planck beam have similar sub-mm colors, indicating a close redshift. It is likely that we have detected the first example of an over-density in the cosmic infrared background (CIB). Such overdensities are expected in the hierarchical structure formation models and are likely to lead to proto-clusters, regions that will eventually collapse to form galaxy clusters seen at z < 2. Here we propose deep IRAC imaging to identify the near-IR counterparts to the sub-mm sources and to identify an excess in the near-IR galaxy distribution, going to fainter galaxy fluxes that are expected below the Herschel-SPIRE confusion noise. The data will also be used to construct an over density map leading to a statistical study on the size, star-formation rate, gas consumption and other properties of this sub-mm galaxy proto-cluster. The IRAC imaging will be combined with planned optical and ground-based K-band imaging at Palomar to establish the photometric redshifts of galaxies in this region to separate foreground interlopers from the proto-cluster members and to reliably confirm the presence of a proto-cluster.

Spitzer Space Telescope - General Observer Proposal #10083

Measuring the IR emission from the host galaxy of PTF11qcj

Principal Investigator: Alessandra Corsi
Institution: Caltech

Technical Contact: Alessandra Corsi, Caltech

Co-Investigators:
Mansi Kasliwal, Carnegie Insitution of Washington

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.0
Priority: 2

Abstract:
In 2011, the Palomar Transient Factory discovered a radio-loud Ic supernova (SN) with broad spectral features, PTF11qcj. As a rare example of a SN with properties in between ordinary Ib/c SNe and the extreme gamma-ray burst (GRB) - associated SN1998bw, PTF11qcj represents an important step forward toward the ambitious goal of unraveling one of the biggest open questions pertaining the death of massive stars: why do some stars die as ordinary SN, while some other die more dramatically launching relativistic jets (GRBs)? A remarkable feature of PTF11qcj is that its radio light curves show abrupt flux variations and a late-time re-brightening, that challenges the simplest models of SN interaction with a smooth circumstellar material (CSM), and suggest the presence of a complex environment. This last hypothesis agrees with the discovery of a precursor eruption from the PTF11qcj progenitor, about 2.5yr before the SN. IR observations are a powerful tool to reveal the CSM properties. With Spitzer we detected an IR counterpart to PTF11qcj, whose flux is above the extrapolation of the optical SN light. This IR excess is likely related to pre-existing dust in the CSM. To confirm this result, here we ask for a new Spitzer image of the PTF11qcj field, so we can remove the galaxy contamination.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80255

PTF11qcj: First Discovery of a Radio Luminous Ibn Supernova

Principal Investigator: Alessandra Corsi
Institution: Caltech

Technical Contact: Mansi Kasliwal, Carnegie Institution for Science

Co-Investigators:
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Avishay Gal-Yam, Weizmann Institute of Science
Shri Kulkarni, Caltech
George Helou, Caltech/IPAC

Science Category: evolved stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.0

Abstract:
The Palomar Transient Factory (PTF) recently discovered PTF11qcj, a supernova with a very rare spectroscopic signature, called '' Type Ibn''. Type Ibn SNe are thought to be hydrogen-free core-collapse supernovae that interact with a dense shell of Helium-rich circum-stellar material (CSM). Before the discovery of PTF 11qcj, only 4 of these objects were known, the prototype, best-studied one being the famous SN 2006jc. The three most important observational properties of SN 2006jc were:(i) the presence of He emission lines in the optical spectra; (ii) an associated thermal X-ray emission; and (iii) the presence of an IR dust echo. We are currently carrying out an extensive optical (Keck and Palomar), radio (EVLA and CARMA), and X-ray (Chandra and Swift) monitoring campaign of PTF11qcj. In agreement with (i), our optical observations of PTF11qcj show the presence of Helium emission lines in its spectra, which are very rare. In agreement with (ii), our Chandra detection reveals the presence of an associated X-ray emission, with an X-ray luminosity about 3 times that of SN 2006jc. Finally, our radio observations are showing something quite unexpected: PTF11qcj is at least 100 times more luminous than SN 2006jc in radio, and represents the first discovery of a radio loud Ibn SN. Here we ask for two (1hr + 2hr) observations of PTF11qcj with Spitzer's IRAC, in search for the proxy (iii). The rarity of radio-loud SNe, and even more so of radio-loud Ibn SNe (only this one case is known), makes this a unique opportunity to study the physics of He-dominated CSM interaction. The fact that this interaction can be probed at the same time in IR, radio, X-ray, and optical, promises an exciting return from investing in the study of PTF 11qcj.

Spitzer Space Telescope - General Observer Proposal #11073

Rounding Up the Misfits: Eclipses, Transits, and Phases of Three Peculiar Hot Jupiters

Principal Investigator: Nicolas Cowan
Institution: Amherst College

Technical Contact: Nicolas Cowan, Amherst College

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Heather Knutson, Caltech
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Emily Rauscher, University of Michigan
Joel Schwartz, Northwestern University
Ming Zhao, Penn State University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 237.1
Priority: 3

Abstract:
We propose to obtain two new eclipses of WASP-1b and full-orbit phase curves of CoRoT-2b and WASP-5b at both 3.6 and 4.5 micron. Unlike other short-period planets, these three have emission spectra poorly fit by spectral models of varying complexity (blackbody, self-consistent radiative transfer, or spectral retrieval). This misfit trio has only benefited from single eclipse observations in the crucial Spitzer bandpasses, only one has Spitzer transit depths, and none have had their thermal phase variations measured. The scenarios invoked to explain their unusual eclipse spectra range from high-altitude optical absorbers, silicate clouds near the photosphere, stellar accretion, and detector systematics; all of these hypotheses are testable with the proposed observations. We will establish robust 3.6 and 4.5 micron eclipse measurements by observing two new eclipses of all three planets in each channel. The full-orbit observations of CoRoT-2b and WASP-5b will also allow us to (1) determine their Bond albedo and heat transport efficiency, (2) compare dayside and nightside mid-IR colors, (3) further constrain their atmospheric opacity via transit spectroscopy, and (4) discriminate between astrophysical and atmospheric scenarios for the inscrutable eclipse spectra. Misfits often provide the most leverage for understanding phenomena, and we expect these observations to greatly enhance our understanding or hot Jupiter atmospheres.

Spitzer Space Telescope - General Observer Proposal #80044

Phase Variations, Transits and Eclipses of the Misfit CoRoT-2b

Principal Investigator: Nicolas Cowan
Institution: Northwestern University

Technical Contact: Nicolas Cowan, Northwestern University

Co-Investigators:
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Michael Gillon, Universite de Liege
Heather Knutson, UC Berkeley
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Emily Rauscher, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 105.6

Abstract:
We propose to observe the nearby transiting hot Jupiter CoRoT-2b for a little over one planetary orbit on two occasions, yielding two secondary eclipses, a transit, and a full phase curve in each of the 3.6 and 4.5 micron channels. These data will help resolve the unique nature of this bloated planet: CoRoT-2b is the only hot Jupiter that is poorly fit by either inverted or non-inverted spectral models (Deming et al. 2011). Two hypotheses have been proposed to explain the peculiar mid-IR colors of CoRoT-2b, and thermal phase measurements with Spitzer's continuous, high-precision photometry will be able to distinguish between them: the planet has a non-inverted atmosphere but is losing mass to its host star, or the planet has a peculiar kind of temperature inversion due to mysterious atmospheric scatterers. CoRoT-2b is also among the most inflated hot Jupiters and, because of its relatively large mass, cannot be reconciled with interior evolution models, despite a small but non-zero eccentricity. A recent planetary collision may be necessary to explain the planet's youthful radius (Guillot & Havel 2011). Finally, the planet's extremely young host star, CoRoT-2, is the most chromospherically active of all transit hosts. This appears to be a common thread connecting all of its planet's peculiarities: the high UV flux of the star will drive mass loss, as well as photochemistry. Most importantly, the radius measurement of the planet at optical wavelengths may be contaminated by star spots. Mid-IR transit measurements from Spitzer will help resolve the mystery of CoRoT-2b's inflated radius.

Spitzer Space Telescope - General Observer Proposal #10078

A Homogeneous Phase Curve Sample for Global Atmospheric Retrieval

Principal Investigator: Ian Crossfield
Institution: Max-Planck-Institut fuer Astronomie

Technical Contact: Ian Crossfield, Max-Planck-Institut fuer Astronomie

Co-Investigators:
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Ignas Snellen, Leiden University
Adam Showman, LPL
Matteo Brogi, Leiden University
Jayne Birkby, Leiden University
Kevin Heng, Bern University
Joseph Harrington, University of Central Florida
Jonathan Fortney, UC Santa Cruz
Florian Rodler, Space Science Institute / CfA
Brad Hansen, UC Los Angeles
Jeffrey Hall, Lowell Observatory
Mercedes Lopez-Morales, Harvard/CfA
Patricio Cubillos, University of Central Florida
Bjoern Benneke, Caltech

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 25.0
Priority: 2

Abstract:
Exoplanet phase curves provide a wealth of information about atmospheric dynamics, energetics, and chemistry. Phase curves have been observed for relatively few planets, yet the current small sample already hints at the inadequacy of current atmospheric models. Our ultimate goal of understanding the global circulation patterns and their relation to atmospheric chemistry requires a larger and more homogenous sample. Here, we propose to more than double the sample of hot Jupiters with high S/N phase observations by targeting five bright non-transiting systems. Combined with the powerful new technique of high-resolution infrared Doppler spectroscopy, our observations will enable an unprecedented comparative study to relate global circulation patterns and atmospheric chemistry, and ultimately facilitate retrieval of the first global abundance and temperature maps of extrasolar planets. The planets in our sample represent the best objects to leverage both space-based phase curves and ground-based spectroscopy in a combined analysis. Spectroscopic observations break the inclination degeneracy that plagued earlier non-transiting phase variations, while phase curves provide crucial information about the planetary thermal continuum that is lost in the inherently relative spectroscopic analysis. Our program uses Spitzer's recently-validated observing mode to obtain high-precision photometry on long timescales with low data volumes and high scheduling flexibility, and our new retrieval approach will become a critical capability in an era of measurements at higher S/N and spectral resolution with JWST and Extremely Large ground-based telescopes.

Spitzer Space Telescope - General Observer Proposal #11044

Bright Hot Jupiters: Phase Curves and Doppler Spectroscopy

Principal Investigator: Ian Crossfield
Institution: University of Arizona

Technical Contact: Ian Crossfield, University of Arizona

Co-Investigators:
Jayne Birkby, Harvard/CfA
Matteo Brogi, CU Boulder
Adam Showman, UA/LPL
Jessica Krick, IPAC
Brad Hansen, UCLA
Jeffrey Hall, Lowell Observatory
Jonathan Fortney, UC Santa Cruz
Joe Harrington, U. Central Florida
Kevin Heng, Uni. Bern
Mercedes Lopez-Morales, Harvard/CfA
Patricio Cubillos, U. Central Florida
Ignas Snellen, U. Leiden
Nick Cowan, Amhert U.
Florian Rodler, MPIA
Bjoern Benneke, Caltech

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 132.3
Priority: 1

Abstract:
Exoplanet phase curves provide a wealth of information about atmospheric dynamics, energetics, and chemistry. Phase curves have been observed for relatively few planets, yet the current small sample already hints at the inadequacy of current atmospheric models. Our ultimate goal of understanding the global circulation patterns and their relation to atmospheric chemistry requires a larger and more homogenous sample. Here, we propose to more than double the sample of hot Jupiters with high S/N phase observations by targeting seven bright systems. Combined with the powerful new technique of high-resolution infrared Doppler spectroscopy, our observations will enable an unprecedented comparative study to relate global circulation patterns to atmospheric chemistry, and ultimately to facilitate retrieval of global abundance and temperature maps of extrasolar planets. The planets in our sample represent the best objects to leverage both space-based phase curves and ground-based spectroscopy in a combined analysis. Spectroscopic observations break the inclination degeneracy that plagued earlier non-transiting phase variations, while phase curves provide crucial information about the planetary thermal continuum that is lost in the inherently relative spectroscopic analysis. Our program uses Spitzer's recently-validated snapshot-phase curve mode to obtain high-precision photometry on long timescales with low data volumes and high scheduling flexibility, and our new retrieval approach will become a critical capability in an era of measurements at higher S/N and spectral resolution with JWST and Extremely Large ground-based telescopes.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13166

Confirming the Brightest Transiting Gas Giant

Principal Investigator: Ian Crossfield
Institution: UC Santa Cruz

Technical Contact: Ian Crossfield, UC Santa Cruz

Co-Investigators:
Jessica Krick, Caltech/IPAC-Spitzer
Nick Cowan, McGill U
Joseph Harrington, U. Central Florida
Paul Butler, Carnegie

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.1

Abstract:
We may have just found the brightest transiting hot Jupiter. HD 75289b was detected in RV (Udry et al., 2000), but no transits have been found, until now. Using a novel snapshot technique we have potentially discovered a shallow transit, and now we request follow-up standard observations of this target to confirm its transiting nature. A transiting exoplanet around such a bright star is a precious resource --- even TESS will deliver only ~5 transiting systems with Ks <= 5 mag. If confirmed to transit, the system will be the future target for ground-based high-resolution IR spectroscopy, low-resolution IR transit and/or eclipse spectroscopy with HST and JWST, HST-UV transit spectroscopy, Rossiter-McLaughlin spin-orbit alignment measurements, and more.

Spitzer Space Telescope - General Observer Proposal #14084

Spitzer Transits of New TESS Planets

Principal Investigator: Ian Crossfield
Institution: UC Santa Cruz

Technical Contact: Ian Crossfield, UC Santa Cruz

Co-Investigators:
Michael Werner, JPL
Diana Dragomir, MIT
Laura Kreidberg, CfA
Bjoern Benneke, U Montreal
Drake Deming, U Maryland
Varoujan Gorjian, JPL
Xueying Guo, MIT
Courtney Dressing, UC Berkeley
Liang Yu, MIT
Stephen Kane, UC Riverside
Jessie Christiansen, Caltech
David Berardo, MIT
Farisa Morales, JPL

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 550.0
Priority: 1

Abstract:
TESS will soon begin searching the sky for new transiting planets around the nearest, brightest stars, and JWST will become the world-leading facility in exoplanet atmospheric characterization. A key TESS goal is to provide the best atmospheric targets to JWST. However, many new TESS planets will exhibit just a few transits each, so their transit ephemerides will be only weakly constrained; without additional constraints on the planet orbit, the transits will be quickly ``lost'' long before JWST transit spectroscopy can commence. Some TESS planets will also be good targets for JWST secondary eclipses observations, but these eclipses will be even harder to pin down from TESS data alone. Spitzer's IR sensitivity and photometric stability can identify the transits and eclipses of the most favorable TESS planets and set the stage for JWST atmospheric characterization on a large scale. We request 550 hr to use Spitzer to measure precise transits and eclipses of new planets from the first year of TESS, refining their properties and ensuring their transits and eclipses can be recovered for many years to come. We will focus on the smaller planets for which ground-based observations are impractical and for which JWST spectroscopy will have a high impact. The time baseline provided by Spitzer will pin down the ephemerides far into the future. Thus our proposed program will secure these planets for future JWST spectroscopy to reveal their atmospheric makeup, chemistry, cloud properties, and formation history in unprecedented detail.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14290

Multiwavelength Phase Curves of a TESS Hot Neptune

Principal Investigator: Ian Crossfield
Institution: MIT

Technical Contact: Ian Crossfield, MIT

Co-Investigators:
Drake Deming, University of Maryland
Bjoern Benneke, University of Montreal
Diana Dragomir, MIT
Laura Kreidberg, Harvard/CfA
James Jenkins, Universidad de Chile
Varoujan Gorjian, IPAC
Nicholas Cowan, McGill University
Thomas Evans, MIT

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 46.8
Priority: 1

Abstract:
Planets are complex three dimensional objects, with variation in temperature, chemistry, and cloud coverage throughout their atmospheres. Spitzer phase curve observations have provided great insight into the atmospheric structure of gas giant exoplanets; however, to date there have been precious few sub-Jovian planets that are accessible for phase curve studies. Here we propose to measure the thermal phase variation of LTT 9779 b, a Neptune-size planet recently discovered by the TESS mission. Our observations will determine the planet's phase-resolved brightness temperature at 3.6 and 4.5 microns, allowing us to test for the presence of a super-rotating equatorial jet, measure the atmospheric metallicity, and evaluate whether nightside clouds are present. These observations will extend Spitzer's phase curve legacy from gas giants to the abundant population of smaller exoplanets.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14292

K2's Greatest Hits: Spitzer Transits of 2 Exceptional Worlds

Principal Investigator: Ian Crossfield
Institution: MIT

Technical Contact: Ian Crossfield, MIT

Co-Investigators: Exoplanets
Varoujan Gorjian, IPAC
Bjoern Benneke, University of Montreal

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 17.5
Priority: 1

Abstract:
Two highly interesting small planets discovered by K2 still lack Spitzer transit photometry. Without it, (as is common for K2 and TESS discoveries) these planets are suffering from gradual ephemeris drift that will preclude future characterization. These two systems, superlative even now in the TESS era, both lie in the ecliptic plane and so will not be observed by TESS. The long lever arm of one extra Spitzer transit taken ~2 yr after discovery will dramatically shrink the timing uncertainties for both planets for many years to come. A modest investment by Spitzer today will pay long-term dividends for the future characterization of both systems. We request 17.5 hr to observe one transit each of HD 73344b and Wolf 503b to enable recovery of their transits far into the future for HST and JWST atmospheric spectroscopy, radial velocity mass measurements, and Rossiter-McLaughlin/Doppler tomography to measure their spin-orbit alignments.

Spitzer Space Telescope - General Observer Proposal #11141

A Spitzer/HST Case Study of Weather on a Y Dwarf

Principal Investigator: Michael Cushing
Institution: U Toledo

Technical Contact: Michael Cushing, U Toledo

Co-Investigators:
J. Davy Kirkpatrick, Caltech/IPAC
John Gizis, University of Delware
Sean Carey, Spitzer Science Center
Jonathan Fortney, Unversity of California
Christopher Gelino, Caltech/IPAC
Sandy Leggett, Gemini Observatory
Gregory Mace, University of Texas
Mark Marley, NASA Ames
Caroline Morley, University of California
Didier Saumon, Los Alomos National Laboratory
Kevin Hardegree-Ullman, University of Toledo
Jesica Trucks, University of Toledo

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.5
Priority: 1

Abstract:
Condensate clouds play a critical role in shaping the emergent spectra of both brown dwarfs and gas giant planets. Our understanding of the vertical structure and horizontal distribution of these clouds remains limited, however, because we typically lack the multi-epoch observations required to study the disk-integrated emergent spectrum modulated by the brown dwarf's rotation. Variability studies can be used to advance our understanding of the three dimensional structure of brown dwarf atmospheres but simultaneous, multi-wavelength observations with broad spectral coverage are required. Noticeably absent from all variability studies of brown dwarfs to date are the Y dwarfs which are the coolest brown dwarfs currently known (Teff < 450 K). Our Cycle 9 Spitzer program has shown that Y dwarfs do indeed show variability in the mid-infrared, but to date no near-infrared variability has been detected. We therefore propose an HST/Spitzer case study of the Y0.5 dwarf WISE 1405+5534. We will obtain simultaneous F105W, F125W, [3.6] and [4.5] photometry of this dwarf and compare the light curves to predictions of partly cloudy model atmospheres. These observations will not only provide critical information for dynamical models of brown dwarf atmospheres but also directly inform the interpretation and characterization of cool gas giant exoplanets detected with the next generation of high-contrast imagers like the Gemini Planet Imager (GPI) and the SPHERE instrument for the VLT.

Spitzer Space Telescope - General Observer Proposal #90015

Brown Dwarf and Exoplanet Weather Forecasts: Are Y Dwarfs Partly Cloudy?

Principal Investigator: Michael Cushing
Institution: JPL

Technical Contact: Michael Cushing, JPL

Co-Investigators:
J. Davy Kirkpatrick, IPAC/Caltech
Christopher Gelino, IPAC/Caltech
John Gizis, University of Delaware
Gregory Mace, UCLA
Mark Marley, NASA Ames
Didier Saumon, LANL
Jonathan Fortney, UC Santa Cruz
Caroline Morley, UC Santa Cruz
Sandy Leggett, Gemini Observatory
Sean Carey, Spitzer Science Center

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 695.0

Abstract:
Condensate clouds play a critical role in shaping the emergent spectra of both brown dwarfs and gas giant planets. Their impact on the appearance of these objects is perhaps most dramatically illustrated on Jupiter where large holes in the cloud decks allow radiation from deeper, hotter layers of the atmosphere to emerge, which gives rise to the so-called 5 micron "hot spots" seen in thermal images of Jupiter. Gelino & Marley (2000) estimate that the disk-integrated 5 micron flux could vary by up to 20% due to the rotational modulation of these hot spots. With the recent discovery of Y dwarfs by NASA's Wide-field Infrared Survey Explorer (WISE), we have finally identified a population of ultracool brown dwarfs (Teff < 600 K) whose atmospheric properties are approaching that of Jupiter (Teff=128 K). There are strong theoretical reasons to expect that the condensate clouds in the Y dwarfs may also be nonuniform so we therefore propose to monitor the known sample of Y dwarfs for photometric variability using warm Spitzer. Our proposed observations will determine and characterize any mid-infrared variability exhibited by the Y dwarfs and determine whether the variability evolves over time scales of many months. These observations will not only improve our understand of the atmospheric dynamics of brown dwarf atmospheres but also directly inform the interpretation and characterization of cool gas giant exoplanets detected with the next generation of high-contrast imagers like the Gemini Planet Imager (GPI) and the SPHERE instrument for the VLT.

Spitzer Space Telescope - General Observer Proposal #13111

Rest-IR photometry of the brightest arc in the universe

Principal Investigator: Hakon Dahle
Institution: University of Oslo

Technical Contact: Hakon Dahle, University of Oslo

Co-Investigators:
Jane Rigby, NASA Goddard Space Flight Center
Michael Gladders, University of Chicago
Keren Sharon, University of Michigan
Matthew Bayliss, Colby College

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2
Priority: 1

Abstract:
We propose IRAC imaging of a uniquely bright (R=17.8) star forming galaxy at z=2.37. The galaxy is gravitationally lensed into a 55" long arc, with a total magnification factor most likely in excess of 50x. The proposed observations will allow us to spatially resolve the stellar mass distribution within the lensed galaxy and compare this to its spatial distribution of star formation, as measured from existing and planned rest-UV/optical data. This will enable us to examine how star formation varies with specific star formation rate within a galaxy at z=2.

Spitzer Space Telescope - General Observer Proposal #14047

Transit Recovery of Kepler-167e: Providing JWST with an Unprecedented Jupiter-analog Exoplanet Target

Principal Investigator: Paul Dalba
Institution: Boston University

Technical Contact: Paul Dalba, Boston University

Co-Investigators:
Philip Muirhead, Boston University
Patrick Tamburo, Boston University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10.0
Priority: 1

Abstract:
The Kepler Mission has uncovered a handful of long-period transiting exoplanets that orbit in the cold outer reaches of their systems, despite their low transit probabilities. Recent work suggests that cold gas giant exoplanet atmospheres are amenable to transmission spectroscopy (the analysis of the transit depth versus wavelength) enabling novel tests of planetary formation and evolution theories. Of particular scientific interest is Kepler-167e, a low-eccentricity Jupiter-analog exoplanet with a 1,071-day orbital period residing well beyond the snow-line. Transmission spectroscopy of Kepler-167e from JWST can reveal the composition of this planet's atmosphere, constrain its heavy-element abundance, and identify atmospheric photochemical processes. JWST characterization also enables unprecedented direct comparison with Jupiter and Saturn, which show a striking diversity in physical properties that is best investigated through comparative exoplanetology. Since Kepler only observed two transits of Kepler-167e, it is not known if this exoplanet exhibits transit timing variations (TTVs). About half of Kepler's long-period exoplanets have TTVs of up to 40 hours. Such a large uncertainty jeopardizes attempts to characterize the atmosphere of this unique Jovian exoplanet with JWST. To mitigate this risk, the upcoming third transit of Kepler-167e must be observed to test for TTVs. We propose a simple 10-hour, single-channel observation to capture ingress or egress of the next transit of Kepler-167e in December 2018. In the absence of TTVs, our observation will reduce the ephemeris uncertainty from an unknown value to approximately 3 minutes, thereby removing the risk in future transit observations with JWST. The excellent photometric precision of Spitzer is sufficient to identify the transit of Kepler-167e. Given the timing and nature of this program, Spitzer is the only observatory---on the ground or in space---that can make this pivotal observation.

Spitzer Space Telescope - General Observer Proposal #11161

Identifying wide, cold planets within 8pc

Principal Investigator: Niall Deacon
Institution: University of Hertfordshire

Technical Contact: Niall Deacon, University of Hertfordshire

Co-Investigators:
Adam Kraus, University of Texas
Ian Crossfield, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 197.1
Priority: 3

Abstract:
Direct imaging exoplanet studies have recently unveiled a previously-unexpected population of massive planets (up to 15 M_Jup) in wide orbits (>100AU). Although most of these discoveries have been around younger stars and have been of similar temperatures to field brown dwarfs, one object (WD 0806-661B), is the coldest planet known outside our solar system. We propose a survey of all stars and brown dwarfs within 8pc to identify massive planetary companions in the 150-1500AU separation range. We will 1) Measure the fraction of wide planetary mass companions to stars in the Solar neighbourhood. 2) Identify all planets within 8 parsecs with masses above 8 Jupiter masses in our chosen projected separation range with lower mass limits for closer and younger stars. 3) Identify approximately 8 planets, four of which will have temperatures below 300K making them ideal targets to study water clouds in cold atmospheres with both JWST and the next generation of ground-based extremely large telescopes. Our survey will be the most complete survey for wide planets to-date and will provide both a measurement of the wide planet population and a legacy of cold, well constrained targets for future observatories.

Spitzer Space Telescope - General Observer Proposal #14018

Detecting cold, wide orbit planets in the solar neighbourhood

Principal Investigator: Niall Deacon
Institution: University of Hertfordshire

Technical Contact: Niall Deacon, University of Hertfordshire

Co-Investigators:
Adam Kraus, University of Texas at Austin

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 40.5
Priority: 2

Abstract:
Direct imaging exoplanet studies have recently unveiled a previously unexpected population of massive planets in wide orbits (>100AU). Although most of these discoveries have been around younger stars and have been of similar temperatures to field brown dwarfs, one object (WD 0806-661B), is the coldest planet known outside our solar system. In Spitzer Cycle 11 we surveyed stars and brown dwarfs within 8pc to identify massive planetary companions in the 150-1500AU separation range. Only 56 of our 196 stars were observed with two epochs of observation. We propose second epoch observations for 80 targets with first, but little or no second epoch observations. We will 1) Measure the fraction of wide planetary mass companions to stars in the Solar neighbourhood. 2) Identify approximately 5 planets, three of which will have temperatures below 300K making them ideal targets to study water clouds in cold atmospheres with both JWST and the next generation of ground-based extremely large telescopes. 3) Identify all planets around our target stars with masses above 8 Jupiter masses in our chosen projected separation range with lower mass limits for closer and younger stars. Our survey will be the most complete survey for wide planets to-date and will provide both a measurement of the wide planet population and a legacy of cold, well-constrained targets for future observations with JWST and Extremely Large Telescopes.

Spitzer Space Telescope - General Observer Proposal #11030

A Spitzer legacy view on high-z QSOs

Principal Investigator: Roberto Decarli
Institution: Max-Planck-Institut fuer Astronomie

Technical Contact: Roberto Decarli, Max-Planck-Institut fuer Astronomie

Co-Investigators:
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Ian McGreer, Steward Observatory
Linhua Jiang, Arizona State University
Dominik Riechers, Cornell University
Eduardo Banados, MPIA
Bram Venemans, MPIA
Fabian Walter, MPIA
Emanuele Paolo Farina, MPIA
Chiara Mazzucchelli, MPIA

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30.0
Priority: 1

Abstract:
Very high-redshift (z>5.5) QSOs are formidable probes of the early universe, and unveil crucial phases in the formation and evolution of galaxies, the build-up of supermassive black holes, and the conditions of the intergalactic medium throughout the epoch of reionization. The number of known z>5.5 QSOs has nearly doubled in the last 2 years, thanks to the advent of surveys like Pan-STARRS and VIKING, which allowed us to substantially expand the parameter space of known high-z QSOs and provided unprecedented statistical power. A critical piece of information that we are still missing is the rest-frame optical luminosities and colors of these sources. We propose to use Spitzer/IRAC to systematically survey all the 81 z>5.5 QSOs for which this information is not available yet (i.e., 2/3 of the entire known population) in only 30 hr. This will allow us to put direct constraints on the spectral energy distributions of these sources, disentangling the rest-frame UV slopes and the contribution of the underlying host galaxy. These observations will allow us to address the diversity in the phenomenology of high-z QSOs. In particular, by combining the proposed observations with our JVLA program, we will directly measure the radio loudness parameter, defined as ratio between radio and (rest-frame) optical fluxes. This will circumvent the typically high uncertainties due to extrapolations from UV bands. These results will allow us to better understand the build-up histories of QSOs within 1 Gyr from the Big Bang. Moreover, these observations will pave the way to a plethora of follow-up studies using HST, ALMA, JVLA, and, eventually, the James Webb Space Telescope.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13201

Rest-frame optical photometry of a z~7.54 quasar and its environment

Principal Investigator: Roberto Decarli
Institution: INAF-OABO

Technical Contact: Roberto Decarli, INAF-OABO

Co-Investigators:
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Xiaohui Fan, Steward Observatory
Fabian Walter, MPIA
Bram Venemans, MPIA
Emanuele Paolo, MPIA
Chiara Mazzucchelli, MPIA
Feige Wang, Kavli Institute
Daniel Stern, JPL

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.5

Abstract:
Bright quasars are unique tools to study the dawn of galaxy and black hole formation, and to investigate the properties of the universe at the earliest cosmic epochs. We recently discovered the luminous quasar ULAS J1342+0928 at a record-breaking redshift of z=7.54 (whereas the previous quasar redshift record holder was at z=7.08). The presence of a damping wing in the quasar's spectrum, associated with a highly neutral intergalactic medium, and the high bolometric luminosity, powered by accretion on a supermassive, 8e8 Msun black hole, set unparalleled constraints on the history of reionization and on the formation and evolution of first massive black holes, only 690 Myr after the Big Bang. Here we propose to obtain sensitive Spitzer observations to sample the rest-frame optical emission of this quasar and of potential bright companion galaxies. By complementing our already secured observations with HST, IRAM/NOEMA, ALMA, and many other facilities, the proposed dataset will allow us (1) to constrain the Spectral Energy Distribution of the quasar, thus disentangling the contribution of its various components at optical wavelengths; (2) to investigate the quasar environment; and (3) to lay the foundation for high-resolution imaging and sensitive spectroscopy at MIR wavelengths with the James Webb Space Telescope.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10166

Measuring absolute flux, radius and effective temperature of a benchmark T-Type free-floating planet

Principal Investigator: Philippe Delorme
Institution: IPAG

Technical Contact: Philippe Delorme, IPAG

Co-Investigators:
Trent Dupuy, Harvard CfA
Mike Liu, IfA
Forveille Thierry, IPAG
Jonathan Gagne, U. Montreal

Science Category: Extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
We propose to obtain a complete spectral energy distribution, from 0.6 to 4.5 micron of CFBDSIR2149-0403, a 4 to 7 Jupiter-mass free-floating planet which we recently identified in the young (< 120 Myr) AB Doradus moving group. This is matched by the youth signatures that we independently identified in the spectrum of this object. At this age, CFBDSIR2149 is a close match to the exoplanets that will be found by the direct imaging searches with extreme adaptive optics, but its being isolated rather than hidden in the glare of a very bright star makes observations much easier. We already determined a preliminary parallax distance of 58+/-10pc, and additional measurements should soon improve this measurement. We also have at hand 10hours of VLT-Xhsooter data covering the 0.6 to 2.5 micron range with high-signal to noise data. With more than 90% of the energy flux of such a cool (~700K) object emitted between 0.6 and 5 micron, we only need 2 broad-band photometric data points from Spitzer channel 1 and 2 (covering 35 to 40% of the total flux) to nail-down a robust SED for this unique object, for less than 26 minutes total observing time. Together with its trigonometric distance, this will enable us to derive its absolute bolometric flux and hence model-independent measurements of its radius and effective temperature. With such a unique constraint on a directly imaged young planetary mass object CFBDSIR2149 will therefore become a much needed benchmark for extrasolar planets atmosphere models.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13175

Improved characterization of the TRAPPIST-1 planets

Principal Investigator: Laetitia Delrez
Institution: University of Cambridge

Technical Contact: Laetitia Delrez, University of Cambridge

Co-Investigators:
Amaury Triaud, University of Cambridge
Michael Gillon, University of Liege
Brice-Olivier Demory, University of Bern
Jim Ingalls, Spitzer Science Center
Sean Carey, Spitzer Science Center
Emeline Bolmont, University of Namur
Didier Queloz, University of Cambridge
Emmanuel Jehin, University of Liege
Julien de Wit, Massachusetts Institute of Technology
Brian Kilpatrick, Brown University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 80.7

Abstract:
The aim of this DDT is to improve the characterization of the TRAPPIST-1 planets by using Spitzer to gather further high- precision infrared photometric time-series.

The observations for this program can be found in program ID 13067.

Spitzer Space Telescope - General Observer Proposal #10102

Eclipses of New Giant Exoplanets

Principal Investigator: Drake Demming
Institution: University of Maryland, College Park

Technical Contact: Drake Deming, University of Maryland, College Park

Co-Investigators:
Heather Knutson, Caltech
Joshua Kammer, Caltech
Jonathan Fraine, Univ. of Maryland, College Park
Kamen Todorov, ETH - Zurich

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 542.3

Abstract:
Although Kepler has dominated discussions of exoplanet statistics in recent years, ground-based transit surveys have been undergoing a quiet renaissance of their own that has resulted in the discovery of an ever-growing sample of hot gas giant planets around bright, nearby stars. Many of these new worlds give us a unique opportunity to resolve several outstanding questions in exoplanetary science, but these new planets are unobserved by Spitzer. Because the transit surveys have improved their ability to find short-period planets, we are now awash in hot giant planets, capable of being measured to high signal-to-noise at secondary eclipse in both Spitzer bands. We propose a focused statistical study based on observations of these new planets at secondary eclipse, in both Spitzer bands. We have calculated the scientifically optimum sample based on all of the currently unobserved planets, imposing a high signal-to-noise requirement. Our proposed observations of 28 new and hotter-than-average giant planets will address the nature and cause of temperature inversions in giant exoplanetary atmospheres, the existence (or not) or carbon-rich planets, the orbital evolution of these worlds, and the statistics of heat redistribution in the high-irradiance regime. Our observations will be an essential legacy for future complementary studies incorporating ground-based and HST observations.

Spitzer Space Telescope - General Observer Proposal #12085

Spitzer Secondary Eclipses of Two Hubble-observed Exoplanets

Principal Investigator: Drake Deming
Institution: Department of Astronomy

Technical Contact: Drake Deming, Department of Astronomy

Co-Investigators:
Bjoern Benneke, Caltech
Jonathan Fraine, University of Maryland
Heather Knutson, Caltech
Nikole Lewis, STScI
Avi Mandell, NASA's GSFC
David Sing, University of Exeter
Kamen Todorov, Institute for Astronomy, ETH Zurich

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 61.5
Priority: 1

Abstract:
We propose Spitzer secondary eclipse observations of two key exoplanets (WASP-76b and HAT-P-38b) that are approved for transmission spectroscopy by HST/WFC3 in our Large Cycle-23 program. Spitzer eclipse data will provide temperature information needed to determine their atmospheric scale heights, and thereby infer their atmospheric water abundances (proxy for metallicity) from the WFC3 spectra. Potential molecular absorption that falls within the Spitzer bandpasses will also help to measure the atmospheric metallicity of these planets, and will be minimally affected by clouds - that can often frustrate transmission spectroscopy. Beyond the utility to our Hubble analyses, both planets have high scientific value for Spitzer eclipse observations in their own right. WASP-76b is a strongly irradiated and very hot, large radius giant planet. Its combination of strong irradiation and large radius puts it in an atmospheric regime where few planets have been observed by Spitzer in eclipse. HAT-P-38b is a sub-Saturn mass planet in a relatively cool temperature regime (1080 Kelvins) where Kammer et al. recently found that the ratio of planetary brightness temperature in the two Spitzer bands is potentially correlated with planetary mass. The low mass of HAT-P-38b (0.27 Jupiters) gives it substantial leverage to test that correlation.

Spitzer Space Telescope - Exploration Science Proposal #13044

Transits and Eclipses of the Best of the Best: 23 Hot Jupiters for Atmospheric Characterization by Spitzer, Hubble, and JWST

Principal Investigator: Drake Deming
Institution: University of Maryland at College Park

Technical Contact: Drake Deming, University of Maryland at College Park

Co-Investigators:
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Jonathan Fraine, Univ. of Arizona
Tiffany Kataria, JPL
Heather Knutson, Caltech
Nikole Lewis, STScI
Nikku Madhusudhan, University of Cambridge, U. K.
Avi Mandell, NASA's GSFC
Peter McCullough, STScI
Kyle Sheppard, Univ. of Maryland
David Sing, Exeter University, U. K.
Kevin Stevenson, Univ. of Chicago
Kamen Todorov, ETH Zurich
Hannah Wakeford, NASA's GSFC
Ashlee Wilkins, Univ. of Maryland
Adam Burrows, Princeton

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 554.0
Priority: 1

Abstract:
We propose a program of Spitzer transit and secondary eclipse observations for 23 of the "best of the best" hot giant planets (R > 0.8 Jupiters). We focus on planets that are already observed by HST, proposed to be observed by HST, or candiates for JWST Early Release Science observations. Our eclipse observations will measure day side temperatures that are needed for HST spectroscopy, and temperatures of the hottest and most favorable planets for JWST spectroscopy and possible phase curve observations. Several of our planets are extremely inflated, with atmospheric scale heights exceeding a thousand kilometers, yielding large atmospheric signatures during transit. Our transit photometry has the potential to detect molecular absorption by comparing transit radii and eclipse depths in the two Spitzer bands. Moreover, our precise transit depths will help to evaluate the magnitude of continuous opacity in the exoplanetary atmospheres, breaking the degeneracy between composition and cloud opacity, as recently demonstrated by Sing et al. We will thereby find the hottest and clearest giant exoplanetary atmospheres, with the largest molecular signatures, for HST and JWST spectroscopy. This will complete the Spitzer hot Jupiter legacy by providing a uniform set of transit and eclipse observations for the most favorable members of the intriguing population of close-in highly-irradiated giant planets. This unique Spitzer data set will guide efforts toward detailed atmospheric characterization of individual hot Jupiters for years to come.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14272

Secondary Eclipses of Key Exoplanets

Principal Investigator: Drake Deming
Institution: University of Maryland

Technical Contact: Drake Deming, University of Maryland

Co-Investigators:
Ian Crossfield, MIT
Yayaati Chachan, Caltech
Guangwei Fu, University of Maryland
Heather Knutson, Caltech
Jacob Bean, Univ. University of Chicago
Megan Mansfield, University of Chicago
Nicole Wallack, Caltech

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 32.1
Priority: 1

Abstract:
We propose observing secondary eclipses of transiting ultra-hot Jupiters at 3.6 microns, thereby providing key spectral constraints for planets where Spitzer has observed phase curves at 4.5 microns only. By adding the day side fluxes in the 3.6 micron bandpass, we will provide a simple first-order check on the shape of their emission spectra with a minimum of Spitzer observing time. Our results will enable comparison of these two-band spectra to the predictions of atmospheric models, and thereby prepare the community to investigate these planets more deeply, and to sharpen their hypotheses in preparation for JWST. We also propose to measure the orbital phase for the secondary eclipse of the transiting exo-Neptune, HAT-P-11b. We will resolve the tension between predictions from radial velocities, and a weak eclipse observed in Kepler photometry. Measuring the orbital phase of the eclipse unequivocally, we will enable JWST to observe the emission spectrum of this archetype exo-Neptune without having to search for the orbital phase of the eclipse.

Spitzer Space Telescope - General Observer Proposal #70049

Towards Earths and Beyond: the GJ1214 Opportunity

Principal Investigator: Drake Deming
Institution: NASA's Godddard Space Flight Center

Technical Contact: Drake Deming, NASA's Godddard Space Flight Center

Co-Investigators:
Michael Gillon, University of Liege, and Observatoire de Geneve
Sara Seager, MIT
Brice-Olivier Demory, MIT
Amoury Triaud, Obervatoire de Geneve
Xavier Bonfils, Universite Joseph Fourier, Grenoble

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 485.0

Abstract:
We propose a continuous 20.2-day photometric monitoring of the nearby M-dwarf star GJ1214b, known to host a transiting super-Earth inward of its habitable zone. The ultimate goal of our program is to detect a habitable world in this planetary system, and many other science goals can be accomplished during that search. Our program will observe 12 consecutive transits and eclipses of GJ1214b at 4.5-microns, thereby measuring its thermal emission, and improving our knowledge of the planetary radius and orbit, as well as quantifying the IR variability of the star. Our observations will be sensitive to moons and trojan planets, and to the presence of other transiting planets down to 0.45 Earth-radii (smaller than Mars). Our 20.2-day monitoring will cover orbits to the outer edge of the habitable zone. Some models of planetary formation predict that rocky planets are common orbiting M-dwarf stars. If these models are correct, then multi-planet systems may be the norm for lower main sequence stars. Our program has the significant potential to culminate by discovering a habitable rocky world transiting this nearby M-dwarf. That discovery would be of historic significance, and the major molecular constituents of such a world would be amenable to characterization by JWST.

Spitzer Space Telescope - General Observer Proposal #80128

Atmospheric Composition of the ExoNeptune HAT-P-11

Principal Investigator: Drake Deming
Institution: NASA's Godddard Space Flight Center

Technical Contact: Drake Deming, NASA's Godddard Space Flight Center

Co-Investigators:
Heather Knutson, UC Berkeley
Nikku Madhusudhan, Princeton Univ.
Kamen Todorov, Penn State Univ.

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30.0

Abstract:
We propose a joint Spitzer-HST program to observe transits of the exoNeptune planet HAT-P-11. From the wavelength dependence of the transit depths, we will infer the composition of this world's atmosphere. Our Spitzer photometry at both 3.6- and 4.5-microns will be sensitive to depletions or enhancements of methane such as recently reported for GJ436b. HST/WFC3 spectroscopy of water vapor at 1.4-microns will measure the oxygen abundance, a proxy for potential heavy-element enrichment of the planet. In addition to molecular composition, our suite of data will be sensitive to the presence of clouds and haze, similar to the recent Bean et al. observations of GJ1214b. Not only is HAT-P-11 key to understanding the unusual atmospheric compositions of small planets, but it also presents us with very favorable observational circumstances. It has the most massive atmosphere of any planet smaller than the gas giants, and it lies in the Kepler field. High-cadence photometry from Kepler will be acquired simultaneously with our Spitzer and HST observations. The Kepler data will not only provide an exquisitely precise optical radius, but will also allow us to model and remove the effect of star spots from our HST and Spitzer data.

Spitzer Space Telescope - General Observer Proposal #11089

A Benchmark Infrared Characterisation of the Super-Earth 55 Cnc e

Principal Investigator: Brice-Olivier Demory
Institution: University of Cambridge

Technical Contact: Brice-Olivier Demory, University of Cambridge

Co-Investigators:
Tiffany Kataria, University of Exeter
Nikole Lewis, MIT
Jessica Krick, IPAC
Didier Queloz, University of Cambridge
Michael Gillon, University of Liege
Vlada Stamenkovic, MIT
Nikku Madhusudhan, University of Cambridge
Jonathan Fortney, UCSC
Julien de Wit, MIT
Stephen Kane, SFSU

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 181.0
Priority: 3

Abstract:
The Kepler mission and radial-velocity surveys have revealed that super-Earth exoplanets are not only ubiquitous in our galaxy but also very diverse in terms of physical properties. However, very little is known about their nature because of the paucity of suitable targets amenable to detailed characterization. Two super-Earths, GJ1214b and 55Cnc e, orbit stars that are bright enough to enable detailed atmospheric and interior composition studies, which are crucial to improve our understanding of this class of exoplanets. As of today, 55Cnc e is the only super Earth amenable to occultation and phase curve infrared photometry, as well as a prime target to understand the nature of highly irradiated super Earths. In the past two years, Spitzer observations of 55 Cnc e resulted in photometric lightcurves of unprecedented quality, thanks to the brightness of its host star. We propose an observing program of 180 hours to pursue this effort. Our main goal is to determine whether 55 Cnc e harbors an atmosphere or not. We propose to obtain four orbital phase curves of 55 Cnc e at 4.5 microns and four other at 3.6 microns. Our observations will unambiguously determine whether 55 Cnc e is volatile-poor or volatile-rich. We will also measure for the first time the 3D climate patterns in a super-Earth atmosphere. Finally, our program will deliver precise transit, occultation and phase-curve photometry that will constitute an important legacy regarding the characterization of a super-Earth exoplanet, well in advance of JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80261

Characterization of a Low-density Exo-Neptune

Principal Investigator: Brice-Olivier Demory
Institution: MIT

Technical Contact: Brice-Olivier Demory, MIT

Co-Investigators:
Michael Gillon, University of Liege
Xavier Bonfils, University of Grenoble
Sara Seager, MIT
Xavier Delfosse, University of Grenoble
Thierry Forveille, University of Grenoble
Stephane Udry, University of Geneva
Christophe Lovis, University of Geneva
Michel Mayor, University of Geneva
Nuno Santos, University of Porto
Vasco Neves, University of Porto

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.0

Abstract:
We propose to observe two transits of the recently-discovered exo-Neptune GJ3470b with Spitzer/IRAC at 4.5 microns. GJ3470b orbits a bright K=8 M-dwarf with a 3.3 day-period. With a mass M = 13.3+-1.6 Earth masses and a radius R = 4.2+-0.7 Earth radii, GJ3470b belongs to the so-called "low-density Neptunes" class of planets. The Kepler Science team has published several similar planets (Kepler-11d,f, Kepler18c), known to represent only the tip of the iceberg, as several hundreds of Neptune-size planet candidates have been detected by Kepler and are pending confirmation. Unfortunately, all of these Kepler planets orbit faint stars and exhibit shallow transit depths, that render follow-up studies challenging. The brightness of its M-dwarf host star combined to a favorable transit depth makes GJ3470b a prime target for investigating the nature of a whole class of planets. While the GJ3470 photometry obtained from the ground confirm the transiting nature of GJ3470b, current data do not precisely tighten the transit parameters, resulting in poorly constrained planet properties. The proposed Spitzer observations will yield a reference radius for GJ3470b, that will constrain its interior structure and provide a benchmark measurement for future multi-wavelength follow-up observations of this planet.

Spitzer Space Telescope - General Observer Proposal #90208

The First Orbital Phase Curve of a Rocky Exoplanet

Principal Investigator: Brice-Olivier Demory
Institution: Massachusetts Institute of Technology

Technical Contact: Brice-Olivier Demory, Massachusetts Institute of Technology

Co-Investigators:
Michael Gillon, Universite de Liege
Sara Seager, MIT
Renyu Hu, MIT
Bjoern Benneke, MIT
Vlada Stamenkovic, MIT
Julien de Wit, MIT
Drake Deming, University of Maryland
Stephen Kane, Caltech-IPAC
Jessica Krick, Caltech-IPAC

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 75

Abstract:
The Kepler mission and radial-velocity surveys have revealed that super-Earth exoplanets are not only ubiquitous in our galaxy but also very diverse in terms of physical properties. However, very little is known about their nature because of the paucity of suitable targets amenable to detailed characterization. Two super-Earths, GJ1214b and 55Cnc e, orbit stars that are bright enough to enable detailed atmospheric and interior composition studies, which are crucial to improve our understanding of this class of exoplanets. As of today, 55Cnc e is the only super Earth amenable to occultation and phase curve infrared photometry, as well as a prime target to understand the nature of highly irradiated super Earths. In the past two years, Spitzer observations of 55 Cnc e resulted in photometric lightcurves of unprecedented quality, thanks to the brightness of its host star. We propose an observing program of 75 hours to pursue this effort. Our main goal is to determine whether 55 Cnc e harbors an atmosphere or not. We propose to obtain four orbital phase curves of 55 Cnc e at 4.5 microns. Our observations will be sensitive to the heat redistribution efficiency from the dayside to the nightside of the planet and will allow a measurement of the atmospheric pressure. This measurement will be the first of its kind for a super-Earth. Finally, our program will deliver precise transit, occultation and phase-curve photometry that will constitute an important legacy regarding the characterization of a super-Earth exoplanet, well in advance of JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #542

Probing the atmosphere of the coolest super-Earth

Principal Investigator: Jean-Michel Desert
Institution: Harvard University

Technical Contact: Jean-Michel Desert, Harvard University

Co-Investigators:
David Charbonneau, Harvard University
Zachory Berta, Harvard University
Christopher Burke, Harvard University
Jonathan Irwin, Harvard University
Philip Nutzman, Harvard University
Eliza Miller-Ricci, University of California, Santa Cruz

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.0

Abstract:
Theoretical models predict that low mass planets are likely to exist with atmospheres that can vary widely in their composition and structure. Our team recently detected a super-Earth transiting the nearby low-mass star GJ1214 (Charbonneau et al., 2009). This detection has opened the door to testing predictions of low mass planet atmosphere theories. We propose to use the Spitzer space telescope to detect the atmosphere and infer the molecular composition of GJ1214b. The mid-infrared (MIR) is particularly well suited to observe numerous molecular signatures such as water vapor. We plan to observe the primary eclipse of the planet (when the planet passes in front of the parent star) with the IRAC instrument in the two available channels at 3.6 and 4.5 microns. Comparing the radius measurements obtained in the two band-passes will allow us to detect the atmosphere of this object and to place constraints on its molecular composition. This study is possible because of the small size of the host star GJ1214. Consequently, the expected atmospheric signatures observed in transmission (0.1%) can be detected with the same level of confidence as has successfully been accomplished with much larger planets (hot-Jupiters). Moreover, the high photometric precision, continuous coverage and no limb-darkening of these light curves will improve the planetary parameters, and allow to search for transiting moons.

Spitzer Space Telescope - General Observer Proposal #90092

New Frontiers for Comparative Exoplanetology In the Era of Kepler

Principal Investigator: Jean-Michel Desert
Institution: Caltech

Technical Contact: Jean-Michel Desert, Caltech

Co-Investigators:
Drake Deming, University of Maryland
Heather Knutson, Caltech
Jacob Bean, University of Chicago
Jonathan Fortney, U.C. Santa Cruz
Adam Burrows, Princeton University
Adam Showman, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 590.4

Abstract:
Statistical surveys and individual characterization are the keys to addressing the fundamental questions in exoplanetology. Thanks to the Kepler mission, there is now a menagerie of new transiting planets that are very different in terms of their physical properties (often cooler) compared to the classical close-in hot giant planets. This laboratory provides an excellent opportunity to characterize the atmospheres of planets in new regimes, and to study those planets that have experienced different formation, evolution and migration scenarios compared to hot-Jupiters. We propose to initiate a comparative exoplanetology survey program using the two existing main classes of known transiting giant planets: the hot-jupiters orbiting bright host stars for which we can obtain precise atmospheric constraints, and the confirmed Kepler giant planets that provide us with the opportunity to probe new regions of planetary parameter space. We have identified two dozen representative giant planets (some are in multiple systems) which are excellent candidates in achieving our scientific goals. Our strategy will be to combine Spitzer observations with a wealth of multi-wavelength transmission spectroscopic measurements that we are currently gathering. This powerful, already tested method has constrained atmospheric compositions of exoplanets through the measurement of their scale height. The strength of this approach is to combine observations which cover a wide spectral range and which are, therefore, sensitive to different atmospheric compositions and structures. Within this framework, Spitzer observations provide the key to achieving the science goals of our program; this is the only facility that can reach the photometric precision required to probe the main atmospheric molecular features (H_2O, CH_4, and CO) that dominate the Infrared spectrum. Our survey will be the largest and the statistically most complete atmospheric program, two prerequisites necessary to make major progress in exoplanetology.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12082

A Search for Sub-Earth Sized Transiting Planets 12 Parsecs from the Sun

Principal Investigator: Jason Dittmann
Institution: Harvard University

Technical Contact: Jason Dittmann, Harvard University

Co-Investigators:
David Charbonneau, Harvard University
Zachory Berta-Thompson, MIT
Jonathan Irwin, Smithsonian Center for Astrophysics
Elisabeth Newton, Harvard University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 100
Priority: 1

Abstract:
The MEarth-South Observatory has recently discovered a 1.2 Earth-radius planet around the mid-M dwarf GJ 1132. GJ 1132 is located only 12 parsecs away, and therefore GJ 1132b is the closest transiting rocky planet whose atmosphere is accessible by the James Webb Space Telescope. Previous studies have indicated that planetary systems around M dwarfs are typically multi-planet systems in close orbital configurations. Therefore, there is a significant likelihood that there are additional transiting objects yet to be discovered. The most ambitious and intense ground-based photometric and radial velocity monitoring campaigns would be insensitive to these putative planets. However, Spitzer is capable of discovering transiting planets the size of Mars and exomoons around GJ 1132b the size of Earth's moon. GJ 1132b is already the most interesting target for JWST, any additional planets in the system would also be prime JWST targets. We propose a 100 hour intensive monitoring campaign of GJ 1132 to uncover these potential objects.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13174

A Search for Exomoons and TTVs from LHS 1140b, a nearby super-Earth orbiting in the habitable-zone of an M dwarf

Principal Investigator: Jason Dittmann
Institution: MIT

Technical Contact: Jason Dittmann, MIT

Co-Investigators:
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Jonathan Irwin, Smithsonian Center for Astrophysics
Eric Agol, University of Washington
David Kipping, Columbia University
Elisabeth Newton, MIT
Zachory Berta-Thompson, University of Colorado
Raphaelle Haywood, Harvard University
Jennifer Winters, Harvard University
Sarah Ballard, MIT

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 39.0

Abstract:
Exoplanets that transit nearby small stars present the best opportunity for future atmospheric studies with the James Webb Space Telescope and the ground based ELTs currently under construction. The MEarth Project has discovered a rocky planet with a period of 27.43 days residing in the habitable zone of the nearby inactive star LHS 1140. This planet will be the subject of GTO observations by JWST, and additional objects in the system would also be tantalizing targets for future study. Owing to the large planetary mass and orbital separation from its star, LHS 1140b is unique among the planets known to transit nearby M dwarfs in its capability to host a large moon. We propose to survey LHS 1140b for signs of exomoons and to search for transit timing variations that may indicate the presence of additional companions. The long orbital period of 25 days, the 12 hour duration for the transit of the Hill sphere, and the small amplitude of the expected signal preclude pursuing this from the ground and make Spitzer uniquely capable to undertake this study. If successful, we may discover additional planets via TTVs for which we may conduct future searches for transits and atmospheric spectroscopy with JWST, and possibly provide the first evidence for exomoons outside of the Solar System.

Spitzer Space Telescope - General Observer Proposal #11004

Planck, Herschel & Spitzer unveil overdense z>2 regions

Principal Investigator: Herve Dole
Institution: IAS

Technical Contact: Ranga-Ram Chary, Spitzer Science Center

Co-Investigators:
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David Guery, IAS
Emeric Le Floc'h, CEA
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Martin Giard, IRAP
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Guilaine Lagache, IAS
Ludovic Montier, IRAP
Nicole Nesvadba, IAS
Alain Omont, IAP
Etienne Pointecouteau, IRAP
Daniele Pierini, IRAP
Jean-Loup Puget, IAS
Douglas Scott, UBC
Genevieve Soucail, IRAP

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 41.6
Priority: 1

Abstract:
At which cosmic epoch did massive galaxy clusters assemble their baryons? How does star formation occur in the most massive, most rapidly collapsing dark-matter-dense environments in the early Universe? To answer these questions, we take the completely novel approach to select the most extreme z>~2 star-forming overdensities seen over the entire sky. This selection nicely complements the other existing selections for high redshift clusters (i.e., by stellar mass, or by total mass like Sunyaev-Zeldovish (SZ) or X-ray selection). We make use of the Planck all-sky submillimetre survey to systematically identify the rarest, most luminous high-redshift sub-mm sources on the sky, either strongly gravitationally lensed galaxies, or the joint FIR/sub-mm emission from multiple intense starbursts. We observed 228 Planck sources with Herschel/SPIRE and discovered that most of them are overdensities of red galaxies with extremely high star formation rates (typically 7.e3 Msun/yr for a structure). Only Spitzer data can allow a better understanding of these promising Planck+Herschel selected sources, as is shown on a first set of IRAC data on 40 targets in GO9: (i) the good angular resolution and sensitivity of IRAC allows a proper determination of the clustered nature of each Herschel/SPIRE source; (ii) IRAC photometry (often associated with J, K) allows a good estimate of the colors and approximate photometric redshift. Note spectroscopic redshifts are available for two cluster candidates, at z=1.7 and z=2.3, confirming their high redshift nature. The successful GO9 observation of 40 fields showed that about half to be >7sigma overdensities of red IRAC sources. These observations were targeting the whole range of Herschel overdensities and significances. We need to go deeper into the Spitzer sample and acquire complete coverage of the most extreme Herschel overdensities (54 new fields). Such a unique sample has legacy value, and this is the last opportunity prior to JWST, WFIRST and Euclid.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14245

A Zoom on Planck, Herschel High-z high-SFR Galaxy Clusters

Principal Investigator: Herve Dole
Institution: Universite Paris-Sud Paris-Saclay

Technical Contact: Herve Dole, Universite Paris-Sud Paris-Saclay

Co-Investigators:
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Matt Lehnert, IAP SU
Alessandro Rettura, Keck
Genevieve Soucail, OMP IRAP
Perdereau Thibaut, IAS Paris-Sud CNRS

Science Category: Galaxy clusters
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.9
Priority:2

Abstract:
Our unique sample of high-z (z>2) high-SFR protoclusters selected with Planck and Herschel over the whole sky has been observed in GO9 and GO11 with Spitzer/IRAC. The SPHerIC (Spitzer, Planck Herschel Infrared Clusters) sample shows about 80 remarkable overdensities of galaxies (Martinache et al., 2018). We discovered last year a dozen new outstanding sources showing strong clustering of red Herschel sources in public Herschel data as well as in our Herschel data, nearby our previous Spitzer pointings (and always belonging to the Planck selection). This small ~9h program aims at resuscitating these few exceptional high-z high-SFR protocluster candidates before the next decade missions, with the legacy value of an homogeneous selection of the most extreme protoclusters.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80238

Spitzer unveils the nature of high-z (2<z<4) overdensities selected by Planck & Herschel

Principal Investigator: Herve Dole
Institution: IAS

Technical Contact: Ranga Chary, IPAC

Co-Investigators:
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Alain Omont, IAP
Niraj Welikala, IAS
Alexandre Beelen, IAS
Jean-Loup Puget, IAS
Guilaine Lagache, IAS
Ines Flores-Cacho, IRAP
Martin Giard, IRAP
Etienne Pointecouteau, IRAP
Douglas Scott, UBC
Ranga Chary, IPAC

Science Category: cosmology
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.0

Abstract:
The Planck mission has the unique capability of finding systematically and on the whole sky the rarest, most luminous high redshift submm sources. These can be lensed objects or obscured star-forming proto groups/clusters of galaxies containing many individual sources forming stars at very high rates. Our full sample of candidates contains about 1 source per 28 sq. deg., and already 3 candidates have been spectroscopically confirmed as interesting high-z sources: one is a potential proto group at z=2 (using Herschel/SPIRE/OT1 and CFHT, VLT/XSHOOTER and PDBI); and 2 others are z=3-5.2 strongly lensed galaxies in the H-ATLAS and around A773 in HLS. We were just granted (last week) Herschel OT2 SPIRE imaging time to target 70 Planck sources, as well as additional 21 sources with SCUBA2 to statistically study these extreme objects probing bright end of the high-z luminosity function. Are these sources mainly lensed galaxies or overdensities? As part of a pilot study to prepare observations of the complete sample, we propose IRAC imaging (down to 1uJy and 1.8uJu 5sigma in channels 1 and 2) of the 20 most promising targets to constrain the photometric redshifts and to measure the stellar mass in galaxies associated with these structures. These sources have no obvious WISE counterparts. Spitzer/IRAC is the only instrument to image these obscured high-z structures efficiently at the necessary angular resolution and sensitivity. We believe that IRAC photometry is an essential component to understand the nature of these high-z structures to be observed by Herschel and SCUBA2 and is the first necessary step towards a further ambitious multi-wavelength follow-up program aiming at getting spectroscopic redshifts and full physical and dynamical diagnostics.

Spitzer Space Telescope - General Observer Proposal #90111

Planck & Herschel unveil extreme submillimeter structures

Principal Investigator: Herve Dole
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Technical Contact: Ranga-Ram Chary, California Institute of Technology

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Jean-Loup Puget, IAS
Martin Giard, IRAP
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David Guery, IAS
Nicole Nesvabda, IAS
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Douglas Scott, UBC
Emeric Le Floc'h, CEA
Brenda Frye, UofA
Genevieve Soucail, IRAP

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 28

Abstract:
Planck is the first FIR/sub-mm all sky survey with the sensitivity required to systematically identify the rarest, most luminous high-redshift sub-mm sources on the sky, either strongly gravitationally lensed galaxies, or the joint FIR/sub-mm emission from multiple intense starbursts as expected for the most massive, most rapidly collapsing dark-matter environments in the early Universe. We use a color selection to identify a population of 500 bright, high-fidelity Planck high-z candidates, 180 of which we are now following up with Herschel/SPIRE, including an extraordinary allocation of ``Must Do'' Director's Discretionary Time. All of our sources have typical SPIRE colors of high-z galaxies, and the redshifts of several have already been confirmed spectroscopically. We will use Spitzer/IRAC to identify and analyze the stellar counterparts of 35 of these sources, aided (but not replaced) by existing and scheduled ground-based optical/NIR photometry. This will allow us to measure photometric redshifts, stellar masses, star formation histories and stellar ages of these sources. We will search for candidate member galaxies of nascent galaxy clusters, and prepare detailed spectroscopic follow-up. At what cosmic epoch did massive galaxy clusters form most of their stars? Will we find that star formation is more or less vigorous in these galaxies compared to galaxies in the field? Is the upper end of the ``red sequence'' already in place? These are only some of the questions that IRAC will help us address.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13250

First Mass Measurement of a "Domestic" Microlens

Principal Investigator: Subo Dong
Institution: Peking University

Technical Contact: Sean Carey, Caltech/IPAC-Spitzer

Co-Investigators:
Sean Carey, Caltech/IPAC-Spitzer
Andrew Gould, Ohio State University
Wei Zhu, Canadian Institute for Theoretical Astrophysics

Science Category: Galactic Structure
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.7

Abstract:
We propose to combine Spitzer, Gaia, and ground-based measurements to determine the mass, distance, and transverse velocity of the "domestic" microlensing event J0507+2447. This is only the second "domestic" event (microlensed source distance less than about 1 kpc) ever discovered, but this number is already 10 times higher than the number that are expected. Hence, determining the nature of these lenses would resolve a major puzzle. The low expected rate is what caused Einstein to delay publication of his microlensing idea by 24 years. By very good fortune, Spitzer's narrow 38 day window of observations overlaps magnified portions of the event. To determine the mass requires to measure both the "microlens parallax" (courtesy of Spitzer) and the "angular Einstein radius" (which can be derived from Gaia astrometry). Thus, this is a truly rare opportunity to probe the nature of "domestic" microlenses.

Spitzer Space Telescope - General Observer Proposal #10105

Characterizing the atmosphere of the warm super-Earth HD 97658b

Principal Investigator: Diana Dragomir
Institution: Las Cumbres Observatory Global Telescope

Technical Contact: Diana Dragomir, Las Cumbres Observatory Global Telescope

Co-Investigators:
Heather Knutson, California Institute of Technology
Michael Gillon, Universite de Liege
Andrew Howard, University of Hawaii
Nikku Madhusudhan, Yale University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 45.0
Priority: 1

Abstract:
Ongoing transit surveys such as Kepler have resulted in the discovery of more than a dozen super-Earth planets with measured masses and radii. These planets are challenging targets for atmospheric characterization studies, and to date only one super-Earth (GJ 1214b) has been studied in detail. We propose to characterize the atmosphere of HD 97658b, a newly detected transiting super-Earth orbiting a bright, nearby star. Our Spitzer measurement of the planet's transit depth will complement our already approved HST observations and contribute to distinguishing between a large scale-heigh, hydrogen-dominated atmosphere from a compact, water steam atmosphere. A water-rich composition would suggest the planet formed near or beyond the ice line of the protoplanetary disk. The Spitzer observations will also uniquely probe the atmospheric methane abundance which is related to the presence of equilibrium vs. non-equilibrium chemistry, and the metallicity. The atmospheric characterization of a second super-Earth, HD 97658b, will give us a first insight into the diversity of this category of exoplanets and constitutes an important step toward understanding the composition of increasingly Earth-like planets.

Spitzer Space Telescope - General Observer Proposal #11131

A Comparative Study of Super-Earth Atmospheres

Principal Investigator: Diana Dragomir
Institution: Las Cumbres Observatory Global Telescope

Technical Contact: Diana Dragomir, Las Cumbres Observatory Global Telescope

Co-Investigators:
Bjoern Benneke, California Institute of Technology
Ian Crossfield, University of Arizona
Andrew Howard, University of Hawaii
Heather Knutson, California Institute of Technology

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 163.5
Priority: 1

Abstract:
Ongoing transit surveys such as Kepler have resulted in the discovery of more than a dozen super?Earth planets with measured masses and radii. These planets are challenging targets for atmospheric characterization studies, and to date only one (GJ 1214b) has been studied in detail. In this proposal we focus on three additional super-Earths that are amenable to transmission spectroscopy studies due to their bright host stars (HD 97658b and 55 Cnc e) or their exceptionally low density (Kepler-138d). Our Spitzer measurements of these planets' transit depths will complement our already approved HST observations and contribute to distinguishing between clear hydrogen?dominated atmospheres and compact high-metallicity atmospheres, as well as constraining the composition of any high-altitude clouds. We will also search for evidence of carbon-bearing molecules, in particular for 55 Cnc e, a planet for which a carbon-rich composition has been suggested. Our observations will probe the poorly understood transition region between gas giant planets and terrestrial worlds, and provide constraints on the formation regions of these super-Earths. The results of this program will inform the direction to be taken by large-scale studies of these worlds with JWST.

Spitzer Space Telescope - General Observer Proposal #12077

The Nature of 55 Cancri e

Principal Investigator: Diana Dragomir
Institution: Las Cumbres Observatory Global Telescope

Technical Contact: Diana Dragomir, Las Cumbres Observatory Global Telescope

Co-Investigators:
Jacob Bean, University of Chicago
Kevin Stevenson, University of Chicago
Laura Kreidberg, University of Chicago
Jonathan Fortney, University of California Santa Cruz
Michael Line, University of California Santa Cruz
Jaymie Matthews, University of British Columbia
Eliza Kempton, Grinnell College
Jean-Michel Desert, University of Amsterdam
Adam Showman, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 52.4
Priority: 1

Abstract:
Recent surveys have revealed an extraordinary and unexplained diversity of low-mass exoplanets. The main frontier for constraining the nature and origins of these planets is atmospheric characterization to reveal their detailed physical properties. Previous spectroscopic observations of small exoplanets have been focused on transmission measurements, but these studies have been limited by clouds. We aim to turn small exoplanet characterization in a new direction in anticipation of JWST. We focus on 55 Cnc e, a quintessential super-Earth in a tight orbit and transiting a nearby star that is visible to the naked eye. We propose to obtain multi-wavelength emission spectroscopy of this planet to test the hypothesis of the recently claimed variable eclipse depth and to determine the bulk composition and dynamics of its atmosphere. The multi-wavelength nature of the observations is essential for our goals: by combining Spitzer and HST data, we will be able to distinguish between different atmospheric compositions with high confidence, constrain the vertical temperature structure of the atmosphere, and examine the variable eclipse depth hypothesis with multiple instruments. This will be a significant improvement over previous efforts to characterize super-Earths because emission spectroscopy isn't limited by clouds like the more common transmission measurements. 55 Cnc e, with its high temperature, short orbital period and bright host star, is the only super-Earth for which this is feasible with current facilities. Ultimately, JWST will perform emission spectroscopy of a much larger sample that will be guided by the results for this key object.

Spitzer Space Telescope - Snapshot Proposal #70092

Close binaries with infrared excess: destroyers of worlds?

Principal Investigator: Jeremy Drake
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Massimo Marengo, Harvard-Smithsonian Center for Astrophysics

Co-Investigators:
Marco Matranga, Smithsonian Astrophysical Observatory
Massimo Marengo, Iowa State University
Marc Kuchner, Goddard Space Flight Center
Vinay Kashyap, Smithsonian Astrophysical Observatory

Science Category: circumstellar/debris disks
Hours Approved: 23.2

Abstract:
The large IR excess seen in small samples of old close binary stars correspond to very warm dust that appears to originate from recent collisions of planets or planetesimals. Somehow, close binaries seem to be destabilizing their planetary progeny, perhaps through secular shrinkage of the stellar separation caused by angular momentum loss. The warm excess can be diagnosed by Spitzer 3.6 and 4.5 um bands. The aim of this proposal is to performan an extensive survey of close binaries to examine the presence or absence of excess for different system parameters and build a picture of the type of systems that appear to create new dust and those that do not.

Spitzer Space Telescope - General Observer Proposal #10149

Parallaxes for the Coldest WISE Brown Dwarfs

Principal Investigator: Trent Dupuy
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Trent Dupuy, Smithsonian Astrophysical Observatory

Co-Investigators:
Adam Kraus, SAO
Michael Liu, Hawaii

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 56.9
Priority: 1

Abstract:
Understanding extremely cool atmospheres is a major goal of both brown dwarf and exoplanet studies. The WISE all-sky survey has uncovered the coolest brown dwarfs to date including the first unambiguous Y dwarfs. These discoveries are spectroscopically estimated to have temperatures of ~300--500 K and masses of ~5--20 Mjup, overlapping discoveries from radial velocity exoplanet surveys. However, direct distances are needed to determine model-independent temperatures and to test the observed properties against theoretical models in this new physical frontier. From our Cycle 8 program, we have successfully measured the first robust parallaxes for these extremely low-luminosity objects using Spitzer [3.6]-band astrometry, made possible with our improved distortion solution for IRAC. Our results, comprising about half the currently known late-T/Y census, have uncovered a number of puzzles. Perhaps the most intriguing is the possibility that the observed near-IR spectral types and spectral energy distributions do not follow a simple correspondence with temperature, in contrast to all other (hotter) substellar and stellar objects. We propose here to obtain definitive parallaxes and temperatures to the ~2 dozen known coldest brown dwarfs. For our initial sample, these new data will double the time baseline, leading to major improvements over our preliminary results. We will also double the total sample with parallaxes for more recent discoveries. Altogether, our work will establish the temperature scale as a function of spectral type, delineate the cooling (and intrinsic scatter) through the T/Y transition, and enable strong test of theoretical models for these coldest brown dwarfs, which are ~100x fainter than previously known objects at near-IR wavelengths.

Spitzer Space Telescope - General Observer Proposal #11147

Parallaxes for the Coldest Brown Dwarfs

Principal Investigator: Trent Dupuy
Institution: University of Texas, Austin

Technical Contact: Trent Dupuy, University of Texas, Austin

Co-Investigators:
Adam Kraus, University of Texas, Austin
Michael Liu, University of Hawaii

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 62.6
Priority: 1

Abstract:
Understanding extremely cool atmospheres is a major goal of both brown dwarf and exoplanet studies. The WISE all-sky survey has uncovered the coolest brown dwarfs to date including the first unambiguous Y dwarfs. These discoveries are spectroscopically estimated to have temperatures of ~300-500 K and masses of ~5-20 Mjup, overlapping discoveries from radial velocity exoplanet surveys. However, direct distances are needed to determine model-independent temperatures and to test the observed properties against theoretical models in this new physical frontier. From our Cycle 8 program, we have successfully measured the first robust parallaxes for these extremely low-luminosity objects using Spitzer [3.6]-band astrometry, made possible with our improved distortion solution for IRAC. Our results, comprising less than half the currently known late-T/Y census, have uncovered a number of puzzles. Perhaps the most intriguing is the possibility that the observed near-IR spectral types and spectral energy distributions do not follow a simple correspondence with temperature, in contrast to all other (hotter) substellar and stellar objects. We propose here to obtain definitive parallaxes and temperatures to the ~2 dozen known coldest brown dwarfs. For our Cycle 8 sample, these new data will double the time baseline, leading to major improvements over our preliminary results. We will also double the total sample with parallaxes for more recent discoveries. Altogether, our work will establish the temperature scale as a function of spectral type, delineate the cooling (and intrinsic scatter) through the T/Y transition, and enable strong test of theoretical models for these coldest brown dwarfs, which are ~100x fainter than previously known objects at near-IR wavelengths.

Spitzer Space Telescope - General Observer Proposal #80183

Testing Ultracool Models with Precise Luminosities and Masses

Principal Investigator: Trent Dupuy
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Trent Dupuy, Smithsonian Astrophysical Observatory

Co-Investigators:
Michael Cushing, JPL
Michael Liu, IfA/Hawaii
Ben Burningham, University of Hertfordshire
Sandy Leggett, Gemini Observatory
Loic Albert, University of Montreal
Philippe Delorme, U. Grenoble

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.6

Abstract:
After years of patient orbital monitoring, there is a growing sample of brown dwarfs with well-determined dynamical masses, representing the gold standard for testing substellar models. A key element of our model tests to date has been the use of integrated-light photometry to provide accurate total luminosity measurements for these binaries. However, some of the ultracool binaries with the most promising orbit motion for yielding dynamical in the masses lack the mid-infrared photometry needed to constrain their SEDs. This is especially crucial for the latest type binaries (spectral types >T5) that will probe the coldest temperature regimes previously untested with dynamical masses. We propose to use IRAC to obtain the needed mid-infrared photometry for a sample of binaries that are part of our ongoing orbital monitoring program with Keck laser guide star adaptive optics. The observational effort needed to characterize these binaries' luminosities using Spitzer is much less daunting in than the years of orbital monitoring needed to measure precise dynamical masses, but it is equally vital for robust tests of theory.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80233

Parallaxes for the Coldest WISE Brown Dwarfs

Principal Investigator: Trent Dupuy
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Trent Dupuy, SAO

Co-Investigators:
Adam Kraus, University of Hawaii
Michael Liu, University of Hawaii

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 27.4

Abstract:
Understanding extremely low temperature atmospheres is a major goal of current studies of both brown dwarfs and exoplanets. Two weeks ago, Cushing et al. (2011) announced the first unambiguous sample of Y dwarfs, brown dwarfs showing clear signatures of ammonia in their NIR spectra. These objects are spectroscopically estimated to have temperatures of ~300-500 K, colder than any previously known free-floating brown dwarfs. However, direct distances are needed to determine model-independent temperatures for this sample and to test their observed properties against current theoretical models in this new physical frontier. We propose to use Spitzer to measure trigonometric parallaxes for these objects, made possible thanks to their bright mid-IR emission and our improved distortion solution for IRAC. The >2-year time baseline achieved by combining our new Spitzer data from 2012 with WISE+Spitzer data from 2010 will enable us to robustly break the degeneracy between parallax and proper motion, resulting in distance errors of 10-20% and corresponding temperature uncertainties of 30-50 K. Our distances will also enable fundamental tests of theoretical models by placing these coldest brown dwarfs on the color-magnitude diagram, where they are expected to lie ~5-10 mag below previously known objects at near-IR wavelengths.

Spitzer Space Telescope - General Observer Proposal #11102

Astrometric Follow Up of Wide Planetary Candidates

Principal Investigator: Stephen Durkan
Institution: Queen's University

Technical Contact: Stephen Durkan, Queen's University

Co-Investigators:
Markus Janson, Stockholm Department of Astronomy
Joseph Carson, College of Charleston

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.4
Priority: 1

Abstract:
The current population of known exoplanets is biased towards close in, short period planets due to the detection rate of transit and radial velocity techniques. However the advancement in direct imaging technologies and image reduction techniques has opened up sensitivity to massive planets at large separations, rapidly expanding the parameter space over which planetary existence and characteristics can be probed. The Spitzer space telescope is ideally suited for the direct imaging of such planets that have peak thermal emission at wavelengths around 4.5 microns. Previous Spitzer data collected under programs 34 and 48 has recently been the subject of a sophisticated principal components analysis reduction technique. This technique has removed stellar PSF to a much greater degree than preceding studies have achieved, the reduced archival Spitzer observations are sensitive to planetary mass companions at a much smaller separations than previously attainable. This reduction technique accompanied by stringent criteria, such as >5 sigma significance, realistic visual characteristics and taking into account the predicted spectral energy distribution of Jupiter mass planets, has identified a number of potential planetary companions. These targets must be observed in a 2nd epoch to test for common proper motion to offer a firm confirmation or refutation of the candidate's planetary nature. Here we propose to observe 12 of these targets for which data does not exist in a 2nd epoch to a sufficient degree of sensitivity to recover the potential planetary candidates for astrometric investigation.

Spitzer Space Telescope - General Observer Proposal #10038

Probing Dust Evolution in the Equatorial Ring and Ejecta of SNR 1987A

Principal Investigator: Eli Dwek
Institution: NASA Goddard Space Flight Center

Technical Contact: Eli Dwek, NASA Goddard Space Flight Center

Co-Investigators:
Richard Arendt, NASA/GSFC
Patrice Bouchet, DSM/DAPNIA/Service d'Astrophysique, CEA/Saclay
David Burrows, Pennsylvania State University
Peter Challis, Harvard-Smithsonian, CfA
John Danziger, Osservatorio Astronomico di Trieste
James De Buizer, NASA Ames Research Center
Robert Gehrz, University of Minnesota
Robert Kirshner, Harvard-Smithsonian, CfA
Sangwook Park, Pennsylvania State University
Elisha Polomski, University of Wisconsin - Eau Claire
Charles Woodward, University of Minnesota

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4
Priority: 1

Abstract:
In this program we propose to use a total of 0.4 hr to obtain 3.6 and 4.5 micron photometry of SNR 1987A at two additional epochs beyond day 9800 after the explosion. The emission in these two IRAC bands arises from a hot dust component residing in the equatorial ring (ER) with a distinctly different spectral shape and temperature from the dominant 180 K silicate dust component in the ER. The dust in the ER is collisionally-heated by the SN blast wave that also gives rise to the soft X-ray emission from the ER. The intensity in the IR emission is generally well correlated with that of the X-ray emission. However, the most recent X-ray observations have showed a difference in the evolution of their respective light curves. These differences could stem from a variety of causes, including the sputtering of the dust or changes in the morphology of the ER. Ongoing X-ray observations of the remnant are taking place. Supplementing these with IR observations is essential for determining the nature and the evolution of this hot dust component. Finally, the observations may reveal the appearance of a new emission component from the SN ejecta which is currently interacting with the reverse shock.

Spitzer Space Telescope - General Observer Proposal #11023

SN 1987A: On the wane?

Principal Investigator: Eli Dwek
Institution: NASA Goddard Space Flight Center

Technical Contact: Eli Dwek, NASA Goddard Space Flight Center

Co-Investigators:
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David Burrows, Pennsylvania State University
Peter Challis, Harvard-Smithsonian, CfA
John Danziger, Osservatorio Astronomico di Trieste
James De Buizer, NASA Ames Research Center
Robert Gehrz, University of Minnesota
Robert Kirshner, Harvard-Smithsonian, CfA
Sangwook Park, University of Texas at Arlington
Elisha Polomski, St. Cloud State University
Charles Woodward, University of Minnesota
Kari Frank, Pennsylvania State University

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.8
Priority: 1

Abstract:
In this program we propose to use a total of 0.8 hr to obtain 3.6 and 4.5 micron photometry of SNR 1987A at four additional epochs beyond day 10000 after the explosion. The emission in these two IRAC bands may arise from a hot dust component residing in the equatorial ring (ER) with a distinctly different spectral shape and temperature from the dominant 180 K silicate dust component in the ER. The dust in the ER is collisionally-heated by the SN blast wave that also gives rise to the soft X-ray emission from the ER. The intensity in the mid-IR emission (24 micron) was generally well correlated with that of the X-ray emission. However, the continued monitoring of the 3.6 and 4.5 micron emission now seems to show that at these wavelengths the IR emission has begun to fade, and is no longer tracking the brightness of the soft X-ray emission. These differences could stem from a variety of causes, including the sputtering of the dust or changes in the morphology of the ER. Ongoing X-ray observations of the remnant are taking place. Supplementing these with IR observations is essential for determining the nature and the evolution of this hot dust component. Finally, the observations may still reveal the appearance of a new emission component from the SN ejecta which is currently interacting with the reverse shock. These observations will complete the record of Spitzer's observations of SN 1987A, spanning more than 12 years from launch to end of mission.

Spitzer Space Telescope - General Observer Proposal #13004

The Continuing Fall of SN 1987A

Principal Investigator: Eli Dwek
Institution: NASA Goddard Space Flight Center

Technical Contact: Eli Dwek, NASA Goddard Space Flight Center

Co-Investigators:
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Patrice Bouchet, CEA-IRFU
John Danziger, Osservatorio Astronomico di Trieste
Kari Frank, Penn State University
Robert Gehrz, Minnesota Institute for Astrophysics
Sangwook Park, University of Texas - Arlington
Charles Woodward, University of Minnesota

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.8
Priority: 1

Abstract:
We propose to use a total of 0.8 hr to obtain 3.6 and 4.5 micron photometry of SNR 1987A at four final epochs between 10900 and 11500 days after the explosion. SN 1987A has been monitored at approximately 6 month intervals throughout the Spitzer mission. The latest IRAC data clearly show that at 3.6 and 4.5 micron, the SN emission has peaked and is now in decline. Continued observation of SN 1987A will allow us to track the decline as the blast wave moves completely past the equatorial ring (ER). The rate at which new dust is swept up should be dropping to zero, and as the presently swept up dust is gradually destroyed (or cools) the emission should continue to fade. The dust traced at these wavelengths is thought to be collisionally-heated by the SN blast wave that also gives rise to the soft X-ray emission from the ER. Early in the mission, the intensity of the mid-IR emission (24 micron) was generally well correlated with that of the X-ray emission. However, the 3.6 and 4.5 micron emission are no longer tracking the brightness of the soft X-ray emission. These differences could stem from a variety of causes, including the sputtering of the dust or changes in the morphology of the ER. Ongoing X-ray observations of the remnant are taking place. Supplementing these with IR observations is essential for determining the spatial distribution, nature, and evolution of this hot dust component. Additionally, the observations may still reveal the appearance of a new emission component from the SN ejecta which is currently interacting with the reverse shock. These observations will complete the record of Spitzer's observations of SN 1987A, spanning more than 15 years from launch to end of mission.

Spitzer Space Telescope - General Observer Proposal #14001

Spitzer's Complete History of SN 1987A

Principal Investigator: Eli Dwek
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Robert Gehrz, Minnesota Institute for Astrophysics, University o
Sangwook Park, University of Texas - Arlington
Charles Woodward, University of Minnesota

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4
Priority: 1

Abstract:
We propose to use a total of 0.4 hr to obtain 3.6 and 4.5 micron photometry of SNR 1987A at two final epochs between 11666 and 11968 days after the explosion. SN 1987A has been monitored at approximately 6 month intervals throughout the Spitzer mission. The latest IRAC data clearly show that at 3.6 and 4.5 micron, the SN emission has peaked and is now in decline. Continued observation of SN 1987A will allow us to track the decline as the blast wave moves completely past the equatorial ring (ER). The rate at which new dust is swept up should be dropping to zero, and as the presently swept up dust is gradually destroyed (or cools) the emission should continue to fade. The dust traced at these wavelengths is thought to be collisionally-heated by the SN blast wave that also gives rise to the soft X-ray emission from the ER. Early in the mission, the intensity of the mid-IR emission (24 micron) was generally well correlated with that of the X-ray emission. However, the 3.6 and 4.5 micron emission are no longer tracking the brightness of the soft X-ray emission. These differences could stem from a variety of causes, including the sputtering of the dust or changes in the morphology of the ER. Ongoing X-ray observations of the remnant are taking place. Supplementing these with IR observations is essential for determining the spatial distribution, nature, and evolution of this hot dust component. Additionally, the observations may still reveal the appearance of a new emission component from the SN ejecta which are currently interacting with the reverse shock. These observations will complete the record of Spitzer's observations of SN 1987A, spanning more than 16 years from launch to end of mission. They also provide an essential bridge to future monitoring with JWST, which will follow in Spitzer's footsteps.

Spitzer Space Telescope - General Observer Proposal #70050

Evolution of the Unidentified Hot Dust in SNR 1987A

Principal Investigator: Eli Dwek
Institution: NASA Goddard Space Flight Center

Technical Contact: Eli Dwek, NASA Goddard Space Flight Center

Co-Investigators:
Richard Arendt, University of Maryland, Baltimore County
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David Burrows, Pennsylvania State University
Peter Challis, Harvard-Smithsonian, CfA
John Danziger, Osservatorio Astronomico di Trieste
James De Buizer, NASA Ames Research Center
Robert Gehrz, University of Minnesota
Robert Kirshner, Harvard-Smithsonian, CfA
Sangwook Park, Pennsylvania State University
Elisha Polomski, University of Wisconsin - Eau Claire
Charles Woodward, University of Minnesota

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
The cryogenic Spitzer campaign to monitor the evolution of SNR 1987A has succeeding in revealing a steady change in the brightness of emission from silicate dust in equatorial ring of the SN progenitor. The change in brightness is well correlated with the X-ray emission. However, the Spitzer IRAC and IRS data unexpectedly revealed a second, hotter dust component. The data did not provide a distinct spectroscopic signature of this dust, but did indicate that it may be evolving at a slightly different rate than the dominant silicate component. In this program we will use a total of 0.4 hr to obtain 3.6 and 4.5 micron photometry of SNR 1987A at two additional epochs. This will allow us to determine the continued evolution of this hot dust component, which provides unique constraints on the location, composition, grain size distribution, and possible destruction of this dust.

Spitzer Space Telescope - General Observer Proposal #80038

Is SN 1987A Fading at IR Wavelengths?

Principal Investigator: Eli Dwek
Institution: NASA Goddard Space Flight Center

Technical Contact: Eli Dwek, NASA Goddard Space Flight Center

Co-Investigators:
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Sangwook Park, Pennsylvania State University
Elisha Polomski, University of Wisconsin - Eau Claire
Charles Woodward, University of Minnesota

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
The cryogenic Spitzer campaign to monitor the evolution of SNR 1987A has succeeding in revealing a steady change in the brightness of emission from silicate dust in equatorial ring (ER) of the SN progenitor. The change in brightness is well-correlated with the X-ray emission. However, the Spitzer IRAC and IRS data unexpectedly revealed at second hotter dust component. The spectra did not provide a distinct spectroscopic signature of this dust, but the time series of observations indicated that it may be evolving at a slightly different rate from the dominant silicate component. In this program we will use a total of 0.4 hr to obtain 3.6 and 4.5 micron photometry of SNR 1987A at two additional epochs. The initial warm observation has revealed a definite flattening of the light curve at these wavelengths. Presently, we lack sufficient information to identify the physical processes responsible for this trend. The requested observations will reveal the long-term behavior of the light curve which may even show the onset of a decline. The continued evolution of this hot dust component will provide important and unique information on the nature and fate of this dust component, and on the origin and morphology of the ER.

Spitzer Space Telescope - General Observer Proposal #90117

Probing Dust Evolution in the Equatorial Ring of SNR 1987A

Principal Investigator: Eli Dwek
Institution: NASA Goddard Space Flight Center

Technical Contact: Eli Dwek, NASA Goddard Space Flight Center

Co-Investigators:
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James De Buizer, NASA Ames Research Center
Robert Gehrz, University of Minnesota
Robert Kirshner, Harvard-Smithsonian, CfA
Sangwook Park, Pennsylvania State University
Elisha Polomski, University of Wisconsin - Eau Claire
Charles Woodward, University of Minnesota

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
In this program we propose to use a total of 0.4 hr to obtain 3.6 and 4.5 micron photometry of SNR 1987A at two additional epochs beyond day 9500 after the explosion. The emission in these two IRAC bands arises from a hot dust component residing in the equatorial ring (ER) with a distinctly different spectral shape and temperature from the dominant 180 K silicate dust component in the ER. The dust in the ER is collisionally-heated by the SN blast wave that also gives rise to the soft X-ray emission from the ER. The intensity in the IR emission is generally well correlated with that of the X-ray emission. However, the most recent X-ray observations have showed a difference in the evolution of their respective light curves. These differences could stem from a variety of causes, including the sputtering of the dust or changes in the morphology of the ER. Ongoing X-ray observations of the remnant are taking place. Supplementing these with IR observations is essential for determining the nature and the evolution of this hot dust component. Finally, the observations may reveal the appearance of a new emission component from the SN ejecta which is currently interacting with the reverse shock.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14230

The Extreme Galaxy Legacy Project

Principal Investigator: Stephen Eales
Institution: Cardiff University

Technical Contact: Steven Wilner, Harvard-Smithsonian Center for Astrophysics

Co-Investigators:
Matt Ashby, CFA
Aris Amvrosiadis, Cardiff
Pierre Cox, IAS
Tom Bakx, Nagoya
Asantha Cooray, Irvine
Dave Clements, Imperial
Simon Dye, Nottingham
Gianfranco de Zotti, Padua
Giovanni Fazio, CFA
Lucia Marchetti, UWC
Mattia Negrello, Cardiff
Matt Smith, Cardiff
Howard Smith, CFA
Steve Serjeant, OU
Alain Omont, IAS

Science Category: High-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 26.7
Priority: 2

Abstract:
Although the submillimetre galaxies (SMGs) discovered two decades ago are extreme systems, the high-redshift SMGs discovered in the Herschel surveys are the most extreme versions of this extreme class. They have star-formation rates that often exceed the "maximal starburst" limit of 1000 solar masses per year and are clearly galaxy-building events. They fall into two classes: lensed systems, which have huge potential for cosmological projects, and unlensed Hyper-Luminous Infrared Galaxies. We have started a long-term multi-wavelength legacy program on these objects, including a Large Program on IRAM, which will soon triple the number of redshifts to almost 200, HST programs, and optical programs. We propose to use IRAC, the only instrument capable of doing this, to measure the stellar masses of 102 sources not previously been observed with Spitzer. We will use the results to determine, through the specific star-formation rate and the ratio of gas mass to stellar mass, the evolutionary state of each galaxy.

Spitzer Space Telescope - General Observer Proposal #13109

Lenses for JWST

Principal Investigator: Harald Ebeling
Institution: University of Hawaii

Technical Contact: Harald Ebeling, University of Hawaii

Co-Investigators:
Johan Richard, University of Lyon
Jean-Paul Kneib, EPF Lausanne
Andrew Repp, University of Hawaii
Hakim Atek, Yale University
Eiichi Egami, University of Arizona
Rogier Windhorst, Arizona State University
Alastair Edge, University of Durham

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.7
Priority: 1

Abstract:
JWST will dramatically advance our knowledge and understanding of the first generations of galaxies at z>10, their role in the re-ionization of the Universe, and the evolutionary processes that gave rise to the complexity and diversity of galaxies at the current epoch. As demonstrated by HST legacy projects like CLASH and the Hubble Frontier Fields, gravitational amplification by massive galaxy clusters can significantly extend the depth of the required observations. However, for JWST, reducing any diffuse background light will be just as crucial. We here propose Spitzer/IRAC observations of six massive cluster lenses, specifically selected as candidates for observation with JWST. By (a) quantifying the amount of intra-cluster light and (b) enabling us to improve our current lens models, the data resulting from the requested observations will be instrumental for the final selection of cluster targets that maximize the scientific returns of deep JWST observations.

Spitzer Space Telescope - Directors Discretionary Time Proposal #545

More of the The IRAC Lensing Survey

Principal Investigator: Eiichi Egami
Institution: U. Arizona

Technical Contact: Eiichi Egami, Arizona

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 67.0

Abstract:
Massive clusters of galaxies are now recognized as very effective 'cosmic telescopes'. Because of the gravitational lensing effect, they can amplify significantly the background sources - by factors of a few tens - thereby bringing into view faint sources that would otherwise be unobservable. Note that in the background-limited case, which is applicable to IRAC observations, a factor of 20-30 gravitational amplification translates into increasing the integration time by a factor of 400-900. Because of this tremendous gain in sensitivity, IRAC imaging of lensing clusters will allow us to achieve JWST depth (~10 nJy) with Spitzer. Despite this great possibility, however, the full potential of the lensing cluster technique has not yet been realized due to the small number of clusters that have well-constrained accurate mass models. Here, we propose to survey 6 more massive lensing clusters for which we have constructed accurate mass models through many years of intensive imaging/spectroscopic campaigns with HST, Keck, and VLT telescopes.

Spitzer Space Telescope - Snapshot Proposal #12095

IRAC Snapshot Imaging of Massive-Cluster Gravitational Lenses Observed by the Herschel Lensing Survey

Principal Investigator: Eiichi Egami
Institution: Steward Observatory, University of Arizona

Technical Contact: Eiichi Egami, Steward Observatory, University of Arizona

Co-Investigators:
Timothy Rawle, ESAC, ESA
Antonio Cava, Geneva Observatory
Benjamin Clement, Centre de Recherche Astronomique de Lyon
Miroslava Dessauges-Zavadsky, Geneva Observatory
Harald Ebeling, University of Hawaii
Jean-Paul Kneib, EPFL/Laboratoire d'Astrophysique
Pablo Perez-Gonzalez, Universidad Complutense de Madrid
Johan Richard, Centre de Recherche Astronomique de Lyon
Wiphu Rujopakarn, IPMU
Daniel Schaerer, Geneva Observatory
Gregory Walth, University of Arizona

Science Category: high-z galaxies (z>0.5)
Hours Approved: 99.8
Priority: 2

Abstract:
Using the Herschel Space Observatory, our team has been conducting a large survey of the fields of massive galaxy clusters, "The Herschel Lensing Survey (HLS)" (PI: Egami; 419 hours). The main scientific goal is to penetrate the confusion limit of Herschel by taking advantage of the strong gravitational lensing power of these massive clusters and study the population of low-luminosity and/or high-redshift dusty star-forming galaxies that are beyond the reach of field Herschel surveys. In the course of this survey, we have obtained deep PACS (100/160 um) and SPIRE (250/350/500 um) images for 54 clusters (HLS-deep) as well as shallower (but nearly confusion-limited) SPIRE images for 527 clusters (HLS-snapshot). The goal of this proposal is to obtain shallow (500 sec/band) 3.6/4.5 um images of 266 cluster fields that have been observed by the HLS-snapshot survey but do not have any corresponding IRAC data. The HLS-snapshot SPIRE images are deep enough to detect a large number of sources in the target cluster fields, many of which are distant star-forming galaxies lensed by the foreground clusters, and the large sample size of HLS-snapshot promises a great potential for making exciting discoveries. Yet, these Herschel images would be of limited use if we could not identify the counterparts of the Herschel sources accurately and efficiently. The proposed IRAC snapshot program will greatly enhance the utility of these Herschel data, and will feed powerful gound observing facilities like ALMA and NOEMA with interesting targets to follow up.

Spitzer Space Telescope - General Observer Proposal #60034

The IRAC Lensing Survey: Achieving JWST depth with Spitzer

Principal Investigator: Eiichi Egami
Institution: University of Arizona

Technical Contact: Eiichi Egami, University of Arizona

Co-Investigators:
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Giovanni Fazio, CfA
Jiasheng Huang, CfA
Linghua Jiang, University of Arizona
Jean-Paul Kneib, Laboratoire d'Astrophysique de Marseille
Roser Pello, Observatoire Midi-Pyrenees
Johan Richard, University of Durham
George Rieke, University of Arizona
Daniel Schaerer, Observatoire de Geneve
Graham Smith, University of Birmingham
Daniel Stark, University of Cambridge
Mike Werner, JPL

Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Approved: 526.4

Abstract:
Massive clusters of galaxies are now recognized as very effective "cosmic telescopes". Because of the gravitational lensing effect, they can amplify significantly the background sources - by factors of a few tens - thereby bringing into view faint sources that would otherwise be unobservable. Note that in the background-limited case, which is applicable to IRAC observations, a factor of 20-30 gravitational amplification translates into increasing the integration time by a factor of 400-900. Because of this tremendous gain in sensitivity, IRAC imaging of lensing clusters will allow us to achieve JWST depth (~10 nJy) with Spitzer. Despite this great possibility, however, the full potential of the lensing cluster technique has not yet been realized due to the small number of clusters that have well-constrained accurate mass models. Here, we propose to conduct an IRAC imaging survey of 47 massive lensing clusters (5 hours/band, 2 bands) for which we have constructed accurate mass models through many years of intensive imaging/spectroscopic campaigns with HST, Keck, and VLT telescopes. This is the first time when such a large, statistical sample of clusters will be systematically employed to probe high-redshift Universe, and this proposed IRAC survey is a key component of our comprehensive program, which includes HST/WFC3 and Herschel observations starting next year. Scientifically, we will use the obtained IRAC data to (1) characterize z>6 galaxies (expecting ~50 z~7-8 galaxy detections), (2) support future Herschel and ALMA surveys, and (3) search for z>6 supernovae. The resultant data set will be a great legacy of Spitzer, allowing us to start tackling JWST sciences well before its launch.

Spitzer Space Telescope - General Observer Proposal #90218

Spitzer/IRAC Imaging of Exceptionally Bright Cluster-Lensed Submillimeter Galaxies Discovered by the Herschel Lensing Survey

Principal Investigator: Eiichi Egami
Institution: Steward Observatory, University of Arizona

Technical Contact: Eiichi Egami, Steward Observatory, University of Arizona

Co-Investigators:
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Benjamin Clement, University of Arizona
Gregory Walth, University of Arizona
Maria Pereira, University of Arizona
Johan Richard, Centre de Recherche Astronomique de Lyon
Jean-Paul Kneib, EPFL/Laboratoire d'Astrophysique
Harald Ebeling, University of Hawaii

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.5

Abstract:
Over the last few years, discoveries of exceptionally bright (e.g., observed S_peak > 100 mJy in the Herschel/SPIRE bands) gravitationally lensed submillimeter galaxies (SMGs) have generated great excitement. This is because these gravitationally lensed SMGs are so bright that they enable us to perform a variety of follow-up observations using a suite of observing facilities in the submillimeter, millimeter, and radio now available on the ground. Using Herschel, our team has been conducting a survey of such bright lensed galaxies in the fields of massive galaxy clusters: ``The Herschel Lensing Survey (HLS)'' (PI: Egami; 419 hours). This large Herschel program targets a total of 581 X-ray/SZ-selected massive clusters, and is currently 80% complete. Cluster lenses are often more powerful than galaxy lenses, producing larger magnifications. For example, typical magnification factors for galaxy-lensed Herschel sources are x10 or less while cluster-lensed systems can often produce magnification factors of x20-30 and even above x100. Cluster lenses will therefore allow us to detect and study intrinsically less-luminous and/or more distant sources with the ability to provide a view of finer-scale (i.e., sub-kpc) structures. Here, we propose to conduct Spitzer/IRAC imaging of 56 bright lensed SMG candidates we have identified in the ~470 HLS cluster fields observed so far. The main scientific goal is twofold: (1) to locate the underlying stellar component, and (2) to study its properties (e.g., stellar mass, specific star-formation rate) by constraining the rest-frame near-infrared SED and comparing with the Herschel and other submillimeter/millimeter data (e.g., SMA, PdB, ALMA, etc.). These rare bright lensed SMGs will allow us to probe the population of heavily dust-obscured vigorously star-forming galaxies at high redshift (z>1), which is thought to play an important role in the cosmic star-formation history of the Universe and yet has been difficult to study due to the heavy internal dust extinction.

Spitzer Space Telescope - Directors Discretionary Time Proposal #549

Deep IRAC Imaging of the z=2.45 Hyper-Luminous IR Galaxy WISE 1814+34

Principal Investigator: Peter Eisenhardt
Institution: JPL

Technical Contact: Peter Eisenhardt, JPL

Co-Investigators:
Jingwen Wu, JPL
Daniel Stern, JPL
Dominic Benford, GSFC
Andrew Blain, Caltech
Roc Cutri, IPAC
Tom Jarrett, IPAC
Carol Lonsdale, NRAO
Adam Stanford, UCDavis
Ned Wright, UCLA
Chao-Wei Tsai, IPAC
Sara Petty, UCLA
Lin Yan, IPAC
Carrie Bridge, Caltech
Emilio Donoso, IPAC

Science Category: ulirgs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.8

Abstract:
We have recently measured a redshift of 2.45 for an unusual WISE source (WISE 1814+34) which rises steeply from 12 to 22 microns and is undetected at 3.4 and 4.6 microns. The source is also detected at 20 cm, and appears to be a Hyper Luminous IR galaxy with well above 1E14 solar luminosities. We propose to observe WISE 1814+34 with IRAC on warm Spitzer at 3.4 and 4.6 microns to a depth 40 times better than WISE, to help assess whether the source is powered by AGN or star formation, whether it is gravitationally lensed, and whether it shows evidence for merging.

Spitzer Space Telescope - Snapshot Proposal #70162

IRAC followup of WISE band 1 and 2 dropouts

Principal Investigator: Peter Eisenhardt
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Technical Contact: Peter Eisenhardt, JPL

Co-Investigators:
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Lin Yan, IPAC

Science Category: AGN/quasars/radio galaxies
Hours Approved: 155.8

Abstract:
The Wide-field Infrared Survey Explorer (WISE) launched on 2009 Dec. 14, and has now surveyed over 57% of the sky at 3.4, 4.6, 12, and 22 microns. By July oit have completed its first coverage of the entire sky. WISE observations will be used to select 1000 objects which are robustly detected at 12 or 22 microns, but not in either 3.4 or 4.6 microns. Most such sources are likely to be dust obscured AGN or starburst galaxies at z ~ 2, one of the two primary science objectives for WISE. Spitzer IRAC snapshot observations will provide sensitivities at 3.6 and 4.5 microns over 10 times fainter than WISE for 500 of these sources, providing basic SED information for classifying these objects as starburst or AGN dominated, allowing their environments to be assessed, and extending the obscurations, luminosities, and star formation rates for ULIRGs into uncharted terrain.

Spitzer Space Telescope - General Observer Proposal #80123

Deep IRAC 3.6 micron Followup of the Most Extreme WISE band 1 and 2 dropouts

Principal Investigator: Peter Eisenhardt
Institution: Jet Propulsion Laboratory

Technical Contact: Peter Eisenhardt, Jet Propulsion Laboratory

Co-Investigators:
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Andrew Blain, U.Leicester
Carrie Bridge, Caltech
Roger Griffith, IPAC
Tom Jarrett, IPAC
Sara Petty, UCLA
Adam Stanford, UC Davis
Daniel Stern, JPL
Chao-Wei Tsai, IPAC
Edward Wright, UCLA
Jingwen Wu, JPL
Lin Yan, IPAC

Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10.4

Abstract:
We propose deep IRAC 3.6 micron followup of the most extreme sources which were detected by the Wide-field Infrared Survey Explorer (WISE) at 12 (W3) or 22 (W4) microns but not at 3.4 (W1) or 4.6 (W2) microns. These W1W2drops are the most reliable sample of redshift 2 infrared luminous galaxies yet identified in the WISE data, and are the target of a cycle 7 snapshot program with IRAC which is detecting 95% of the population in five 30 second exposures. By reobserving the 5% which are not well detected with IRAC using 8 times longer exposures, we expect to obtain 5 sigma or better measurements of essentially all of the few dozen most extreme such sources in the Universe. The measurements will constrain their stellar populations and redefine the range that needs to be accommodated by scenarios for AGN and galaxy formation.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14278

Deep Observations of the WLM Disk

Principal Investigator: Bruce Elmegreen
Institution: BM T.J. Watson Research Center

Technical Contact: Leslie Hunt, INAF - Osservatorio Astrofisico di Arcetri

Co-Investigators:
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Elias Brinks, Univ of Hertfordshire
Juan Cortes, JAO ALMA
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Monica Rubio, Univ Chile Santiago
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Monica Tosi, INAF-OAS Bologna

Science Category: Local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 21.1
Priority: 1

Abstract:
Exponential stellar disks have been traced in spiral galaxies to extraordinarily low surface density levels. Tiny dwarf irregular (dIrr) galaxies also have exponential profiles that are unexpectedly extended, but the size and true 3D shape of dIrr stellar disks are not known. Yet, this information holds critical constraints on the formation and evolution of the most common galaxy type. We propose IRAC observations of the isolated, Local Group, low-metallicity (13% solar) dIrr WLM to produce a deep, wide area survey of the resolved AGB population and determine the disk profile and thickness. This galaxy is uniquely suited to: (a) determine the mathematical form and extent of the radial profile for this morphological class, in comparison to predictions for the origin of exponential profiles, (b) measure the thickness and vertical profile of a dIrr for comparison to simulations that predict the formation of large stellar halos when a dark matter cusp is converted into a core, (c) determine the masses, ages, ejected gas masses and dust formation masses in low-metallicity AGB stars, in addition to the highly-resolved star formation history in a dIrr during the last Gyr, (d) constrain the debate over in situ star formation versus scattered stars in outer disks and the nature of the galactic environment in which star formation takes place, and (e) find embedded protostars in conjunction with our ALMA CO observations of cloud cores and for future follow-up with JWST and ALMA of proto-stellar evolution and disk chemistry at low metallicity.

Spitzer Space Telescope - General Observer Proposal #14132

Rotationally resolved colors of the targets of NASA's Lucy mission

Principal Investigator: Joshua Emery
Institution: University of Tennessee

Technical Contact: Joshua Emery, University of Tennessee

Co-Investigators:
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Mike Brown, Caltech
Keith Noll, NASA Goddard
Richard Binzel, MIT

Science Category: asteroids
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 48.4
Priority: 1

Abstract:
We propose rotationally resolved photometry at 3.6 and 4.5 um of 5 Trojan asteroids and one Main Belt asteroid - the targets of NASA's Lucy mission. The proposed Spitzer observations are designed to meet a combination of science goals and mission support objectives. Science goals 1) Search for signatures of volatiles and/or organics on the surfaces. a. This goal includes resolving a discrepancy between previous WISE and Spitzer measurements of Trojans 2) Provide new constraints on the cause of rotational spectral heterogeneity detected on 3548 Eurybates at shorter wavelengths a. Determine whether the heterogeneity (Fig 1) extends to the 3-5 um region 3) Assess the possibility for spectral heterogeneity on the other targets a. This goal will help test the hypothesis of Wong and Brown (2015) that the near-surface interiors of Trojans differ from their surfaces 4) Thermal data at 4.5 um for the Main Belt target Donaldjohanson will refine estimates of size, albedo, and provide the first estimate of thermal inertia Mission support objectives 1) Assess scientifically optimal encounter times (viewing geometries) for the fly-bys a. Characterizing rotational spectral units now will enable the team to choose the most scientifically valuable part of the asteroid to view 2) Gather data to optimize observing parameters for Lucy instruments a. Measuring brightness in the 3 - 5 um region and resolving the discrepancy between WISE and Spitzer will enable better planning of the Lucy spectral observations in this wavelength range 3) The size, albedo, and thermal inertia of Donaldjohanson are fundamental data for planning the encounter with that Main Belt asteroid

Spitzer Space Telescope - General Observer Proposal #60155

IRAC Reflectances of Cold Classical KBOs and Centaurs

Principal Investigator: Joshua Emery
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Technical Contact: Joshua Emery, University of Tennessee

Co-Investigators:
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Dale Cruikshank, NASA Ames Research Center
Cristina Dalle Ore, SETI Institute
Yanga Fernandez, University of Central Florida
Wes Fraser, California Institute of Technology
John Stansberry, University of Arizona
David Trilling, Northern Arizona University

Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 108.5

Abstract:
We propose to measure reflected fluxes of 22 Centaurs and 27 cold classical Kuiper belt objects (KBOs) with IRAC in order to determine surface compositions. The small bodies of the outer solar system provide probes of the statistical conditions, history, and interactions in the solar system. We focus in this proposal on two groups that isolate two key aspects of the complicated larger puzzle: starting compositions and physical effects of thermal evolution. The cold classical KBOs are the only dynamical group among the Kuiper belt that remain in (or very near) the region in which they formed (~40 AU), offering insight into the conditions in a known region of the early nebula. The prevailing hypothesis that their surfaces are dominated by complex organic molecules derived from irradiation of originally CH4-rich bodies will be directly tested by searching for strong absorption within the 3.6 micron channel. A subset will also be observed at 4.5 microns as a measure of other volatiles (e.g., residual CH4, CO2, N2) informative of original compositions. The Centaurs have been scattered inward into their unstable orbits among the giant planets. While closer to the Sun, accelerated thermal evolution is hypothesized to replace thin organic mantles with dust coatings through vigorous sublimation, creating the two distinct color groups (less red/gray and ultra-red). We will test this hypothesis by searching for and characterizing absorptions at 3.6 micron due to the hypothesized organics. The IRAC 3.6 and 4.5 micron reflectances will distinguish among multiple surface compositions that could explain the less red/gray group, only one of which (silicate dust) is consistent with the prevailing hypothesis. No other existing or near-term ground or space-based facility can measure reflectances at these critical wavelengths for these faint bodies. Our cycle-2 and cycle-4 programs to observe an initial set of outer solar system objects have been tremendously successful, and this proposal builds on that success.

Spitzer Space Telescope - General Observer Proposal #70115

IRAC Reflectances of Hot Classical KBOs and Scattered Disk Objects

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Institution: University of Tennessee

Technical Contact: Joshua Emery, University of Tennessee

Co-Investigators:
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Cristina Dalle Ore, SETI Institute
Yanga Fernandez, University of Central Florida
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John Stansberry, University of Arizona
David Trilling, Northern Arizona University

Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 110.2

Abstract:
We propose to measure reflected fluxes of 22 (dynamically) hot classical Kuiper Belt objects (KBOs) and 19 scattered disk objects to determine surface compositions. The small bodies of the outer Solar System provide probes of the statistical conditions, history, and interactions in the Solar System. We focus in this proposal on two groups in order to extend our previous observations to address the origin of the hot vs. cold classical populations, the source and fate of Centaurs, and the overall spectral diversity among KBOs. Hot classical KBOs reside in the classical Kuiper Belt, between ~40 and 48 AU, but have high inclinations (>5 or 10 deg), in contrast to their dynamically cold (low inclination) counterparts, which likely formed in (or very near) their current locations. Some dynamical models predict source regions entirely exclusive of the cold classical source region, while others predict that that there should be samples of cold classical material within the hot classical population. The ultra-red material that dominates the cold classical surfaces has been widely hypothesized to come from irradiation of CH4-rich surfaces over 4.5 Gyr, which we see as a strong absorption in channel 1 in our cycle-6 data. We will test scenarios for the origin of hot classical objects by searching for this strong absorption at 3.6 microns and further characterizing composition with the 4.5 micron channel. The scattered disk is hypothesized to be the immediate source of Centaurs. Since the dynamical pathway into the Centaur region is reversible, the scattered disk would also be populated by ex-Centaurs ? objects that have previously gone through a phase of low heliocentric distance. We will test this hypothesis by searching for compositional analogs of the two classes of Centaurs. This proposal directly builds on the success of previous Spitzer observations that have characterized a small sampling of the KBO diversity and obtained a deeper view of two related populations (cold classical KBOs and Centaurs).

Spitzer Space Telescope - General Observer Proposal #70163

Physical Characterization of Near-Earth Asteroids: Backup Targets for the OSIRIS-REx Asteroid Sample Return Mission

Principal Investigator: Joshua Emery
Institution: University of Tennessee

Technical Contact: Joshua Emery, University of Tennessee

Co-Investigators:
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Lucy Lim, NASA Goddard
Michael Mueller, Nice Observatory
Marco Delbo, Nice Observatory
Alan Harris, DLR Institute of Planetary Research
Antonella Barucci, LESIA
Dante Lauretta, Univ. Arizona

Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 27.0

Abstract:
We propose to use Spitzer/IRAC to physically characterize 8 near-Earth asteroids (NEAs). These eight targets have particular interest as potential backups for the OSIRIS-REx asteroid sample return mission. Specifically, we will measure the sizes and albedos of all 8 objects, the thermal inertias of two of these, and the rotation period of one. Fluxes of NEAs in the two IRAC channels are dominated by thermal emission, measurement of which enables determination of size and albedo. Knowledge of these two fundamental properties is critical for interpreting the origin and evolution of the NEA population, as well as for determining whether an object is a good target for a given spacecraft mission. Two targets have both pre- and post-opposition apparitions during GO7. Obtaining thermal fluxes of both the morning and evening side of a target provides the opportunity to not only improve the size/albedo determination, but to constrain the thermal inertia. Lightcurves of one of these NEAs measured with IRAC will provide rotation periods and constraints on shapes

Spitzer Space Telescope - General Observer Proposal #80116

IRAC Reflectances of Resonant KBOs and Scattered Disk Objects

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Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 138.1

Abstract:
We propose to measure broadband reflected fluxes of 25 Resonant Kuiper Belt objects (KBOs), 16 scattered disk objects, and 6 Centaurs with IRAC in order to determine surface compositions. The small bodies of the outer Solar System provide probes of the statistical conditions, history, and interactions in the Solar System. We focus in this proposal on two groups in order to extend our previous observations to address the origin of the hot vs. cold classical populations, the source and fate of Centaurs, and the overall spectral diversity among KBOs. Many objects have been found occupying mean-motion resonances (MMRs) with Neptune. The existence of these resonant populations led to the understanding that Neptune had migrated outward during its history. Different styles of migration have been suggested for Neptune, with distinct implications for the distribution of the physical properties of resonant objects. We will test which scenario is best explains the origin of resonant objects by searching for the strong 3.6-micron absorption, further characterizing composition with the 4.5-micron channel, and searching for trends among the various resonances (i.e. with distance). Objects in the scattered disk have been or are currently being gravitationally scattered by Neptune. The overall range of compositions should be similar to that among the resonant population as a whole, since the two groups sample the same primordial population, but the scattered disk objects should be more well-mixed. We will use this group to identify endmember compositions for the resonant bodies. This proposal directly builds on the success of previous Spitzer observations that have characterized a small sampling of the KBO diversity and obtained a deeper view of the other major dynamical populations.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80232

Physical characterization of Near-Earth objects: OSIRIS-REx targets

Principal Investigator: Joshua Emery
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Co-Investigators:
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Lucy Lim, NASA Goddard
Michael Mueller, Nice Observatory
Marco Delbo, Nice Observatory
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Science Category: NEOs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.8

Abstract:
We propose to use Spitzer/IRAC to physically characterize 7 near-Earth asteroids (NEAs). These seven targets have particular interest as the primary and potential backups for the OSIRIS-REx asteroid sample return mission. Specifically, we will measure the sizes and albedos of all 6 backup targets and the thermal inertias of three of these. We will measure thermal flux in both IRAC bands for a full rotation of the primary target, 1999 RQ36, to search for temperature variations indicative of small-scale albedo variation. Fluxes of NEAs in the two IRAC channels are dominated by thermal emission, measurement of which enables determination of size and albedo. Knowledge of these fundamental properties is critical for interpreting the origin and evolution of the NEA population, as well as for determining whether an object is a good target for a given spacecraft mission. Three targets have both pre- and post-opposition apparitions during GO8. Obtaining thermal fluxes of both the morning and evening side of a target provides the opportunity to improve the size/albedo determination and constrain the thermal inertia.

Spitzer Space Telescope - General Observer Proposal #11071

Exploring the Dust-Gas Connection in the Protoplanetary Disk of GM Aur

Principal Investigator: Catherine Espaillat
Institution: Boston University

Technical Contact: Catherine Espaillat, Boston University

Co-Investigators:
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Jesus Hernandez, Centro de Investigaciones de Astronomia
Nuria Calvet, University of Michigan

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.0
Priority: 1

Abstract:
Previous Spitzer infrared observations of disks around young, low-mass pre-main sequence stars have given us an unprecedented look at dust evolution in young objects, particularly in disks which were revealed to have large inner holes (i.e., the transitional disks). Despite this ground-breaking progress in studying the dust in young disks, the relationship between the dust and gas properties in the inner disk remains essentially unknown. Here we propose to quantify the variability of both the dust and gas in the transitional disk surrounding GM Aur to study how or if accretion onto the star is tied to inhomogeneities in the inner disk. To do this, we will use simultaneous Spitzer, HST, and Swift observations to constrain the IR, UV, and X-ray emission of GM Aur and provide a picture of the interaction between dust and gas in the inner ~0.5-1 AU of the disk down to the stellar surface.

Spitzer Space Telescope - General Observer Proposal #12036

Footprints of the Magnetosphere: the Star-Disk Connection in T Tauri Stars

Principal Investigator: Catherine Espaillat
Institution: Boston University

Technical Contact: Catherine Espaillat, Boston University

Co-Investigators:
Sierra Grant, Boston University
Jesus Hernandez, CIDA
Nuria Calvet, University of Michigan

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6
Priority: 1

Abstract:
Previous Spitzer infrared observations of disks around young, low-mass pre-main sequence stars have given us an unprecedented look at dust evolution in young objects. Despite this ground-breaking progress in studying the dust in young disks, the relationship between the dust and gas properties in the inner disk remains essentially unknown. Here we propose to quantify the variability of both the dust and gas in the disks surrounding two T Tauri stars to study how or if accretion onto the star is tied to inhomogeneities in the inner disk. To do this, we will use simultaneous Swift, HST, and Spitzer observations to constrain the X-ray, far-ultraviolet, near-ultraviolet, optical, and near-infrared emission of our sample and provide a picture of the interaction between dust and gas in the inner ~0.5 AU of the disk down to the stellar surface.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13227

Connecting mass accretion and ejection in pre-main sequence stars

Principal Investigator: Catherine Espaillat
Institution: Boston University

Technical Contact: Catherine Espaillat, Boston University

Co-Investigators:
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Mark Reynolds, University of Michigan
Connor Robinson, Boston University

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.6

Abstract:
Many pre-main sequence stars are surrounded by circumstellar material and display the typical signatures of astrophysical accretion disks, namely mass accretion onto the central object and mass ejection via jets. There is an observed correlation between the accretion rate onto the star and the mass loss rate. This suggests a linked formation mechanism, presumably the stellar magnetic field which can both channel material onto the star as well as eject it in collimated jets along twisted field lines. Here we propose a test of the observed correlation between mass accretion and ejection by using NIR emission to trace the mass reservoir available for accretion in the innermost disk, UV emission to detect accreting gas, and centimeter emission to trace the jet while disentangling the influence of high-energy X-ray radiation from the star. These would be the first simultaneous Chandra-HST-Spitzer-VLA observations of a young, accreting star.

Spitzer Space Telescope - General Observer Proposal #10121

NGC 6872’s Tidal Dwarf Galaxy

Principal Investigator: Rafael Eufrasio
Institution: Catholic University of America

Technical Contact: Rafael Eufrasio, Catholic University of America

Co-Investigators:
Richard Arendt, UMBC
Eli Dwek, NASA Goddard

Science Category: interacting/merging galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.6
Priority: 2

Abstract:
Interacting galaxies are ideal laboratories to study not only star formation but also galaxy formation. We propose to observe a small system recently discovered using GALEX data just outside the interacting pair of galaxies NGC6872/IC4970. This system has the general characteristics of a young tidal dwarf galaxy (TDG), but Spitzer data is crucial for us to determine its stellar mass and thus its nature. NGC 6872 is the largest-known spiral galaxy, with its disk extending for more than 160 kpc and regions with very different Spectral Energy Distributions across the galaxy, with the TDG-candidate being one of its the bluest regions. We propose to obtain IRAC imaging to constrain the stellar mass of this TDG, complementing our studies of UV GALEX data.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13242

A global map of the atmospheric circulation and thermal structure for an ultrahot exoplanet

Principal Investigator: Tom Evans
Institution: University of Exeter

Technical Contact: Tom Evans, University of Exeter

Co-Investigators:
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Kataria Tiffany, NASA JPL
Nikolay Nikolov, University of Exeter
Drake Deming, University of Maryland
Nikole Lewis, STScI
Hannah Wakeford, University of Exeter
Mark Marley, NASA Ames
Neale Gibson, Queens University Belfast
Jessica Spake, University of Exeter
Benjamin Drummond, University of Exeter
Joanna Barstow, University College London
Gregory Henry, Tennessee State University
Nathan Mayne, University of Exeter

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 80.0

Abstract:
WASP-121b is one of the standout exoplanets available for atmospheric characterization, both in transmission and emission, due to its large radius (1.8 Jupiter radii), high temperature (~2700K), and bright host star (H=9.4mag). Recent HST/WFC3 eclipse observations made by our group have revealed the 1.4 micron water band in emission on the dayside hemisphere of WASP-121b, implying that the atmosphere has a thermal inversion. This new development, combined with the favorable system properties, makes it clear that WASP-121b is an ideal target to empirically probe the variation of thermal inversions with longitude. To do this, we propose phase curve measurements of WASP-121b over a full orbital period in each of the Spitzer/IRAC channels. Given the measurement precision demonstrated by our previous IRAC observations of WASP-121b, we anticipate this dataset will be one of the highest signal-to-noise phase curve measurements for an exoplanet to date. It will provide a powerful complement to full-orbit phase curves that have recently been confirmed for shorter wavelengths, to be made by HST/WFC3 and JWST/NIRISS. Combined, this Spitzer+HST+JWST phase curve dataset will produce an unprecedented map of the longitudinally-resolved thermal structure, chemical composition and global circulation of an exoplanet atmosphere, and, in particular, give crucial new insight into the long-standing mystery of thermal inversions in strongly-irradiated gas giants.

Spitzer Space Telescope - Directors Discretionary Time Proposal #70206

T Pyx: a long-overdue recurrent nova

Principal Investigator: Aneurin Evans
Institution: Keele University

Technical Contact: Charles Woodward. Minnesota

Co-Investigators:
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Dipankar Banerjee, PRL
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Joachim Krautter, Heidelberg
Erik Kuulkers, ESA

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.2

Abstract:
We request DDT observations of the recurrent nova T Pyx, whose 2011 eruption was long overdue. Spitzer/IRAC observations at 3.6 and 4.5 microns will complement the 1-2.5 micron data we are getting from the ground, and the >50 micron data we are getting from Herschel (DDT approved). For the first time we will get infra-red data on an erupting nova from 1-100 microns, throwing new and unique insight into the evolution of a recurrent nova.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10127

Two Eyes on the Prize: Revealing the Complete Architectures of Planetary Systems through Transit Timing with Kepler and Spitzer

Principal Investigator: Daniel Fabrycky
Institution: University of Chicago

Technical Contact: Kevin Stevenson, University of Chicago

Co-Investigators:
Kevin Stevenson, University of Chicago
Sarah Ballard, University of Washington
Eric Agol, University of Washington
Matthew Holman, Smithsonian Institution (CfA)
Jacob Bean, University of Chicago
Darin Ragozzine, Florida Institute of Technology

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 100.0
Priority: 1

Abstract:
The transit timing variation (TTV) technique has recently become a crucial method for determining the complete architectures (i.e., planet masses, orbital eccentricities, inclinations, and resonant properties) of extrasolar planetary systems. This technique has blossomed because of the Kepler mission's discovery of systems with multiple transiting planets and individual planets exhibiting very large TTVs. All of Kepler's results in this area so far have been for relatively short-period planets, but Kepler has also discovered dynamically-interacting systems with planets that have longer periods, similar to those of the Solar System. However, the ill-timed failure of the Kepler telescope has left us with an incomplete picture of these systems due to a lack of the required time baseline. Fortunately, Spitzer is positioned to leverage the unique potential that these planets offer, by extending the time baseline of transit observations. We propose to observe transits of seven Kepler-discovered planets in four particularly compelling systems to precisely determine their transit times. Combining the legacy Kepler transit times with the new times from Spitzer will give us the baseline that is needed to confirm and characterize these dynamically interacting systems of planets. This information will allow us to assess the complete architectures of these systems -- we will discover planets that do not transit and determine the masses and orbital properties of all the planets. For 6 planets in these systems, the TTVs will allow us to measure the planetary masses to better than 20%, which will approximately double the number of cool giant planets with known masses and radii. Several of the systems have mean-motion resonances between the planets, and characterizing these interactions yields information on the formation and migration of giant planets. The required precision and duration of these observations render Spitzer the only remaining instrument capable of such study.

Spitzer Space Telescope - General Observer Proposal #10053

Evolution of dwarfs in the filament-cluster system Abell 85

Principal Investigator: Dario Fadda
Institution: Spitzer Science Center, Caltech

Technical Contact: Dario Fadda, Spitzer Science Center, Caltech

Co-Investigators:
Andrea Biviano, INAF Trieste
Florence Durret, IAP
Francine Marleau, Innsbruck University

Science Category: galaxy clusters and groups(low-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.3
Priority: 2

Abstract:
While we have a basic understanding of how bright and normal galaxies evolve in clusters, the evolutionary scenario of the faintest population of dwarf galaxies remains essentially unexplored. Observations show a sharp decrease of blue dwarfs and an increase of red dwarfs in the central region of clusters during the last 4 billion years. Current models, still controversial, try to link this change in population to the infall of small groups into clusters. To verify this scenario, we propose to obtain deep IRAC 3.6 and 4.5 micron images of the rich nearby cluster A85 (z=0.055) which has a feeding filament, discovered by our team in the X-rays, with two infalling groups. Based on our recent follow-up with ultra-deep GALEX and Herschel observations, we see a clear enhancement of specific star formation along the direction of the filament. IRAC images will allow us to extend our study to a sample of approximately 700 new faint dwarfs (down to a stellar mass of dex(7.5) solar masses) which are not detected with WISE or have confused counterparts. Comparing spectral energy distributions to stellar population models, we will be able to estimate accurate stellar masses, ages, and metallicities as well as to unveil dust-enshrouded active galactic nuclei. IRAC observations will be fundamental to define a controlled sample of dwarf galaxies to explore their number densities and properties in the different environments of the A85 system, shedding new light on the evolution of dwarfs in galaxy clusters.

Spitzer Space Telescope - General Observer Proposal #14076

The Coldest Discoveries of Backyard Worlds

Principal Investigator: Jacqueline Faherty
Institution: American Museum of Natural History

Technical Contact: Jacqueline Faherty, American Museum of Natural History

Co-Investigators:
Marc Kuchner, NASA Goddard
Sarah Logsdon, NASA Goddard
Daniella Bardalez Gagliuffi, American Museum of Natural History
Aaron Meisner, University of California Berkeley
Adam Schneider, Arizona State University
Jonathan Gagne, Carnegie DTM
Dan Caselden, ICEBRG

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 26.8
Priority: 1

Abstract:
Over the past five years, our view of the local solar neighborhood has changed drastically thanks to the Wide Field Infrared Survey Explorer (WISE). Not only did WISE redefine the five closest systems to the Sun with the discovery of Luhman16AB and WISE0855, but it also revealed the Sun's closest fly by and it defined an entirely new class of extremely cold and close compact objects: the Y dwarfs. At present, all but two of the Y dwarfs were discovered through a WISE single epoch photometric identification. As a whole, these objects are of critical importance to identifying the efficiency of star formation at the lowest masses. As individuals, each of these objects represents a unique probe into the complex chemistry present in the coldest photospheres produced in the Universe. Every single Y dwarf discovered is an observational treasure. In February 2017, we launched a citizen science project called Backyard Worlds: Planet 9 with the intention of scanning the entire sky using not just photometric information but positional as well to identify the coldest, closest, and fastest moving objects near the Sun. In this Spitzer Cycle 14 proposal, we have identified 65 tantalizingly fast moving objects that appear to be extremely cold hence potentially among the Sun's nearest neighbors. We ask for 26.8 hours with Spitzer to obtain critical ch1 and ch2 photometry as well as astrometric information (to confirm motion) which will allow us to characterize these new cold brown dwarf neighbors. The coldest objects discovered through this proposal will be important follow-up targets for JWST spectroscopy.

Spitzer Space Telescope - General Observer Proposal #14128

The Young and the Restless: Revealing the Turbulent, Cloudy Nature of Young Brown Dwarfs and Exoplanets

Principal Investigator: Jacqueline Faherty
Institution: American Museum of Natural History

Technical Contact: Jacqueline Faherty, American Museum of Natural History

Co-Investigators:
Kelle Cruz, CUNY Hunter
Emily Rice, CUNY CSI
Jonathan Gagne, Carnegie DTM
Mark Marley, NASA AMES
John Gizis, University of Delaware

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 591.4
Priority: 1

Abstract:
Emerging as an important insight into cool-temperature atmospheric physics is evidence for a correlation between enhanced clouds and youth. With this Spitzer Cycle 14 large GO program, we propose to obtain qualifying evidence for this hypothesis using an age calibrated sample of brown dwarf-exoplanet analogs recently discovered and characterized by team members. Using Spitzer's unparalleled ability to conduct uninterrupted, high-cadence observations over numerous hours, we will examine the periodic brightness variations at 3.5 microns, where clouds are thought to be most disruptive to emergent flux. Compared to older sources, theory predicts that younger or lower-surface gravity objects will have cooler brightness temperatures at 3.5 microns and larger peak to peak amplitude variations due to higher altitude, more turbulent clouds. Therefore we propose to obtain light curves for 26 sources that span L3-L8 spectral types (Teff~2500-1700 K), 20-130 Myr ages, and predicted 8-30 MJup masses. Comparing to the variability trends and statistics of field (3-5 Gyr) Spitzer Space Telescope General Observer Proposal equivalents currently being monitored by Spitzer, we will have unequivocal evidence for (or against) the turbulent atmospheric nature of younger sources. Coupling this Spitzer dataset with the multitude of spectral information we have on each source, the light curves obtained through this proposal will form the definitive library of data for investigating atmosphere dynamics (rotation rates, winds, storms, changing cloud structures) in young giant exoplanets and brown dwarfs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14299

Cold new worlds from a citizen science project

Principal Investigator: Jacqueline Faherty
Institution: American Museum of Natural History

Technical Contact:Jacqueline Faherty, American Museum of Natural History

Co-Investigators:
Marc Kuchner, NASA GODDARD
Sarah Logsdon, NASA GODDARD
Daniella Bardalez Gagliuffi, American Museum of Natural History
Aaron Meisner, NOAO
Adam Schneider, ASU
Jonathan Gagne, University of Montreal
Dan Caselden, ICEBRG

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.0
Priority: 1

Abstract:
Over the past five years, our view of the local solar neighborhood has changed drastically thanks to the Wide Field Infrared Survey Explorer (WISE). Not only did WISE redefine the five closest systems to the Sun with the discovery of Luhman16AB and WISE0855, but it also revealed the Sun's closest fly by and it defined an entirely new class of extremely cold and close compact objects: the Y dwarfs. At present, all but two of the Y dwarfs were discovered through a WISE single epoch photometric identification. As a whole, these objects are of critical importance to identifying the efficiency of star formation at the lowest masses. As individuals, each of these objects represents a unique probe into the complex chemistry present in the coldest photospheres produced in the Universe. Every single Y dwarf discovered is an observational treasure. In February 2017, we launched a citizen science project called Backyard Worlds: Planet 9 with the intention of scanning the entire sky using not just photometric information but positional as well to identify the coldest, closest, and fastest moving objects near the Sun. In this Spitzer DDT proposal, we have identified 30 tantalizingly fast moving objects that appear to be extremely cold hence potentially among the Sun's nearest neighbors. We ask for 12.4 hours with Spitzer to obtain critical ch1 and ch2 photometry as well as astrometric information (to confirm motion) which will allow us to characterize these new cold brown dwarf neighbors. The coldest objects discovered through this proposal will be important follow-up targets for JWST spectroscopy.

Spitzer Space Telescope - Directors Discretionary Time Proposal #11182

A Double Dusty Dilemma

Principal Investigator: Jay Farihi
Institution: University College London

Technical Contact: Jay Farihi

Co-Investigators:

Boris Gansicke, University of Warwick
Steven Parsons, Universidad de Valpara

Science Category: Debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:

We have serendipitously discovered the first metal-polluted white dwarf with what appears to be a circumbinary dust disk. Both the atmospheric metals and infrared excess were found by our team a few years ago, but only recently (and much to our surprise) did we measure a spectroscopic periodicity of 2.27 hr which unambiguously identifies this peculiar system as a close binary. Most remarkable for this DDT proposal is that the system must be (highly) dynamically unstable, as a companion and canonical dust disk occupy overlapping orbital regions. We therefore conclude the system must be in a high state of flux and propose a short, single observation with IRAC to compare with our prior flux measurements obtained in late 2009. Any change will prompt an observing campaign for detailed monitoring. We speculate we are witnessing a destructive event in real time, and if correct, this system may yield an unprecedented view into the long-term evolution of circumbinary planetary systems.

Spitzer Space Telescope - General Observer Proposal #12103

Extending our Unbiased Survey for Disks Around White Dwarfs; One Foot in Terra Incognita

Principal Investigator: Jay Farihi
Institution: University College London

Technical Contact: Jay Farihi, University College London

Co-Investigators:
Boris Gaensicke, University of Warwick

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 32.8
Priority: 1

Abstract:
Eleven cycles of Spitzer studies have firmly linked the presence of atmospheric metals in white dwarfs to closely orbiting circumstellar dust; the result of large planetesimal disruptions in active planetary systems. These evolved stars represent a unique tool to study long term planetary system evolution in the descendants of A-type and similar stars. Yet despite 35 IRAC-detected dust disks at white dwarfs, we are still unable to determine true disk frequency as a function of post-main sequence planetary system age. In Cycle 8 we carried out the first double-blind Spitzer/HST survey of a large white dwarf sample in the cooling age range 25-100 Myr. We found a fraction of 4% have an IRAC excess, while 30% of the sample display atmospheric metals, indicating that many white dwarf dust disks are faint in the infrared, and hinting at an undiscovered disk population. Additionally, these joint observations provided the first quantitative link between circumstellar dust and atmospheric metals in an unbiased sample of stars. Here we propose to extend our work to younger (5-25 Myr) and older (100-300 Myr) cooling ages, using a sample of 106 white dwarfs selected only for temperature and brightness. As with our previous survey, the same sample of 106 stars will be searched for atmospheric metals with HST/COS in approved Cycle 22 and 23 Snapshots. These combined observations will measure true disk frequency over a range of cooling ages for the first time, and thus constrain models of post-main sequence, planetary system dynamical instabilities. Importantly, Spitzer observations are critical to determine the fraction of disks in the cooling age range 5-25 Myr, which has not been explored, and where dynamical instabilities are expected to be relatively frequent.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13216

A Changing Legacy for Dead Rock Stars

Principal Investigator: Jay Farihi
Institution: University College London

Technical Contact: Jay Farihi, University College London

Co-Investigators:
Tom Wilson, University College London
Boris Gaensicke, University of Warwick
David Wilson, University of Warwick

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.1

Abstract:
The discovery of irregular transiting events toward the polluted white dwarf WD1145+017 has recently spurred new observational and theoretical efforts to place these evolved planetary systems into context. Yet despite over three dozen systems that were first discovered and later characterized by Spitzer, we do not yet know the frequency and size of incoming bodies that are tidally disrupted, nor the collective effect they have on pre-existing disks. A few models have come forth since the last call for proposals, predicting active changes in dust production-accretion rates, some of which are on decade-long timescales. We propose to test these models by re-observing all polluted white dwarfs with an infrared excess from dust, most of which were first observed a decade prior. This simple test to search for changes in dust emission can be done in only 15.1 hours. We expect these data to have legacy value for future models, and to inform on the most active targets for follow up with JWST.

Spitzer Space Telescope - General Observer Proposal #14100

Maximizing JWST Science for Dusty White Dwarfs

Principal Investigator: Jay Farihi
Institution: University College London

Technical Contact: Jay Farihi, University College London

Co-Investigators:
Erik Dennihy, University of North Carolina, Chapel Hill
Nicola Gentile Fusillo, University of Warwick
John Debes, Space Telescope Science Institute
Boris Gaensicke, University of Warwick

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.3
Priority: 2

Abstract:
We propose a small program to increase the number of dusty white dwarfs that can be studied in detail by the James Webb Space Telescope. Currently, there are 8 systems for which MIRI MRS spectroscopy can be carried out in less than a few hours per target, and here we propose to double this number. Using cross-correlation of AllWISE photometry with Southern Hemisphere surveys such as Edinburgh-Cape and ATLAS, we have selected the strongest 22 potential dusty white dwarf candidates. We propose to use warm IRAC imaging photometry as the ultimate discriminant between dust and common photometric contaminants. This program has immediate legacy value via detailed mineralogical studies of debris disks using JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14258

The Second Life of Planetary Systems: Youthful Variability in White Dwarf Debris Disks

Principal Investigator: Jay Farihi
Institution: University College London

Technical Contact: Jay Farihi, University College London

Co-Investigators:
Amy Bonsor, Institute for Astronomy
John Debes, Space Telescope Science Institute
Erik Dennihy, Gemini Observatory
Boris Gaensicke, University of Warwick
Don Hoard, Eureka Scientific
Scott Kenyon, Center for Astrophysics
Mukremin Kilic, University of Oklahoma
Chris Manswer, University of Warwick
Carl Melis, University of California San Diego
Roman Rafikov, University of Cambridge
Seth Redfield, Wesleyan University
Laura Rogers, Institute for Astronomy
Kate Su, University of Arizona
Andrew Swan, University College London
Ted von Hippel, Embry Riddle Aeronautical University
David Wilson, University of Texas Austin
Tom Wilson, University College London
Mark Wyatt, Institute for Astronomy
Siyi Xu, Gemini Observatory

Science Category: Debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 89.2
Priority: 2

Abstract:
The legacy of Spitzer includes the paradigm shift of metal-polluted white dwarfs. Once thought to be picking up bits of interstellar dust and gas as they swirl around the Milky Way over aeons, white dwarfs are now known to have dynamically young planetary systems, and this enables astronomers to infer bulk abundances of extrasolar planetesimals whose debris is often seen to emit in the infrared. It is ironic that only now, more than 14 years after the first white dwarf debris disk was observed by Spitzer, and near the looming end of mission, we know with confidence that these disks are varying, possibly universally, and that this is relatively straightforward to observe with Spitzer. We do not yet know which physical processes govern the observed behavior -- candidates include tidal disintegration, sublimation, collisions from without or within the disk, and planets. While disk variations on disparate timescales of hours and years have been established, the data in hand are at least an order of magnitude too sparse to provide model constraints. Given what we know about the bulk planetesimal compositions as measured via atmospheric pollution, these evolved planetary systems appear to have major rock bodies in abundance, but literally nothing is empirically known of what lies beyond a few solar radii. Sensitive infrared monitoring of dusty white dwarfs will allow constraints on the timescale and amplitude of the changes, in turn constraining the underlying physical mechanisms. We propose to densely monitor 16 of the brightest dusty white dwarfs to observe the relevant timescales and size of the changes in their dust emission. The proposal team represents the majority of the community that work on infrared observations and circumstellar dust modeling around white dwarfs. Thus, there is a clear scientific consensus that these data will play a critical role in the future of these and adjacent research fields, and that we must gather these data before this amazing telescope is lost.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14261

A Second Transiting White Dwarf System

Principal Investigator: Jay Farihi
Institution: University College London

Technical Contact: Jay Farihi, University College London

Co-Investigators:
Boris Gaensicke, Univeristy of Warwick
Sethe Redfield, Wesleyan University
Tom Marsh, University of Warwick
Vik Dhillon, University of Sheffield
Andrew Swan, University College London

Science Category: Debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0
Priority: 1

Abstract:
On 24 Mar 2019, using high-time cadence photometry, we discovered the second white dwarf system with planetary transit events. We have confirmed the period of numerous events to all be 25 h, which corresponds to a semimajor axis well within the habitable zone of the stellar remnant. The transit activity is essentially continuous at the few to several percent level, from blue to red wavelengths with no color dependence. There are no Spitzer observations of this source, but the multi-epoch WISE and NEOWISE data suggest the infrared disk emission has possibly switched from an undetectable to detectable state. We propose one hour total observatory time to perform IRAC photometry at both 3.6 and 4.5 micron to confirm or rule out a current infrared excess corresponding to the transiting disk material. We request time-critical DDT time based on the potentially transient nature of these ongoing events, and to efficiently capitalize on this major discovery.

Spitzer Space Telescope - General Observer Proposal #60113

A Search for Circumstellar Dust at SDSS White Dwarfs with K-Band Excess

Principal Investigator: Jay Farihi
Institution: UCLA

Technical Contact: Jay Farihi, UCLA

Co-Investigators:
Boris Gaensicke, University of Warwick
Jonathan Girven, University of Warwick
Matt Burleigh, University of Leicester
Paul Steele, University of Leicester

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.7

Abstract:
We propose IRAC 3.6 and 4.5 micron observations of white dwarfs observed to have a K-band excess via cross-correlation of the the Sloan Digital Sky Survey (SDSS) and the UKIRT Infrared Deep Sky Survey (UKIDSS). We have searched tens of thousands of sources in SDSS DR7 with spectra (by eye) and/or photometry and identified a few thousand SDSS white dwarfs with good YJHK photometry in UKIDSS. Of those sources, we select the best seven candidates with a likely K-band excess to search with Spitzer / IRAC for confirmation of warm circumstellar dust. Our selection criteria should be both completely unbiased and highly efficient relative to previous white dwarf dust disk searches. There is now strong evidence that the closely orbiting dust disks at white dwarfs are caused by the tidal disruption of a minor planet or planets. In addition to producing an infrared excess, the debris also pollutes the otherwise pristine white dwarf atmosphere with metals, via accretion. Any confirmed dust disks will almost certainly have contaminated their white dwarf hosts, but metal absorption features cannot typically be seen in the relatively low S/N and low resolution SDSS spectra. However, ground- and space-based ultraviolet and optical spectroscopy of the heavy element abundances (at high resolution and superior S/N) will yield the bulk composition of the terrestrial, polluting material. Our targets represent high probability of dust disk detection and, if confirmed, will substantially increase the number of exoplanetary debris disks for which a bulk chemical composition can be obtained.

Spitzer Space Telescope - General Observer Proposal #60119

Completing the Census of Disrupted Minor Planets at White Dwarfs: Photospheric Pollution by Single or Multiple Asteroids?

Principal Investigator: Jay Farihi
Institution: UCLA

Technical Contact: Jay Farihi, UCLA

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.7

Abstract:
We propose IRAC photometry for a sample of 11 highly metal-enriched white dwarfs, to confirm or rule out infrared excess due to warm circumstellar dust. Our ongoing Spitzer work has been highly successful in the identification of white dwarfs that are, simultaneously, externally polluted by metals and have closely orbiting circumstellar dust. Both the orbiting material and the photospheric heavy element abundances are refractory-rich and volatile-poor, implying these stars are polluted by rocky material. In this way we continue to build a target list on which to perform spectroscopy of extrasolar rocky planetesimals, via their heavy element signatures in the otherwise pristine photospheres of white dwarfs. No other currently available technique can observe the bulk composition of extrasolar, terrestrial, planetary material -- this is the singular, enormous advantage offered by metal-rich white dwarfs. Our model invokes the tidal destruction of a single, large asteroid to produce circumstellar dust, while multiple, smaller asteroids are invoked to explain stars that are dust-free. In the latter case, orbiting dust is readily destroyed via collisions and sputtering as additional asteroids enter a pre-existing, closely orbiting disk at slightly different inclinations, resulting in a gaseous disk. In both cases, the white dwarf accretes, and becomes polluted by, material which is rich in heavy elements. Therefore, identification of warm circumstellar dust implies pollution by a single body, whose heavy element abundances should reflect an idiosyncratic pattern of an extrasolar analog to a large asteroid like Ceres. On the other hand, a lack of orbiting dust implies the metal abundance pattern reflects pollution by an ensemble of smaller extrasolar asteroids, and closer to an average chemical composition. Discriminating between these two cases is critical to the interpretation of optical and ultraviolet spectroscopy of the photospheric heavy elements seen in polluted white dwarfs.

Spitzer Space Telescope - General Observer Proposal #70037

A Last Look at the Most Highly Metal-Polluted White Dwarfs

Principal Investigator: Jay Farihi
Institution: University of Leicester

Technical Contact: Jay Farihi, University of Leicester

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.2

Abstract:
Our ongoing Spitzer work has been highly successful in the identification of metal-polluted white dwarfs with circumstellar dust. Both the orbiting material and the photospheric heavy element abundances are refractory-rich and volatile-poor, revealing these stars are polluted by rocky material. In this way we continue to build a target list on which to perform spectroscopy of extrasolar rocky planetesimals, via their heavy element signatures in white dwarf atmospheres. No other currently available technique can observe the bulk composition of extrasolar, terrestrial, planetary material -- this is the singular, enormous advantage offered by these metal-enriched stars. We propose IRAC imaging of the three remaining, highly metal-rich white dwarfs that have not yet been searched for warm orbiting dust. Our prior work indicates that each target has a 75% chance of having an infrared excess. Our model invokes the tidal destruction of a single, large asteroid to produce circumstellar dust, while multiple, smaller asteroids are invoked to explain stars that are dust-poor. In the latter case, orbiting dust is readily destroyed via collisions and sputtering as additional asteroids enter a pre-existing, closely orbiting disk at slightly different inclinations, resulting in a gaseous disk. In both cases, the white dwarf accretes, and becomes polluted by, material which is rich in heavy elements. Thus, the presence of warm dust implies pollution by a single body, whose heavy element abundances should reflect an idiosyncratic pattern of an extrasolar analog to a large asteroid like Ceres. On the other hand, a lack of orbiting dust implies the metal abundance pattern reflects pollution by an ensemble of smaller extrasolar asteroids, and closer to an average chemical composition. Discriminating between these two cases is critical to the interpretation of optical and ultraviolet spectroscopy of the photospheric heavy elements seen in polluted white dwarfs.

Spitzer Space Telescope - General Observer Proposal #70116

A Last Look at the Common, Moderately Polluted White Dwarfs

Principal Investigator: Jay Farihi
Institution: University of Leicester

Technical Contact: Jay Farihi, University of Leicester

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.9

Abstract:
Our ongoing Spitzer work has been highly successful in the identification of metal-polluted white dwarfs with circumstellar dust. Both the orbiting material and the photospheric heavy element abundances are refractory-rich and volatile-poor, revealing these stars are polluted by rocky material. In this way we continue to build a target list on which to perform spectroscopy of extrasolar rocky planetesimals, via their heavy element signatures in white dwarf atmospheres. No other currently available technique can observe the bulk composition of extrasolar, terrestrial, planetary material -- this is the singular, enormous advantage offered by these metal-enriched stars. We propose IRAC imaging of the twelve remaining, moderately metal-rich white dwarfs that have not yet been searched for warm orbiting dust. The nature of their relativley common and moderate pollution is still somewhat uncertain. Our model invokes the tidal destruction of a single, large asteroid to produce circumstellar dust, while multiple, smaller asteroids are invoked to explain stars that are dust-poor. In the latter case, orbiting dust is readily destroyed via collisions and sputtering as additional asteroids enter a pre-existing, closely orbiting disk at slightly different inclinations, resulting in a gaseous disk. In both cases, the white dwarf accretes, and becomes polluted by, material which is rich in heavy elements. Thus, the presence of warm dust implies pollution by a single body, whose heavy element abundances should reflect an idiosyncratic pattern of an extrasolar analog to a large asteroid like Ceres. On the other hand, a lack of orbiting dust implies the metal abundance pattern reflects pollution by an ensemble of smaller extrasolar asteroids, and closer to an average chemical composition. Discriminating between these two cases is critical to the interpretation of optical and ultraviolet spectroscopy of the photospheric heavy elements seen in polluted white dwarfs.

Spitzer Space Telescope - General Observer Proposal #80149

An Unbiased, Double-Blind Study of Terrestrial Debris in Evolved Planetary Systems

Principal Investigator: Jay Farihi
Institution: University of Leicester

Technical Contact: Jay Farihi, University of Leicester

Co-Investigators:
Boris Gaensicke, University of Warwick
Jonathan Girven, University of Warwick

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 52.9

Abstract:
We propose to observe, in an unbiased manner, a large sample of white dwarfs with post-main sequence ages between 20 and 120 Myr to search for evidence of rocky circumstellar debris. Our targets are identical to those selected for an approved HST Cycle 18 Snapshot program for ultraviolet spectroscopy with COS. These stars were chosen only for their brightness and to be within a narrow range of effective temperatures amenable to our science goals. The COS observations will measure the metal content of the stars while the Spitzer observations will search for the presence of warm, circumstellar dust. In this manner, for the first time, we will obtain an unbiased picture of planetary debris in the post-main sequence -- in frequency of occurence per star, in its chemical composition via the atmospheric metal pollution, and in its accretion-production rate -- all as a function of cooling age and main-sequence progenitor mass. It will be the first and only unbiased search for both atmospheric metals and circumstellar dust at a complete sample of white dwarfs with well defined post-main sequence ages and reliable mass determinations. As such, we will be able to overcome existing limitations in the field, determine clean statistics for the first time, and distinguish the influences of cooling age and atmospheric metal content on the observed disk frequency.

Spitzer Space Telescope - General Observer Proposal #90121

Disk Confirmation at a New Highly Polluted White Dwarf

Principal Investigator: Jay Farihi
Institution: University of Cambridge

Technical Contact: Jay Farihi, University of Cambridge

Co-Investigators:
Boris Gansicke, University of Warwick

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0

Abstract:
We propose to use warm Spitzer IRAC to confirm the presence of circumstellar dust, and thus ongoing accretion, at a new and highly metal-enriched white dwarf. This spectacular star is contaminated by nearly solar abundances of O, Mg, Si, Ca, and Fe, making it a contender for the most metal-polluted white dwarf yet discovered. Spitzer observations are critical for the correct interpretation of the atmospheric metal abundances and their translation into those of the accreted matter. In turn, the composition of the planetesimal (or asteroidal) debris will provide insight on the bulk chemistry of solid planets being found with Kepler and other state of the art facilities.

Spitzer Space Telescope - General Observer Proposal #10060

Watching a supermassive black hole eat -- Sgr A* and cloud G2

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Steven Willner, Center for Astrophysics

Co-Investigators:
Matthew Ashby, SAO
Eric Becklin, SOFIA Science Center
Sean Carey, IPAC
Andrea Ghez, UCLA
Joseph Hora, SAO
Jiasheng Huang, SAO
James Ingalls, IPAC
Leo Meyer, UCLA
Mark Morris, UCLA
Howard Smith, SAO
Zhong Wang, SAO
Gunther Witzel, UCLA
Steven Willner, SAO

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 96.4/48.2
Priority: 1/2

Abstract:
The Galactic center supermassive black hole is a fluctuating source of electromagnetic radiation derived from its accretion flow. For the past decade, the black hole's ingestion has been modest, but in the near future, its accretion rate and luminosity are expected to surge as the cloud G2 swings by and feeds Sgr A* with a helping of fresh gas. We propose to monitor Sgr A* with Spitzer/IRAC at a wavelength of 4.5 microns as the elevated accretion episode proceeds. Near-infrared wavelengths are where the black hole's emission has been best characterized in the past, and IRAC observations will complement planned observations with other observatories at X-ray, radio, and submillimeter wavelengths. The variability of Sgr A* is a random red-noise process, but the limited duration of continuous ground-based observations (<6 hr) has prevented direct measurement of the correlation timescale. This timescale corresponds to a thermal or viscous timescale associated with the inner radius of the accretion disk, and knowing it is critical for the black hole accretion physics. IRAC offers the unique capability to observe in the infrared for 24 hours continuously at each epoch and to observe during the critical winter months when no ground-based observatories will be able to carry out infrared or submm observations. Our plan is to observe at seven epochs spread over a 14-month interval, including initial observations before the G2 periapsis. This will let us follow the initial stages of what is expected to be an extended accretion episode. Although Sgr A* lies in a crowded field, the sensitivity and the known, stable point spread function of IRAC will allow us recover all variability information on time scales longer than about 20 minutes (and perhaps shorter). The IRAC observations will at last reveal the correlation time of the variation and whether it changes during the accretion episode, yielding new information about black hole accretion disk physics.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12034

Understanding How a Black Hole Feeds: Sgr A*

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Steven Willner, Center for Astrophysics

Co-Investigators:
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Eric Becklin, SOFIA Science Center
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Charles Gammie, Univ. of Illinois
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Daniel Marrone, Univ. of Arizona
Leo Meyer, UCLA
Mark Morris, UCLA
Howard Smith, SAO
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Steven Willner, SAO

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 49.6
Priority: 1

Abstract:
The Galactic center supermassive black hole is by far the closest example for studying the mechanisms of accretion onto such objects. Sgr A* is the fluctuating source of electromagnetic radiation derived from the accretion flow or perhaps a related jet. The variable radiation has been detected at radio, submillimeter (submm), near infrared (NIR), and X-ray wavelengths. Recent numerical general relativistic magneto-hydrodynamic (GRMHD) flare models across the electromagnetic spectrum indicate that variability may be connected to a tilted inner disk or to the black hole gravitationally lensing a bright spot in the accretion flow. Different models predict different amplitudes of flaring, and observations can therefore distinguish between strong-mean-magnetization accretion and weak magnetization. Disentangling the power source and emission mechanisms of the flares is a central challenge to our understanding of the Sgr A* accretion flow. Following our successful observations of the variability of Sgr A* with IRAC in 2013 and 2014, we propose simultaneous IRAC (4.5 micron) and Chandra (2-10 keV) observations to (1) probe the accretion physics of Sgr A* on event-horizon scales via multi-wavelength monitoring and (2) detect any effect of the object G2 on Sgr A*. Specifically, we propose two epochs of observation, each of 24 uninterrupted hours (86.4 ks), in 2016 July. Independent of this proposal we will also request NuSTAR (3-79 keV), SMA/ALMA/APEX (0.8 mm), and Keck/Magellan NIR (2.2 micron) observations during the two IRAC/Chandra epochs. Only such long-duration, continuous, multi-wavelength observations can achieve a comprehensive view of the dominant emission process(es) and quantify the physical properties near the event horizon. Theoretical models are increasing in physical sophistication, and our study will provide essential constraints for the next generation of models.

Spitzer Space Telescope - General Observer Proposal #13027

Diagnosing the Black Hole Accretion Physics of Sgr A*

Principal Investigator: Giovanni Fazio
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Gunther Witzel, UCLA

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 48.0
Priority: 1

Abstract:
The Galactic center offers the closest opportunity for studying accretion onto supermassive black holes. The fluctuating source, Sgr A*, is detected across the electromagnetic spectrum and may originate in the accretion flow or jet. Recent general relativistic magneto-hydrodynamic (GRMHD) models indicate that variability can be produced by a tilted inner disk, gravitational lensing of bright spots in the disk by the hole, or particle acceleration in reconnection events. These models produce different flare characteristics, and in particular better characterization of flares may enable us to distinguish between strong and weakly magnetized disks. Disentangling the power source and emission mechanisms of the flares is a central challenge to our understanding of the Sgr A* accretion flow. Following our successful observations of the variability of Sgr A* with IRAC in 2013 and 2014, we propose simultaneous IRAC (4.5 micron) and Chandra (2-10 keV) observations to (1) probe the accretion physics of Sgr A* on event-horizon scales and (2) detect any effect of the object G2 on Sgr A*. Specifically, we propose six additional epochs of observation, each of 24 uninterrupted hours; four in 2017 July and two in 2018 July. In this proposal we request two 24-hour (86.4 ks) Chandra periods, and are requesting another four through the Chandra TAC to have simultaneous X-ray observations in each of the six Spitzer epochs. Independent of this proposal we will also request NuSTAR (3-79 keV), SMA/ALMA/APEX (0.8 mm), and Keck/Magellan NIR (2.2 micron) observations during the IRAC/Chandra epochs. Only such long-duration, continuous, multi-wavelength observations can achieve a comprehensive view of the dominant emission process(es) and quantify the physical properties near the event horizon. Theoretical models are increasing in physical sophistication, and our study will provide essential constraints for the next generation of models.

Spitzer Space Telescope - General Observer Proposal #14026

The Vital Infrared to X-ray Link in the Sgr A* Accretion Flow

Principal Investigator: Giovanni Fazio
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Howard Smith, SAO
Steven Willner, SAO
Gunther Witzel, UCLA

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 49.6
Priority: 2

Abstract:
Black hole accretion drives extreme astrophysical phenomena in the universe. Sgr A*, the radiating counterpart of the nearest supermassive black hole, is highly variable, but sparse data and short observations have left its emission physics in question. Despite enormous advances in accretion models, physical description of the interacting radiation mechanisms is incomplete. The X-ray emission mechanism in particular remains unknown. Because the necessary information is contained in the time-dependent relation between X-ray and infrared emission, we have begun monitoring Sgr A* simultaneously with Chandra in X-rays and with Spitzer in the infrared. Defining the X-ray to infrared flux density ratio will allow the entire energy distribution to be understood. We therefore request two new 24-hour epochs of Spitzer monitoring at 4.5 microns simultaneous with Chandra time already approved. This will increase the exposure time for X-ray flares where the NIR state is known, moving us out of the realm of small-number statistics and enabling diagnostics of the true X-ray/IR ratio. Under current NASA plans, this will be the last chance for these valuable Spitzer+Chandra observations.

Spitzer Space Telescope - General Observer Proposal #60022

SEDS: The Spitzer Extended Deep Survey

Principal Investigator: Giovanni G. Fazio
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Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Approved: 2108.0

Abstract:
The Spitzer Extended Deep Survey (SEDS) will provide a unique opportunity to obtain the first complete census of the assembly of stellar mass and black holes as a function of cosmic time back to the era of reionization, yielding unique information on galaxy formation in the early Universe. The survey will also measure galaxy clustering over a wide redshift range, which will provide the critical link between galaxies and their dark matter halos and critical tests of

models of early star formation. SEDS will achieve these goals by tracing the stellar mass growth in mass-selected samples of galaxies via their broadband spectral energy distributions. The baseline proposal is an unbiased survey with 12 hours/pointing at 3.6 and 4.5 microns over five well-studied fields of 0.90 square degree total. We expect to find (a) >10,000 galaxies at z = 4--6 (including ~1000 galaxies at z = 6), reaching galaxies down to ~5 x 10^9 Msun at z = 6, necessary to robustly measure M* at that redshift, i.e., the galaxies that dominate the global stellar mass density, and (b) >100 massive galaxies at z = 7, which will firmly anchor the high mass end of the early galaxy populations and provide targets bright enough for future spectroscopic follow-up with 20--30 meter telescopes, JWST, and ALMA. The proposed five-field deep survey will enable several secondary science objectives. These include: (1) galaxy evolution in the redshift range z ~ 1--4, (2) AGN variability, and (3) measurement of the cosmic infrared background spatial fluctuations. SEDS is the most efficient and most highly optimized program that we can imagine to achieve core scientific goals of the warm mission. The opportunity to probe the Universe so widely and at such a depth at mid-IR wavelengths will not come again in the foreseeable future. SEDS is a unique program that will leave an important legacy for years to come.

Data from this program was split into multiple PIDs.
You can find the data in program IDs 60022, 61040, 61041, 61042, 61043

Spitzer Space Telescope - Directors Discretionary Time Proposal #7020

The Spitzer Ultra-Deep Survey of the HST/ERS Field

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Steven Willner, Harvard-SAO

Co-Investigators:
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Zhong Wang, Harvard-SAO

Science Category: high-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 150

Abstract:
The HST WFC3 Early Release Science (ERS) observations in the GOODS South field, together with the existing HST ACS observations provide a panchromatic 10-band survey of the ERS field that cover 40-50 square arcmin over the wavelength interval 0.2 to 1.7 microns to WFC3/IR depths of AB ~ 27.3 mag (5 sigma) for point sources. Such a deep, multiwavelegth survey provides a unique opportunity to study galaxy evolution out to z ~ 8 and even possibly to z ~ 10. These early galaxies are important because they serve as beacons of the first sites of star formation, as a constraint on galaxy formation models, and as probes of reionization. The only limitation to even further progress in exploring the early universe using the ERS data is the current depth of Spitzer/IRAC mid-infrared data in this field. IRAC adds the unique and important capability of tracing early galaxy stellar mass growth, stellar ages, and star formation rates back to z ~ 7 - 10. In this DDT program we propose significantly increasing the IRAC depth achieved in a 5’x5’ area in the ERS field to ~ 27 AB mag (5 sigma, 3.6 micron). This probe of the early Universe to such a depth by HST and Spitzer/IRAC, will have a major impact on our knowledge of the galaxy evolution and leave an important legacy for years to come.

Spitzer Space Telescope - General Observer Proposal #80057

Spitzer Very Deep Survey of the HST/CANDELS Fields

Principal Investigator: Giovanni Fazio
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Steven Willner, Center for Astrophysics

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Sandra Faber, University of California Santa Cruz
Henry Ferguson, Space Telescope Science Institute
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Joseph Hora, Smithsonian Astrophysical Observatory
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Anton Koekemoer, Space Telescope Science Institute
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Zhong Wang, Smithsonian Astrophysical Observatory
Steven Willner, Smithsonian Astrophysical Observatory

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1181.5

Abstract:
The Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (CANDELS) is a new and powerful multicycle HST treasury imaging survey. It is the next major step forward in the study of galaxy evolution in the early universe (z = 2 to 8). Using WFC3/IR and ACS, the program incorporates a two-tiered strategy: a "Wide" component (~0.2 sq. degrees) and a "Deep" component (~0.04 sq. degrees). Combining these fields with the ultra-deep imaging from the HST Cycle 17 HUDF09 program (~0.004 sq degrees) yields a three-tiered strategy for efficient sampling of both rare/bright and faint/common objects. This approach mitigates cosmic variance and yields statistically robust samples of galaxies out to z = 8. These early galaxies are important because they serve as beacons of the first sites of star formation, as a constraint on galaxy formation models, and as probes of reionization. A major limitation on further progress in exploring the early universe using the new CANDELS data is the relatively modest depths of the current Spitzer/IRAC mid-infrared data in these fields. IRAC adds the unique and important capability of tracing early galaxy stellar mass growth, stellar ages, and star formation rates back to z ~ 7 to 10. This Cycle-8 Spitzer Exploration Science program proposes significantly increasing the IRAC depth in the CANDELS fields to 26.8 AB mag (5 sigma, 3.6 micron; 50 hrs/pointing), thus providing deep IRAC coverage in all the CANDELS fields. With this sensitivity Spitzer/IRAC will detect every source detected in the CANDELS Wide survey, probe galaxies to z ~ 8 at ~10^9 Msun, and permit measurement of their spectral energy distributions. The proposed program will increase the total area mapped jointly by WFC3/IR and IRAC to 26.8 mag AB depth by a factor of ~35. This probe of the early Universe, over a relatively large area and to such a depth by HST and Spitzer/IRAC, will have a major impact on our knowledge of the galaxy evolution and leave an important legacy for years to come.

Data from this program was split into multiple PIDs. You can find the data in program IDs 80057, 80215, 80216, 80217, 80218

Spitzer Space Telescope - General Observer Proposal #11121

Searching the Sky for the Brightest Galaxies in the Distant Universe

Principal Investigator: Steven Finkelstein
Institution: University of Texas, Austin

Technical Contact: Steven Finkelstein, University of Texas, Austin

Co-Investigators:
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Keely Finkelstein, The University of Texas at Austin
Mimi Song, The University of Texas at Austin
Casey Papovich, Texas A&M University
Rachel Somerville, Rutgers University
Matt Mechtley, MPIA
Rachael Livermore, The University of Texas at Austin

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 77.2
Priority: 1

Abstract:
We propose a Spitzer/IRAC survey of nine independent sight-lines in the sky which have been identified to host plausible candidates for the brightest galaxies in the z > 9 universe. While the z > 9 universe is still a vast unknown, tremendous progress has been made with ultra-deep surveys such as the Hubble Ultra Deep Field. However, these data only constrain the faint-end of the rest-frame ultraviolet luminosity function, while the bright-end is largely unconstrained. Attempts to search for bright z > 9 galaxies in the few well-studied deep fields have been met with discrepant results, dominated by cosmic variance uncertainties. We searched 70 fields from two Hubble Space Telescope pure parallel surveys for bright z > 9 galaxies, and found 16 candidates. However, the available imaging cannot discern between true z > 9 galaxies, and passive/dusty z~2.5 galaxies. The addition of IRAC imaging at 3.6um unambiguously breaks this degeneracy. We request 77.2 hours of IRAC imaging over these nine fields to build the most robust sample of bright z > 9 galaxies. We also request 18 orbits of HST imaging (two orbits per field, one with ACS/F814W and one with WFC3/F140W) to refine the photometric redshift, with the deep optical imaging further ruling out a low-redshift solution, and the near-infrared imaging discerning z~9 from z~10 galaxies. This combined dataset will place stringent constraints on the abundance of bright z~9 galaxies, robust against cosmic variance, which can be used to constrain the physics behind galaxy evolution in the distant universe. These observations highlight the remarkable utility of this 80cm telescope for studying galaxies at a time only 500 Myr removed from the Big Bang.

Spitzer Space Telescope - General Observer Proposal #80160

Time-Series IRAC Photometry of Protostars in L1641

Principal Investigator: William Fischer
Institution: University of Toledo

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Peter Plavchan, NExScI
Luisa Rebull, Spitzer Science Center
John Stauffer, Spitzer Science Center
Amelia Stutz, MPIA

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 59.4

Abstract:
We propose time-series monitoring with Spitzer/IRAC of a sample of 62 embedded protostars in the Orion molecular cloud Lynds 1641. Photometric variability at 3.6 and 4.5 microns probes the protostellar accretion disk inside of 1 AU, a spatial regime that is otherwise difficult to observe in highly embedded systems. We will discern the role of stellar rotation, disk instabilities, and episodic accretion in producing variable protostellar light curves. The protostars of L1641 are exceptionally well-characterized; we have supporting data on them from ground- and space-based observatories extending from the near-IR to the sub-mm. These data allow us to carefully choose a sample that includes a range of envelope densities and infall rates, environments ranging from small groups to isolation, multiplicity, and viewing angle. Our goal is to understand how these factors, acting on scales of 10 to 5000 AU, influence accretion from the inner disk onto the central star at the youngest, most embedded stages in the formation of low-mass stars. These data from a range of protostellar environments, from isolated to densely grouped, will also serve as an excellent comparison to similar data obtained for protostars in the rich Orion Nebula Cluster by the Spitzer YSOVAR program. With this program we will gain an improved understanding of the evolution of disk accretion during the protostellar phase.

Spitzer Space Telescope - General Observer Proposal #12090

Studying Inner Protoplanetary Disk Structure through its Rapid and Gradual Variability

Principal Investigator: Kevin Flaherty
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Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.7
Priority: 2

Abstract:
While most of our knowledge of protoplanetary disks is based on single snapshots of many systems, their evolution is in fact highly dynamic on short timescales. Spitzer has led the way in studying the infrared fluctuations of the inner edge of the disk, finding that the majority of young stellar objects are variable over days to weeks on the scale of ~0.05-0.2 magnitudes. Due to the narrow ~40 day visibilitiy windows of many of the observed cluster in these surveys, they were unable to characterize gradual fluctuations arising from farther out in the disk. In 2013 we observed part of the 2 Myr Chameleon I star-forming region over much of its 220 day visibility and found that all of the systems exhibit gradual fluctuations, with timescales ~100 days and longer. Given the low cadence of these observations it is not clear if the slower modulations in flux associated with circumstellar material at ~0.1-0.5 AU is connected to the more rapid dipper/bursty/stochastic behavior seen in previous surveys. We propose to extend our prior survey with high cadence observations to provide a direct link between rapid and gradual fluctuations and a constraint on the timescale, and hence the location, of the physical cause of the variability.

Spitzer Space Telescope - General Observer Proposal #80174

Connecting Young Stellar Object Variability Across the Great Observatories: A Combined Spitzer and Chandra Study of Variability in IC 348

Principal Investigator: Kevin Flaherty
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Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 21.5

Abstract:
While most of our knowledge of circumstellar disks is based on single snapshots of many systems, their evolution is in fact highly dynamic on short timescales. We propose to monitor a cluster of young stars at 3.6 and 4.5 micron with Spitzer, as well as in the X-ray with Chandra, in order to trace infrared variability on timescales of months to years as well as connect it with known sources of X-ray variability. Previous observations have found that many young stellar objects fluctuate in as little as a few days. Possible sources of this variability include variable heating by X-ray, accretion or stellar flux, dynamical interactions with the stellar magnetic field or perturbations from a possibly planetary-mass companion embedded in the disk. Coordinated Spitzer and Chandra observations, along with supporting data tracing the accretion and stellar flux, will be able to put strong constraints on the source of the variability and study the importance of X-rays in setting the disk structure. This type of multi-wavelength multi-epoch campaign has not been performed in the past and has the potential to greatly advance our understanding of young stellar object evolution.

Spitzer Space Telescope - General Observer Proposal #90141

Understanding Protoplanetary Disk Structure through the Timescale of its Variability

Principal Investigator: Kevin Flaherty
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S. Thomas Megeath, University of Toledo
Elise Furlan, IPAC
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Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 26.5

Abstract:
While most of our knowledge of protoplanetary disks is based on single snapshots of many systems, their evolution is in fact highly dynamic on short timescales. Previous surveys have found that the majority of young stellar objects are variable in the infrared, due to large structural perturbations of the inner disk, over the course of weeks and months. These studies of large samples of objects over two month observing windows have not been able to completely constrain the physical source of these fluctuations. We propose to use the variability timescale as a novel method for understanding the underlying physics processes setting the protoplanetary disk structure. With roughly one observation per day for 200 days, a more intensive monitoring campaign than has been previously attempted, we can distinguish between variability on the stellar rotation period (related to variable heating by star spots), the dynamical timescale (related to MRI effects and perturbation by a companion) and the thermal timescale (related to thermal waves in the disk). By focusing on a small field within the 2 Myr Chameleon star-forming region, we will obtain detailed light curves for ~16 young stellar objects, including a 15 Jupiter mass brown dwarf with a disk. This type of intensive, long baseline monitoring has not been attempted in the past, is only feasible with the observing capabilities of Spitzer, and has the potential to greatly advance our understanding of young stellar object evolution.

Spitzer Space Telescope - General Observer Proposal #70172

Circumstellar disk heating II: linking stellar X-ray flares with IR disk afterglows on timescales from hours to months

Principal Investigator: Jan Forbrich
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Maria Morales, Caltech
Barbara Whitney, Space Science Institute
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Bettina Posselt, SAO

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.0

Abstract:
We propose to study the young cluster GGD 12-15 to test theoretical predictions of X-ray heating in circumstellar disks, leveraging extensive mid-IR light curves to be obtained via our Spitzer Warm Mission program YSOVAR. With contemporaneous X-ray/mid-IR light curves, we will: 1) test if YSO X-ray and mid- IR variability are correlated, indicating that stellar X-rays significantly heat disks, and 2) test if disk accretion rates rise in the days and weeks following stellar X-ray flares, as expected from disk accretion models. Supplementary Spitzer observations will expand the scope of the program to shorter timescales. Ancillary science includes the identification of weak-line T Tauri stars to study their mid-IR variability and the LX-rotation of protostars, using mid-IR periods.

Spitzer Space Telescope - Snapshot Proposal #10139

Probing Pre-Supernova Mass Loss With Circumstellar Dust Shells

Principal Investigator: Ori Fox
Institution: UC Berkeley

Technical Contact: Ori Fox, UC Berkeley

Co-Investigators:
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Mike Skrutskie, University of Virginia
Schuyler van Dyk, IPAC
Pat Kelly, UC Berkeley

Science Category: evolved stars/pn/sne
Hours Approved: 39.0
Priority: 2

Abstract:
Late-time (>100 day) mid-infrared (mid-IR) observations of supernovae (SNe) offer a valuable probe of the progenitor mass-loss. Already, this technique has been exemplified with the Type IIn subclass, which often have large, dusty, pre-existing shells formed in pre-SN eruptions. While other SN subclasses are generally thought of having relatively low density circumstellar environments, a growing number of objects in other subclasses now show evidence for significant pre-SN mass loss and similar mid-IR characteristics. Long after the SN radioactive tail disappears, warm dust can stay bright at mid-IR wavelengths due to alternative heating mechanisms, such as shocks. The success of Spitzer archival studies has already been highlighted by the work of several members of this team. Here we propose a SNAPSHOT survey of a well-studied and high-profile SN sample, extending over a range of subclasses, and including both recent and historical events with evidence of a dense CSM and/or dust. This program will (a) discover new SNe with warm dust and (b) monitor the evolution of warm dust in previously detected SNe. Expanding upon our previous mid-IR work on SNe IIn, these observations will probe the similarities in and differences between the subclasses’ circumstellar environments, pre-SN mass-loss, and ultimately, the progenitors themselves.

Spitzer Space Telescope - Snapshot Proposal #11053

Probing Pre-Supernova Mass Loss With Circumstellar Dust Shells

Principal Investigator: Ori Fox
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Science Category: evolved stars/pn/sne
Hours Approved: 40.7
Priority: 2

Abstract:
Late-time (>100 day) mid-infrared (mid-IR) observations of supernovae (SNe) offer a valuable probe of the progenitor system's mass-loss. Already, this technique has been demonstrated with the Type IIn subclass, which often have large, dusty, pre-existing shells formed in pre-SN eruptions. While other SN subclasses are thought of having relatively low density circumstellar environments, a growing number of objects in other subclasses now show evidence for significant pre-SN mass loss and similar mid-IR characteristics. Long after the SN radioactive tail fades, warm dust can stay bright at mid-IR wavelengths due to alternative heating mechanisms, such as shocks. Here we propose a SNAPSHOT survey of a well-studied and high-profile SN sample, extending over a range of subclasses, including both recent and historical events with evidence of a dense CSM and/or dust. This program will (a) discover new SNe with warm dust and (b) monitor the evolution of warm dust in previously detected SNe. Harnessing the success of our previous Spitzer programs, these observations will expand upon that work by probing the similarities in and differences between the subclasses' circumstellar environments, pre-SN mass-loss, and ultimately, the progenitors themselves.

Spitzer Space Telescope - Directors Discretionary Time Proposal #11183

V404 Cyg - an Interacting Black-Hole Low-Mass X-ray Binary

Principal Investigator: Ori Fox
Institution: UC Berkeley

Technical Contact: Ori Fox, UC Berkeley

Co-Investigators:
Jon Mauerhan, UC Berkeley
Melissa Graham, UC Berkeley

Science Category: Compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.5

Abstract:
This DDT proposal is prompted by the June 15, 2015 outburst of V404 Cyg, a black-hole (BH) low-mass X-ray binary (LMXB). This outburst stands out since it is the first black hole system with a measured parallax, lying at a distance of only 2.39+/-0.14 kpc. An extensive and loosely organized multi-wavelength campaign is already underway by the astronomical community. One of the missing pieces of the puzzle is the mid-infrared (IR). Combined with radio, optical, and X-ray data, the mid-IR will help to discriminate discriminate between an accretion disk, jet emission, or circumstellar dust scenarios. Spitzer offers a unique opportunity to observe at these wavelengths. Here we propose 4 very short (5-minutes at 3.6 and 4.5 micron) observations of IRAC photometry to search for the presence of warm dust and, if present, constrain the heating mechanism.

Spitzer Space Telescope - General Observer Proposal #12086

Mid-Infrared Signatures from Type Ia Supernovae Strongly Interacting with a Circumstellar Medium

Principal Investigator: Ori Fox
Institution: UC Berkeley

Technical Contact: Ori Fox, UC Berkeley

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.1
Priority: 2

Abstract:
Type Ia supernovae (SNe Ia) are well-known for their use as precise cosmological distance indicators due to a standardizable peak luminosity resulting from a thermonuclear explosion. A growing subset of SNe Ia, however, show evidence for interaction with a dense circumstellar medium during the first year post-explosion, and sometimes longer (SNe Ia-CSM). The origin of this dense CSM is unknown and suggests either a) the less typical single-degenerate progenitor scenario must be considered or b) the exploding star was not a thermonuclear explosion of a white dwarf at all (i.e., core-collapse). Mid-infrared (IR) observations, in particular, are critical for tracing the density profile of dust (and hence gas) in the surrounding CSM. Yet no Spitzer light curve exists for this subclass within the first year post-expolosion. Here we propose a "low-impact" (>8 weeks) ToO to obtain 3 epochs of Spitzer imaging of a SN Ia-CSM within 100 Mpc over 1 year post-explosion. The strength of this program is that it will be in conjunction with pre-approved multi-wavelength programs on HST/STIS/UV (GO 13649), Chandra/ASIS-S (#17500672), the Keck/LRIS optical spectrograph (#U037LA), and the RATIR visible/infrared robotic imager. Requiring only 2.1 hours of observation total, this program will not only distinguish between the SN explosion mechanisms, but also trace CSM interaction, constrain the progenitor mass loss history, and identify late-time heating mechanisms of warm dust.

Spitzer Space Telescope - General Observer Proposal #13130

Mid-Infrared Signatures from Type Ia Supernovae Strongly Interacting with a Circumstellar Medium

Principal Investigator: Ori Fox
Institution: STScI

Technical Contact: Ori Fox, STScI

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.1
Priority: 1

Abstract:
Type Ia supernovae (SNe Ia) are well-known for their use as precise cosmological distance indicators due to a standardizable peak luminosity resulting from a thermonuclear explosion. A growing subset of SNe Ia, however, show evidence for interaction with a dense circumstellar medium during the first year post-explosion, and sometimes longer (SNe Ia-CSM). The origin of this dense CSM is unknown and suggests either a) the less typical single-degenerate progenitor scenario must be considered or b) the exploding star was not a thermonuclear explosion of a white dwarf at all (i.e., core-collapse). Mid-infrared (IR) observations, in particular, are critical for tracing the density profile of dust (and hence gas) in the surrounding CSM. Yet no Spitzer light curve exists for this subclass within the first year post-expolosion. Here we propose a "low-impact" (>8 weeks) ToO to obtain 3 epochs of Spitzer imaging of a SN Ia-CSM within 100 Mpc over 1 year post-explosion. The strength of this program is that it will be in conjunction with pre-approved multi-wavelength programs on HST/STIS/UV (GO 13649), Chandra/ASIS-S (#17500672), the Keck/LRIS optical spectrograph (#U037LA), and the RATIR visible/infrared robotic imager. Requiring only 2.1 hours of observation total, this program will not only distinguish between the SN explosion mechanisms, but also trace CSM interaction, constrain the progenitor mass loss history, and identify late-time heating mechanisms of warm dust.

Spitzer Space Telescope - General Observer Proposal #14098

A Mid-IR Census of Dusty Supernovae From the Past Decade In Preparation for JWST

Principal Investigator: Ori Fox
Institution: STScI

Technical Contact: Ori Fox, STScI

Co-Investigators:
Jennifer Andrews, Arizona
Rick Arendt, NASA Goddard
Geoff Clayton, LSU
Eli Dwek, NASA Goddard
Alex Filippenko, UC Berkeley
Joel Johansson, Uppsala University, Sweden
Patrick Kelly, UC Berkeley
Kelsie Krafton, LSU
Tony Marston, STScI
Jon Mauerhan, UC Berkeley
Tamas Szalai, Fizikai Intezet, Hungary
Schuyler Van Dyk, IPAC

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 25.2
Priority: 2

Abstract:
Over the past decade, our team has shown that a surprising number of different supernova (SN) subclasses have members that exhibit mid-infrared (mid-IR) emission from warm dust at late times (>100 days post-explosion). This work has used Spitzer 3.6 and 4.5 micron imaging to constrain the dust origin and heating mechanisms, but a number of questions still remain. How much dust can SNe IIP produce in their ejecta? What progenitor can produce such extreme mass-loss events required to form the large, dense, pre-existing dust shells observed in so many cases? Many of these SNe remain bright today, in some cases more than a decade after discovery. Continued mid-IR monitoring is necessary to answer these questions by measuring the full extent of either the newly formed dust mass or pre-existing dust shell. Furthermore, Spitzer observations of both old and new SNe will provide up to date flux estimates as we prepare for continued observations with JWST. This proposal will cap off nearly a decade of work and bridge the gap to the first few cycles of JWST.

Spitzer Space Telescope - General Observer Proposal #60122

A Survey for Dust in Type IIn Supernovae

Principal Investigator: Ori Fox
Institution: University of Virginia

Technical Contact: Ori Fox, University of Virginia

Co-Investigators:
Michael Skrutskie, University of Virginia
Roger Chevalier, University of Virginia

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.4

Abstract:
We propose to carry out a Spitzer/IRAC mid-infrared survey for thermal dust emission in all observable Type IIn supernovae from the past 10 years. The source of the large amounts of dust observed in high redshift galaxies has remained uncertain for nearly 40 years. Despite the success of models in producing dust within supernova explosions, only a handful of supernovae show direct observational evidence for dust condensation, and these examples all yield 2-3 orders of magnitude less dust than predicted by the models. Recent observations suggest Type IIn supernovae may condense more dust than typical core-collapse events. Due to the small number of Type IIn events (2-3% of all core-collapse supernovae), there exist too little data to draw any unbiased conclusions concerning the nature of dust production in this particular subclass. The few dust forming Type IIn supernovae, however, show late-time infrared emission sometimes more than five or six years following their initial detection, making remnant archeology possible. While previous Spitzer/IRAC surveys have searched for dust in supernovae, none have targeted these Type IIn events. A Spitzer/IRAC follow-up survey of all observable Type IIn supernovae from the past ten years will determine the extent to which this subclass produces dust. Ground-based observations are insufficient. Spitzer/IRAC provides the necessary sensitivity at wavelengths spanning the peak of the blackbody emission from the warmest grains, as well as the tail-end emission from colder dust. With only 5 minutes of integration in both 3.6 and 4.5 micron bands, this survey is sensitive to dust in almost all of our targets given our flux estimates. In only 22.4 hours, we can obtain follow-up photometry in both bands for all positions of observable Type IIn supernovae discovered in the past ten years.

Spitzer Space Telescope - General Observer Proposal #80023

Constraining the Origin and Heating Mechanism of Dust in Type IIn Supernovae

Principal Investigator: Ori Fox
Institution: NASA Goddard Space Flight Center

Technical Contact: Ori Fox, NASA Goddard Space Flight Center

Co-Investigators:
Michael Skrutskie, University of Virginia
Roger Chevalier, University of Virginia
Samuel Harvey Moseley, NASA Goddard Space Flight Center

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.3

Abstract:
More than any other supernova subclass, Type IIn supernovae tend to exhibit late-time (>100 days) infrared emission from warm dust. Identifying the origin and heating mechanism of the dust provides an important probe of the supernova explosion, circumstellar environment, and progenitor system. Yet mid-infrared observations, which span the peak of the thermal emission, are rare. Two years ago, we executed a warm Spitzer survey (P60122) of sixty-eight Type IIn events from the past ten years. The survey uncovered nine supernovae with unreported late-time infrared excesses, in some cases more than 5 years post-explosion. From this single epoch of data, and ground-based optical data, we have determined the likely origin of the mid-infrared emission to be pre-existing dust that is continuously heated by optical emission generated by ongoing circumstellar interaction between the forward shock and circumstellar medium. Furthermore, we noticed an emerging trend suggests these supernovae ``turn off'' at ~1000-2000 days post-discovery once the forward shock overruns the dust shell. Now is the ideal time to build upon this work with a second epoch of observations, which will be necessary to constrain our models. If we catch even a single supernova turning off between the first and second epochs of observation, we will be able to both measure the size of the circumstellar dust shell and characterize of the supernova progenitor system. We can obtain all the necessary data in only 9.3 hours of observation. Our team has extensive experience in infrared supernovae observations. We have already published two papers on one Type IIn supernovae (SN 2005ip) and authored two successful proposal for Spitzer observations of this subclass. This is an ideal application for the Spitzer warm mission, as the 3.6 and 4.5 micron bands span the peak of the thermal emission and provide the necessary constraints on the dust temperature, mass, and luminosity.

Spitzer Space Telescope - General Observer Proposal #90031

A Search for the Missing Supernovae in Ultraluminous, Star Forming Galaxies

Principal Investigator: Ori Fox
Institution: UC Berkeley

Technical Contact: Ori Fox, UC Berkeley

Co-Investigators:
Alex Filippenko, UC Berkeley
Michael Skrutskie, University of Virginia
Rick Arendt, NASA Goddard Space Flight Center
Brad Cenko, UC Berkeley
Schuyler Van Dyk, Caltech

Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 300.0

Abstract:
Supernova (SN) rates serve as an important probe of star formation models and initial mass functions, particularly at high redshifts due to the SN intrinsic luminosity. Surveys typically discover nearly ten times fewer SNe than predicted, challenging our understanding of massive star formation and evolution. These results are generally attributed to the high dust extinction associated with the nuclei of star forming galaxies, such as Ultra Luminous InfraRed Galaxies (ULIRGs). Even near-infrared surveys have been unsuccessful due to extinction values exceeding A_V > 25 mag. Even on an 8-m AO system, subtraction algorithms used to find the SNe inevitably leave large residuals associated with the inner 2'' of the galactic nucleus, which is where a majority of the SNe occur. A successful survey must be conducted at longer wavelengths and with a space-based telescope, which has stable seeing that reduces the necessity for any subtraction algorithms and, therefore, residuals. Here we propose a Spitzer 3.6 micron survey for dust-extinguished SNe in the nuclear regions of ULIRGs within 200 Mpc. To obtain the necessary statistics, we show that we need to observe 41 galaxies over 2 years totaling 348 hours. Any fewer hours would not allow us to differentiate between the actual SN rates and counting statistics. The direct product of this study is an improved understanding of the connection between the far-IR luminosity of ULIRGs and massive star formation.

Spitzer Space Telescope - General Observer Proposal #90137

A Study of Massive Star Evolution and Mass Loss With Multi-Wavelength Observations of Type IIn Supernovae

Principal Investigator: Ori Fox
Institution: UC Berkeley

Technical Contact: Ori Fox, UC Berkeley

Co-Investigators:
Michael Skrutskie, University of Virginia
Roger Chevalier, University of Virginia
Nathan Smith, University of Arizona
Poonam Chandra, Tata Institute of Fundamental Research (TIFR)
Alex Filippenko, UC Berkeley

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5

Abstract:
Type IIn supernovae (SNe IIn) are a rare (<10%) subclass of SNe that exhibit narrow emission lines due to a dense, pre-existing circumstellar medium (CSM). Although all evidence points to massive star progenitors, the precise stellar type remains elusive since few observed stars and no theoretical models can reproduce the mass-loss characteristics. More confusing, the narrow lines and dense winds associated with SNe IIn have now been identified in an unexpectedly diverse list of subclasses, suggesting multiple progenitors may be responsible. Multi-wavelength observations, spanning the X-ray to the infrared (IR) to the radio regime, can probe various aspects of shock interaction and dust formation associated with the dense CSM for months to years after the radioactive emission fades. Such diagnostics probe the progenitor mass-loss history, CSM characteristics, and even the elusive SN shock breakout. Given the required coordination amongst space-based and large ground-based telescopes, however, existing data sets are sparse and insufficient. Here we submit a joint Spitzer/Chandra proposal to trace the mass-loss history of SNe IIn with a thorough, coordinated, multi-wavelength approach. With guaranteed time on Keck and JVLA already at our disposal and an aligned team of SNe IIn experts spanning all wavelengths, now is the time for such a program.

Spitzer Space Telescope - General Observer Proposal #90174

Constraining the Origin and Heating Mechanism of Dust in Type IIn Supernovae

Principal Investigator: Ori Fox
Institution: UC Berkeley

Technical Contact: Ori Fox, UC Berkeley

Co-Investigators:
Michael Skrutskie, UC Berkeley
Alex Filippenko, UC Berkeley

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.1

Abstract:
More than any other supernova subclass, Type IIn supernovae tend to exhibit late-time (>1 year) infrared emission from warm dust. Identifying the origin and heating mechanism of the dust provides an important probe of the supernova explosion, circumstellar environment, and progenitor system. Yet mid-infrared observations, which span the peak of the thermal emission, are rare. Three years ago, we executed a warm Spitzer survey (P60122) that uncovered a unique sample of ten supernovae with unreported late-time infrared excesses, in some cases more than 5 years post-explosion. The data from this single epoch are most consistent with a pre-existing dust shell that is continuously heated by visible and/or X-ray emission generated by ongoing shock interaction. Furthermore, the lack of any detections beyond ~2000 days suggests the dust is destroyed once the forward shock overruns the pre-existing shell. The actual shell sizes remain unknown, however, since the derived blackbody radii offer only lower limits. Last year, we obtained second epoch observations of these ten re-discovered SNe IIn (plus the well-studied Type IIn SN 2010jl). The project aimed for non-detections to constrain the light-curve ``turn-off'' times and, thereby, the shell sizes and progenitor mass-loss models. Only two SNe (2005gn and 2008J), however, went undetected. The other nine SNe remain bright at mid-IR wavelengths, which means the dust shell radii are larger than expected. Here we propose continued monitoring of these nine SNe IIn to constrain the size of the circumstellar dust shell and characterize the supernova progenitor system. We can obtain all the necessary data in only 6.1 hours of observation.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13245

Maximizing JWST GTO Observations of HAT-P-26b with Time-Critical Spitzer Eclipse Measurements

Principal Investigator: Jonathan Fraine
Institution: STScI

Technical Contact: Jonathan Fraine, STScI

Co-Investigators:
Kevin Stevenson, STScI
Hannah Wakeford, STScI
Heather Knutson, CalTech
Nicole Wallack, CalTech
Jayesh Goyal, University of Exeter
David Sing, University of Exeter
Nikole Lewis, STScI
Jeff Valenti, STScI
Natasha Batalha, STScI
Giovanni Bruno, STScI
Brian Kilpatrick, Brown University
Tom Greene, NASA Ames

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 32.9

Abstract:
We propose to observe the Neptune-mass exoplanet HAT-P-26b with Spitzer-IRAC at 4.5 microns (CH2) over 4 eclipses to achieve a statistically-significant eclipse depth SNR of at least 4 sigma (<50 ppm uncertainty). Extant data yield a tentative (<3 sigma) detection that requires additional observations to obtain more precise orbital constraints. These observations will be crucial in executing multiple JWST GTO programs because we do not currently have a precise constraint on HAT-P-26b's time of secondary eclipse. The approved JWST GTO programs, which will spectroscopically probe the dayside atmosphere of HAT-P-26b, have scheduled several 6.5 hour spectroscopic eclipse observations; with an eclipse duration of 2.5 hours and only 4 hours of baseline, precisely knowing the time of eclipse is pivotal to the success of these observations. The long-term legacy value of our Spitzer observations will be to perform a critical role in maximizing the observational efficiency of several JWST GTO exoplanet programs by definitively confirming the time of secondary eclipse.

Spitzer Space Telescope - General Observer Proposal #12099

Dust in the interacting transient SN 2009ip

Principal Investigator: Morgan Fraser
Institution: University of Cambridge

Technical Contact: Morgan Fraser, University of Cambridge

Co-Investigators:
Rubina Kotak, Queens University Belfast
Seppo Mattila, University of Turku

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.3
Priority: 2

Abstract:
For the first time in the history of astronomy we have monitored a star for many years before it has (probably) exploded as a supernova. SN 2009ip was first discovered as a giant outburst of a luminous blue variable star in 2009, and three years later an explosive event caused it to reach SN luminosities of M_V ? ?18, and a bolometric luminosity of 10E43 erg/s. In late 2016, we will reobserve the site of SN 2009ip with the Hubble Space Telescope, to test if it has faded below the magnitude of the progenitor. Complementary Spitzer observations will allow us to detect thermal emission from any newly formed dust, which could act to obscure the progenitor of SN 2009ip, and will for the first time allow us to place limits on the dust production from such a massive star.

Spitzer Space Telescope - General Observer Proposal #60010

The Hubble Constant

Principal Investigator: Wendy L. Freedman
Institution: Carnegie Institution of Washington

Technical Contact: Jane R. Rigby, Carnegie Institution of Washington

Co-Investigators:
Barry Madore, OCIW
Jane Rigby, OCIW
Eric Persson, OCIW
Violet Mager, OCIW
Laura Sturch, OCIW

Science Category: cosmology
Observing Modes: IracPostCryoMap
Hours Approved: 705.0

Abstract:
We present a plan to measure a value of the Hubble constant having a final systematic uncertainty of only 3% by taking advantage of Spitzer's unique mid-infrared capabilities. This involves using IRAC to undertake a fundamental recalibration of the Cepheid distance scale and progressively moving it out to pure Hubble flow by an application of a revised mid-IR Tully-Fisher relation. The calibration and application, in one coherent and self-consistent program, will go continuously from distances of parsecs to several hundred megaparsecs. It will provide a first-ever mid-IR calibration of Cepheids in the Milky Way, LMC and Key Project spiral galaxies and a first-ever measurement and calibration of the TF relation at mid- infrared wavelengths, and finally a calibration of Type Ia SNe. Most importantly this program will be undertaken with a single instrument, on a single telescope, working exclusively at mid-infrared wavelengths that are far removed from the obscuring effects of dust extinction. Using Spitzer in this focused way will effectively eliminate all of the major systematics in the Cepheid and TF distance scales that have been the limiting factors in all previous applications, including the HST Key Project. By executing this program, based exclusively on Spitzer data, we will deliver a value of the Hubble constant, having a statistical precision better than ±1%, with all currently known systematics quantified and constrained to a level of less than 3%. A value of Ho determined to this level of systematic accuracy is required for up-coming cosmology experiments, including Planck. A more accurate value of the Hubble constant will directly result in other contingently measured cosmological parameters (e.g., Omega_m, Omega_L, & w) having their covariant uncertainties reduced significantly now. Any further improvements using this route will have to await JWST, for which this study is designed to provide a lasting and solid foundation, and ultimately a value of Ho accurate to 2%.

Data from this program was split into multiple PIDs. You can find the data in program IDs 60010, 61000, 61001, 61002, 61003, 61004, 61005, 61006, 61007, 61008, 61009

Spitzer Space Telescope - General Observer Proposal #90002

The Carnegie RR Lyrae Program

Principal Investigator: Wendy Freedman
Institution: OCIW

Technical Contact: Vicky Scowcroft, Carnegie Institution of Washington

Co-Investigators:
David Law, University of Toronto
Barry Madore, Carneige Observatories
Victoria Scowcroft, Carnegie Observatories
Gisella Clementini, INAF Bologna
Maria-Rosa Cioni, University of Hertfordshire
Roeland van der Marel, Space Telescope Science Institute
Andrzej Udalski, Warsaw University Observatory
Grzegorz Pietrzynski, Warsaw University Observatory
Igor Soszynski, Warsaw University Observatory
David Nidever, University of Virginia
Nitya Kallivayalil, Yale University
Gurtina Besla, Columbia University
Steve Majewski, University of Virginia
Andy Monson, Carnegie Observatories
Mark Seibert, Carnegie Observatories
Horace Smith, Michigan State University
George Preston, Carnegie Observatories
Juna Kollmeier, Carnegie Observatories
Kathryn Johnston, Columbia University
Giuseppe Bono, Universita di Roma Tor Vergata
Massimo Marengo, Iowa State University
Eric Persson, Carnegie Observatories
Ian Thompson, Carnegie Observatories

Science Category: stellar populations
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 779.0

Abstract:
The Carnegie RR Lyrae Program is designed to take maximum advantage of the ultra-high-precision, mid-infrared Period-Luminosity relation for RR~Lyrae variables. A zero point, slope and width of the RR Lyrae PL relation will be derived from existing HST trigonometric parallaxes of 4 RR~Lyrae stars; in future Gaia will observe an order of magnitude more calibrators. Individual distances will be obtained with Spitzer having a precision of 2% per star. Systematic extinction effects will be reduced by a factor of 4 over other on-going near-infrared surveys, and 20 times below V-band optical surveys. Systematics due to metallicity variations will also be significantly reduced by moving to the mid-IR. With Spitzer we will establish a self-consistent distance scale to 31 Galactic globular clusters, map the complex 3-dimensional structure of the bulge and halo of the Milky Way, derive a robust and accurate distance to the nearest high-mass black hole at the center of our galaxy, calibrate the tip of the red giant branch (TRGB) luminosity, thereby establishing a pure Population II distance scale out to and including galaxies with Type Ia supernovae, and ultimately probing the pure Hubble flow, providing a totally independent determination of the Hubble constant decoupled from and complementary to the Cepheid distance scale. Leveraging decades of dedicated ground-based surveys aimed at addressing many of the important problems listed above, Spitzer can, within a one-year timeline, address them all with the highest precision and with the lowest systematic uncertainty, because 1) it is operating at the longest available wavelengths, 2) it can be efficiently scheduled and 3) all of the foundations have already been laid. The timing could not be better.

Data from this program was split into multiple PIDs. You can find the data in program IDs 90002, 90088, 90089, 90090

Spitzer Space Telescope - General Observer Proposal #60095

The IRAC-ORELSE Survey: Galaxy Masses in Large Scale Structures at z=1

Principal Investigator: Roy Gal
Institution: University of Hawaii

Technical Contact: Roy Gal, University of Hawaii

Co-Investigators:
Lori Lubin, University of California, Davis
Gordon Squires, Spitzer Science Center
Dale Kocevski, University of California, Davis
Brian Lemaux, University of California, Davis
Mark Lacy, Spitzer Science Center
Jason Surace, Spitzer Science Center

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 59.8

Abstract:
We propose an IRAC mapping campaign of 14 large scale structures at 0.7 < z < 1.3 to obtain stellar mass estimates and photometric redshifts for their constituent galaxies. As part of the Observations of Redshift Evolution in Large Scale Environments (ORELSE) Survey, these clusters represent a mix of confirmed X-ray, optically and radio selected systems. They range from multi-group mergers to superclusters with multiple clusters and groups, all with existing deep rizK_s imaging and are the subjects of a Keck-DEIMOS survey that has already yielded thousands of high-resolution spectra of constituent galaxies. The wide-area regions around high redshift clusters are are dynamic environments where galaxies are undergoing many transformative events, including mergers, tidal encounters, harassment and ram pressure stripping. By targeting known structures at an active period in their history, we can efficiently examine the physical processes responsible for the quenching and/or ignition of star formation and AGN activity, and the transformation of disk (spiral) galaxies to spheroids (ellipticals) over the last ~9 Gyr as a function of both environment and galaxy stellar mass. In comparison, field surveys such as COSMOS encounter only one such structure, while our targeted approach is an efficient means of generating a statistically significant sample. The IRAC data is essential to accurately determine photometric redshifts and estimate stellar masses for the full galaxy population in each structure.

Spitzer Space Telescope - General Observer Proposal #60166

Late-Time Light from Type Ia Supernovae

Principal Investigator: Peter Garnavich
Institution: University of Notre Dame

Technical Contact: Peter Garnavich, University of Notre Dame

Co-Investigators:
Peter Milne, University of Arizona
Ryan Foley, Center for Astrophysics
Kevin Krisciunas, Texas A&M
Howie Marion, Texas A&M
Michael Wood-Vasey, Univ. Pittsburgh
Bradley Tucker, Austrailian National Univ.
Thomas Matheson, NOAO

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.0

Abstract:
We propose to study the physics of type Ia supernovae at late and very-late phases of their evolution. Type Ia events produce radioactive elements that keep the expanding debris glowing for years after the explosion. Between one and three months after maximum, nearly all type Ia events have identical colors in optical bands: the Lira law. This is surprising and useful as it is not predicted by models but empirically allows dust reddening to be reliably measured. The colors in the infrared are not as well known and we propose to obtain multi-band light curves of three type Ia events during this "Lira law" phase. These will be low-impact ToO observations triggered near maximum light with observations 5 weeks later. At very late times (>200 days) the supernova light is driven by positrons from the radioactive decay and the light curve becomes sensitive to the magnetic environment in the debris. As the type Ia ages, near-IR data suggest that more and more of the luminosity comes out at long wavelengths. We propose to observe SN2008Q and another nearby supernova to determine the fraction of bolometric luminosity coming from the mid-IR. These observations will be supported with an extensive network of ground-based telescopes.

Spitzer Space Telescope - General Observer Proposal #80126

Late-Time Light from Type Ia Supernovae

Principal Investigator: Peter Garnavich
Institution: University of Notre Dame

Technical Contact: Peter Garnavich, University of Notre Dame

Co-Investigators:
Peter Milne, University of Arizona
Colin McClelland, University of Notre Dame

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.5

Abstract:
We propose to study the physics of type Ia supernovae at late and very-late phases of their evolution. Type Ia events synthesize radioactive elements that keep the expanding debris glowing for years after the explosion. Our Spitzer observations combined with archival images show a wide range of mid-IR luminosities between 100 and 200 days after maximum light while optical light curves are very uniform. The IRAC bands appear be quite sensitve to ionization and excitation differences caused by density variations in the supernova nebulae. Beyond 200 days the energetics are driven by positrons alone and the light curve becomes sensitive to the magnetic environment of the debris. Dust formation, as confirmed in SN 2009dc with our Cycle 6 observations, or an IR catastrophe may also be important at very late times. We propose to observe five type Ia supernovae at late epochs with Spitzer. SN 2010ih, 2010eb and 2011B are nearby events that can be classically scheduled. We also request low-impact target-of-opportunity observations for two supernovae to be discovered during the cycle.

Spitzer Space Telescope - General Observer Proposal #90179

Portrait of a Giant HII Bubble: Star Formation Processes in the Cepheus Loop

Principal Investigator: Konstantin Getman
Institution: Pennsylvania State University

Technical Contact: Konstantin Getman, Pennsylvania State University

Co-Investigators:
Eric Feigelson, Pennsylvania State University
Aurora Sicilia-Aguilar, Universidad de Madrid
Patrick Broos, Pennsylvania State University
Michael Kuhn, Pennsylvania State University
Gordon Garmire, Pennsylvania State University

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.2

Abstract:
Giant HII regions represent the dominant model of star formation (SF) in the Galaxy, and the Cepheus Loop is an excellent nearby prototype for giant, asymmetric HII bubbles. We propose a Spitzer/IRAC mosaic of the rich and compact principal ionizing cluster Be59 and its parental cloud. These Spitzer data in conjunction with our X-ray, archival IR, and follow-up optical data will allow us: 1) to search for and characterize a suspected older generation of stars that could have both carved the Cepheus Loop and induced the formation of Be59, and 2) to quantify recent and current SF in Be59 and numerous cloudlets and pillars. This study will test an important model for the morphology and evolution of asymmetric bubbles and advance our understanding of the effect of SF that is layered in time and space on the SF rate in giant Galactic bubbles.

Spitzer Space Telescope - General Observer Proposal #10107

The Origin of Metals in Extremely Low Mass White Dwarfs

Principal Investigator: Alexandros Gianninas
Institution: University of Oklahoma

Technical Contact: Alexandros Gianninas, University of Oklahoma

Co-Investigators:
Mukremin Kilic, University of Oklahoma
Warren R. Brown, Smithsonian Astrophysical Observatory

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.8
Priority: 1

Abstract:
Over the course of several years, we have discovered more than 50 extremely low mass white dwarfs with surface gravities ranging from log g ~ 5.0 to log g ~ 7.0. Furthermore, radial velocity measurements confirm that all of these white dwarfs are in short period (P < 1 day) merging binary systems. In addition, we detect absorption lines due to Ca in all of the extremely low mass white dwarfs with log g < 6.0. Just like their higher mass counterparts, we expect that the source of these metals is accretion of material from a surrounding debris disk. Given the binary separation of < 1 Rsun, such a disk would have to be circumbinary. Here, we propose to obtain IRAC band 1 and 2 imaging of 22 extremely low mass white dwarfs with Ca lines in their spectra to detect the presence of debris disks through infrared excess. If confirmed, these would be the first circumbinrary disks ever detected around white dwarfs. This would demonstrate that planets and debris disks can form in very unusual environments. Consequently, this would open a window into studying the evolution of planetary systems in short period binary systems after the host stars have undergone one or more phases of common-envelope evolution. Most of our targets will start mass transfer in several Gyr, and potentially create faint supernovae .Ia explosions. Our observations will help us understand the environments in which these explosions take place.

Spitzer Space Telescope - Directors Discretionary Time Proposal #11180

A 4 Earth-mass Planet Transiting a Naked-Eye Star?

Principal Investigator: Michael Gillon
Institution: University of Liege

Technical Contact: Michael Gillon

Co-Investigators:
Brice-Olivier Demory, Cambridge
David Charbonneau, Harvard
Andrew Collier Cameron, St Andrews
David Latham, Harvard
Christophe Lovis, Geneva Observatory
Emilio Molinari, IAC
Fatemeh Motalebi, Geneva Observatory
Francesco Pepe, Geneva Observatory
Stephane Udry, Geneva Observatory

Science Category: Extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.5

Abstract:

Doppler surveys and the Kepler space mission have revealed "super-Earths", i.e. planets of a few Earth masses, to be very frequent around solar-like stars, while being notably absent from our solar system. Improving our understanding of these ubiquitous planets requires the detection of a significant sample of them in transit in front of very nearby stars, to make possible the detailed exploration of their atmospheric composition. The most efficient method to achieve this goal remains to search for the transits of the low-mass planets detected by Doppler surveys, as exemplified by the cases of 55 Cnc e and HD 97658b which are the only two super-Earths orbiting solar-type stars that are amenable for detailed atmospheric characterization with existing and near-future facilities. In this context, we propose here to use the exquisite photometric precision of Spitzer to search for the transit of a new short-period (~3d) low-mass (~4 Earth masses) super-Earth that we have just detected with the recently commissioned HARPS-N spectrograph. This planet orbits at <0.04 au of an extremely nearby (6.5pc) naked-eye (V=5.6) early K-dwarf, resulting in a transit probability better than 9%. If transiting, the extreme infrared brightness (K=3.25) and the small size (0.78 solar radius) of the host star will make possible the first detailed atmospheric characterization of an exoplanet of a few Earth-masses.

Spitzer Space Telescope - General Observer Proposal #12031

A Multiple-Transiting Super-Earth System at 6.5pc ?

Principal Investigator: Michael Gillon
Institution: University of Liege

Technical Contact: Michael Gillon, University of Liege

Co-Investigators:
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David Charbonneau, Harvard University
Andrew Collier Cameron, University of St-Andrews
David Latham, Harvard University
Christophe Lovis, University of Geneva
Emilio Molinari, INAF
Fatemeh Motalebi, University of Geneva
Francesco Pepe, University of Geneva
Damien Segransan, University of Geneva
Stephane Udry, University of Geneva

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 29
Priority: 1

Abstract:
We recently detected a compact multi-planetary system orbiting the very nearby K-dwarf HD219134, including a transiting 3.1d-period super-Earth for which we measured a mass and radius consistent with a rocky composition. Thanks to the extreme brightness and small size of its host star, this planet is a prime target for the detailed characterization of an extrasolar rocky world. We aim to initiate this characterization by measuring one more transit of the planet with Spitzer, to refine the constraints on its composition and orbit, and to drastically improve the transit ephemeris, which is crucial for future follow-up studies with, e.g., JWST. Furthermore, the transiting nature of this planet, HD219134b, indicates that the system is seen nearly edge-on, resulting in significantly increased transit probability for the other planets. This is especially true for HD219134c, another super-Earth orbiting the star every 6.7d, for which the updated transit probability is above 20%. We aim to monitor its full transit window with Spitzer, with a precision high enough to firmly detect or discard its transiting configuration for any plausible composition. A detection would provide us with the opportunity to apply the approach of comparative planetology, so successful in the study of our solar system, to shed new light on the origin and evolution of the ubiquitous compact systems of super-Earths.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12126

On the eclipsing binary nature of a nearby ultracool dwarf

Principal Investigator: Michael Gillon
Institution: University of Liege

Technical Contact: Michael Gillon, University of Liege

Co-Investigators:
Julien de Wit, MIT
Emmanuel Jehin , University of Liege
Artem Burdanov, University of Liege
Valerie Van Grootel, University of Liege
Laetitia Delrez, University of Liege
Pierre Magain, University of Liege
Adam Burgasser, UC San Diego
Brice-Olivier Demory, University of Cambridge
Amaury Triaud, University of Cambridge
Didier Queloz, University of Cambridge
Sue Lederer, NASA

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5.7

Abstract:
The eclipsing binary nature of a nearby ultracool dwarf has just been revealed. The aim of this DDT is to investigate this nearby system further through high-precision infrared time-series photometry.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12130

On the eclipsing binary nature of a nearby ultracool dwarf

Principal Investigator: Michael Gillon
Institution: University of Liege

Technical Contact: Michael Gillon, University of Liege

Co-Investigators:
Emmanuel Jehin, University of Liege
Julien de Wit, MIT
Brice-Olivier Demory, Cambridge
Adam Burgasser, UCSD
Valerie Van Grootel, University of Liege
Susan Lederer, NASA
Amaury Triaud, Cambridge
Laetitia Delrez, University of Liege
Artem Burdanov, University of Liege
Didier Queloz, Cambridge
Pierre Magain, University of Liege

Science Category: Extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 32.5

Abstract:
The eclipsing binary nature of a nearby ultracool dwarf has just been revealed. The aim of this DDT is to investigate this nearby system further through high-precision infrared time-series photometry.

Spitzer Space Telescope - General Observer Proposal #13057

Search for the transit of a nearby 2 Earth-mass planet

Principal Investigator: Michael Gillon
Institution: University of Liege

Technical Contact: Michael Gillon, University of Liege

Co-Investigators:
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Alessandro Sozzetti, INAF - Osservatorio Astrofisico di Torino, Italy

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.0
Priority: 1

Abstract:
The frontier of exoplanetology is being pushed to the identification of Earth-sized exoplanets well-suited for detailed characterization with future observatories, notably with JWST. Transit searches targeting nearby M-dwarfs are at the forefront of this effort. Indeed, the favorable planet-star contrast ratios of M-dwarfs enable the best opportunities in the near-future for detailed characterization studies of transiting terrestrial planets and their atmospheres. In this context, we propose here to use the exquisite photometric precision of Spitzer to search for the transit of a new short-period (2.6d) very-low-mass (2 Earth-mass) super-Earth that we have just detected with the HARPS-N spectrograph. This planet orbits at <0.03 au of a nearby (18pc) M1-type dwarf, resulting in a transit probability of 8%. A transit detection would make possible to discriminate metal-rich, silicate rich, and ice-rich planetary compositions, and to test further the hypothesis that the population of dense, close-in planets of 1-6 Earth-mass can be described by a fixed Earth-like compositional model. Furthermore, it would make the planet join the handful of super-Earths well-suited for detailed atmospheric characterization with JWST, thanks to the infrared brightness (K=6.8) and the small size (0.5 solar radius) of its M-dwarf host star.

Spitzer Space Telescope - Exploration Science Proposal #13067

Red worlds: Spitzer exploration of a compact system of temperate terrestrial planets transiting a nearby Jupiter-sized star

Principal Investigator: Michael Gillon
Institution: University of Liege

Technical Contact: Michael Gillon, University of Liege

Co-Investigators:
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Laetitia Delrez, University of Liege, Belgium
Emmanuel Jehin, University of Liege, Belgium
Pierre Magain, University of Liege, Belgium
Valerie Van Grootel, University of Liege, Belgium
Emeline Bolmont, University of Namur, Belgium
Jeremy Leconte, University of Bordeaux, France
Sean Raymond, University of Bordeaux, France
Franck Selsis, University of Bordeaux, France
Brice-Olivier Demory, University of Cambridge, UK
Didier Queloz, University of Cambridge, UK
Amaury Triaud, University of Cambridge, UK
Julien de Wit, MIT, USA
Adam Burgasser, UCSD, USA
Sean Carey, SSC - IPAC, USA
Jim Ingalls, SSC - IPAC, USA
Sue Lederer, NASA Johnson Space Center, USA
Eric Agol, University of Washington, USA
Katherine Deck, Caltech, USA

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1000.0
Priority: 1

Abstract:
The recently detected TRAPPIST-1 planetary system represents a unique opportunity to extend the nascent field of comparative exoplanetology into the realm of temperate terrestrial worlds. It is composed of at least three Earth-sized planets similar in sizes and irradiations to Earth and Venus transiting an ultra-cool dwarf star only 39 light-years away. Thanks to the Jupiter-size and infrared brightness of their host star, the planets are amenable for detailed atmospheric characterization with JWST, including for biosignatures detection. Our Spitzer Exploration Science Program aims to prepare and optimize the detailed study of this fascinating planetary system through the two following complementary sub-programs: (1) a 480 hrs continuous monitoring of the star to explore its full inner system up to its ice line in a search for any other transiting object(s) (planet, moon, Trojan) with a sensitivity high enough to detect any body as small as Ganymede, and (2) the observation of ~130 transits of the planets (520 hrs). This second part has two goals. First, to measure precisely the planets' masses and eccentricities through the Transit Timing Variations method, to constrain strongly their compositions and energy budgets. Secondly, to measure with an extremely high precision the planets' effective radii at 4.5 microns to assess, when combined with future HST/WFC3 observations, the presence of an atmosphere around them. The two complementary parts of this program will make it a long-lasting legacy of Spitzer to the fields of comparative exoplanetology and astrobiology, by providing the necessary measurements on the inner system of TRAPPIST-1 (complete census, masses, eccentricities, first insights on atmospheres) required to initiate and optimize the detailed atmospheric characterization of its different components with JWST and other future facilities.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13158

Search for the transits of super-Earths orbiting nearby M-dwarfs

Principal Investigator: Michael Gillon
Institution: University of Liege

Technical Contact: Michael Gillon, Liege

Co-Investigators:
Sean Carey, Caltech/IPAC-Spitzer
Julien de Wit, MIT
Jim Ingalls, Caltech/IPAC-Spitzer

Science Category: exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 50.1

Abstract:
The field of transiting extrasolar planets has recently focused more and more on the search for potentially terrestrials planets transiting host stars nearby and small enough to make possible their detailed atmospheric characterization with JWST and other upcoming facilities. A straightforward approach to detect such highly interesting exoplanets is the search for the transits of low-mass planets first detected around nearby M-dwarfs by Doppler surveys. In the context, we propose to use Spitzer to search for the transits of four short-period planets of 1-2 Earth masses whose detection by radial velocity has just been announced. If caught in transit by Spitzer, each of these planets would become a new Rosetta stone for our understanding of the large population of short-period low-mass planets orbiting the ubiquitous red dwarfs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #60027

Detecting the Transits of Nearby Super-Earths

Principal Investigator: Michael Gillon
Institution: Geneva University

Technical Contact: Michael Gillon, Geneva University

Co-Investigators:
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Christophe Lovis, Geneva University
Michel Mayor, Geneva University
Francesco Pepe, Geneva University
Didier Queloz, Geneva University
Stephane Udry, Geneva University
Xavier Bonfils, Grenoble University
Xavier Delfosse, Grenoble University
Thierry Forveille, Grenoble University
Sara Seager, Massachusetts Institute of Technology
Drake Deming, NASA's Goddard Space Flight Center
Joseph Harrington, University of Central Florida

Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Approved: 100.0

Abstract:
We have an amazing opportunity to change the field of exoplanet characterization by finding Super-Earths transiting bright nearby stars. Our HARPS radial-velocity survey has detected more than 50 low-mass planets in the solar vicinity, most of them being short period Super-Earths having a large transit probability. We propose an Exploration Science Program of 500 hours to detect the few of them that transit their host star. These detections will bring exoplanetology into the realm of terrestrial planets. The expected harvest of the proposed project is the detection of 1 - 2 transiting Super-Earths and 1 transiting hot Neptune. Future ambitious transit surveys like Kepler should detect much more low-mass planets, but the faintness of the target stars means thorough characterization of detected Kepler planets will not be possible with existing or near-future instruments like JWST. On the contrary, the few planets that will be detected by the proposed project all will be exquisite targets for high S/N follow-up studies. In particular, they will enable the first studies of the atmospheric properties and habitability of terrestrial extrasolar planets.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80231

The first detection of the thermal emission from a solid exoplanet

Principal Investigator: Michael Gillon
Institution: University of Liege

Technical Contact: Brice-Olivier Demory, MIT

Co-Investigators:
Drake Deming, University of Maryland
Brice-Olivier Demory, MIT
Brian Jackson, NASA Goddard SFC
Bjoern Benneke, MIT
Sara Seager, MIT

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.0

Abstract:
We propose to use Spitzer to perform the historical first detection of the emission from a solid extrasolar planet. Our team has recently detected with Spitzer the transit of the planet 55 Cnc e, the first 'super-Earth' transiting a nearby solar-type star, and thus amenable for a thorough characterization. Our measured radius, confirmed afterwards by MOST transit photometry, favors a solid planet composed or rock and volatiles. Its closest counterparts in our solar system are the rock+ice cores of Neptune and Uranus, but the value of this comparison is certainly limited. Measuring the brightness temperature of 55 Cnc e will allow us to constrain its heat distribution efficiency, bulk and atmospheric compositions, and thus to improve our understanding of its mysterious nature.

Spitzer Space Telescope - General Observer Proposal #90072

Understanding Other Worlds with Spitzer: From Hot Jupiters to Super-Earths

Principal Investigator: Michael Gillon
Institution: University of Liege

Technical Contact: Michael Gillon, University of Liege

Co-Investigators:
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Nikku Madhusudhan, Yale University
David Anderson, Keele University
Brice-Olivier Demory, Massachusetts Institute of Technology
Sara Seager, Massachusetts Institute of Technology
David Ehrenreich, Geneva University
Christophe Lovis, Geneva University
Michel Mayor, Geneva University
Francesco Pepe, Geneva University
Stephane Udry, Geneva University
Didier Queloz, Geneva University
Andrew Collier-Cameron, University of St-Andrews
Don Pollacco, University of Warwick
Peter Wheatley, University of Warwick
John Rostron, University of Warwick
Barry Smalley, Keele University
Coel Hellier, Keele University
Pierre Maxted, Keele University
Deepak Mahtani, Keele University
Alexis Smith, Keele University
Xavier Bonfils, Grenoble University
Diana Dragomir, University of British Columbia

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 300.0

Abstract:
The intense study of transiting exoplanets over the past decade has begun to unveil the vast diversity of planetary systems in the Milky Way and to place our own solar system in perspective. Notably, ground-based Doppler and transit surveys are finding at an increasing pace planets suitable for detailed characterization. These planets around bright stars fall into two distinct families providing exciting new avenues at the frontiers of exoplanetary science. On one hand are the numerous highly irradiated gas giants whose atmospheres can be studied in great detail with a wide range of existing instruments from space and ground, notably their temperature profiles, chemical compositions, energy transport efficiencies, and atmospheric circulation patterns. On the other hand are the small but growing list of ‘super-Earths’ around bright stars for which the first detections of transits and atmospheric signatures are becoming available. The Spitzer space telescope has played a prominent role in both these areas through a plethora of ground-breaking results, many involving members of our team. Our proposed Exploration Science program with Spitzer aims to pursue major advancements in the nascent field of comparative exoplanetology with a two-pronged approach focused on these two exoplanet families. On the one hand, we will use Spitzer to thoroughly characterize a large and diverse sample of new giant exoplanets, chosen for their ability to place unprecedented constraints on the classification of irradiated giant planets, and stringent constraints on the planets’ atmospheric thermal, chemical, and dynamical properties. On the other hand, we will search for the transits of 15 low-mass planets detected by our HARPS Doppler survey, both to constrain their compositions and to increase the small sample of low-mass planets amenable for atmospheric studies with future facilities like JWST. Together, these two complementary parts of our program will form a new major legacy of Spitzer in the study of other worlds.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10167

Simultaneous Spitzer and Kepler K2 Observations of a Bright, Nearby L8 dwarf

Principal Investigator: John Gizis
Institution: University of Delaware

Technical Contact: John Gizis, University of Delaware

Co-Investigators:

Science Category: Brown Dwarfs/Very Low Mass Stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.0

Abstract:
Observations of brown dwarfs allow empirical characterization of mineral clouds and weather, physical processes also important in gas giant exoplanets. The revival of Kepler as the K2 mission offers the unique opportunity in May 2014 to obtain precise, reliable, simultaneous optical and mid-infrared photometry of one of the nearest brown dwarfs, the L8 dwarf WISEP J060738.65+242953.4. We will use Spitzer to measure a full rotation period in each of its IRAC channels while Kepler obtains a 78 day time series. This will enable the the first joint measurement of cloud properties and lifetimes at the L dwarf side of the L/T transition where the main cloud deck is believed to break up.

Spitzer Space Telescope - General Observer Proposal #13086

Investigating the long-lived clouds of early L dwarfs with Spitzer and K2.

Principal Investigator: John Gizis
Institution: University of Delaware

Technical Contact: John Gizis, University of Delaware

Co-Investigators:
Patrick Lowrance, IPAC/Caltech
Rishi Paudel, University of Delaware

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30.6
Priority: 1

Abstract:
We propose to monitor two bright L0 dwarfs with Spitzer. Unlike cooler brown dwarfs whose clouds evolve on timescales of hours and days, the best studied L1 dwarf star has a cloud feature that lasted for over two years. This discovery was enabled by Kepler optical photometry combined with Spitzer mid-infrared photometry. The upcoming K2 Campaign 10 happens to include two bright L0 dwarfs, and they will repeated in K2 Campaign 17, providing two uniquely accurate optical light curves that sample timescales from minutes to years. By probing higher altitudes in the L dwarf atmospheres, the Spitzer IRAC photometry would enable us to test whether the optical variability in these two objects also come from long-lived clouds. This would establish whether the Kepler field L1 dwarf is a fluke or whether the weather and cloud lifetimes in warm (~2300K) atmospheres are qualititatively different than in cooler brown dwarfs.

Spitzer Space Telescope - General Observer Proposal #90152

Spitzer-Kepler Studies of a Periodic L Dwarf

Principal Investigator: John Gizis
Institution: University of Delaware

Technical Contact: John Gizis, University of Delaware

Co-Investigators:
Edo Berger, Harvard
Adam Burgasser, University of California, San Diego
Kelle Cruz, City University of New York
Stanimir Metchev, SUNY Stonybrook

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 21.5

Abstract:
We propose Spitzer observations of the L1 dwarf WISEP J190648.47+401106.8. This chromospherically active very-low-mass star or brown dwarf happens to lie in the Kepler field, allowing a unique opportunity to monitor optical variations over the next several years. The first nine months of Kepler data establish that the object shows periodic variations that have remained in phase -- this is in contrast to many of the results reported for less sensitive ground-based campaigns with much poorer time coverage. There is evidence of magnetic activity, and Spitzer observations can distinguish between proposed starspot, cloud, and aurora models for the optical variations. The proposed observations will lead to a better understanding of warm substellar atmospheres.

Spitzer Space Telescope - General Observer Proposal #60158

Two Lensed Ly-A Emitters at z ~ 5

Principal Investigator: Michael Gladders
Institution: University of Chicago

Technical Contact: Michael Gladders, University of Chicago

Co-Investigators:
Eva Wuyts, University of Chicago
Benjamin Koester, University of Chicago
Matthew Bayliss, University of Chicago
Keren Sharon, University of Chicago
Joseph Hennawi, University of California, Berkeley
Masamune Oguri, Stanford University

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.8

Abstract:
We propose 3.6 micron imaging of two newly discovered Ly-A emitters at z=5.0 and 5.2. These spectroscopically confirmed sources, located behind a pair of strong lensing clusters from the SDSS Giant Arcs Survey, are lensed and appear an order of magnitude brighter than the small samples of typical Ly-A emitters previously found at high redshifts in ultra-deep fields. As such they offer the opportunity for detailed individual study which these other sources do not, and can be well measured in modest (less than 1 hour) total integrations. The proposed observation provides a critical measure of the presence or absence of older stars in these objects, and hence helps constrain stellar mass, and in conjunction with ground-based near-IR imaging will yield a detailed picture of the spectral energy distribution of these sources from rest-frame UV to optical wavelengths.

Spitzer Space Telescope - General Observer Proposal #70154

Mass across the Redshift Desert: Stellar Masses in a Large and Uniform Sample of Strongly-Lensed Galaxies at 1 < z < 3

Principal Investigator: Michael Gladders
Institution: University of Chicago

Technical Contact: Michael Gladders, University of Chicago

Co-Investigators:
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Jane Rigby, Carnegie
Keren Sharon, University of Chicago
Joseph Hennawi, Max Planck Institut fur Astronomie
Megan Gralla, University of Chicago
Matthew Bayliss, University of Chicago
Benjamin Koester, University of Chicago
Hakon Dahle, University of Oslo
Masamune Oguri, Stanford

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 69.1

Abstract:
We propose 3.6 and 4.5 micron imaging of a sample of 89 strongly-lensed high redshift (1 < z < 3) galaxies, selected uniformly from the SDSS. The magnification by galaxy cluster-scale lenses of this otherwise faint sample of galaxies offers both a statistical and an individualized look into the evolution of the mass-metallicity relation and the build-up of stellar mass at the peak of the star-formation history of the universe. The mid-IR imaging delivered by IRAC is critical to establishing the stellar mass measurements necessary for this program, and complements extensive and ongoing imaging and spectroscopic programs at optical and near IR wavelengths. We require modest (5-20 min) exposures at both 3.6 and 4.5 microns. Ultimately, the derived stellar masses will depend on a careful measurement of the source magnification, which itself requires an accurate lens model. The color baseline provided by IRAC will enable the identification of strongly-lensed image families that greatly improve this modeling. Finally, as these sources are all found behind cluster lenses, the total gravitational lensing cross-section inherent in this proposal is considerable. Combining the proposed imaging with extant optical data for these lenses offers an efficient opportunity to detect z > 6 dropout galaxies, particularly at bright limits where followup spectroscopy using current facilities should be possible.

Spitzer Space Telescope - General Observer Proposal #80103

An ultra-deep Spitzer look at the most distant galaxy cluster

Principal Investigator: Raphael Gobat
Institution: Commissariat a l’Energie Atomique (CEA)

Technical Contact: Raphael Gobat, Commissariat a l’Energie Atomique (CEA)

Co-Investigators:
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Masato Onodera, ETH Zurich
Marcella Carollo, ETH Zurich
Alvio Renzini, INAF-Padova
Alexis Finoguenov, UMBC
Mark Dickinson, NOAO
Andrea Cimatti, University of Bologna
Nobuo Arimoto, NAOJ

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.1

Abstract:
We propose to obtain very deep IRAC imaging in the 3.6 and 4.5 micron passbands on the recently discovered Cl J1449+0856, the most distant galaxy cluster to date, at z=2.07. This very distant cluster is different from z>2 proto-clusters in that it shows both an X-ray emission and a significant population of quiescent galaxies, suggesting an evolved state despite its high redshift. It thus offers a unique opportunity of studying galaxy evolution in overdense environments at early cosmic times. The proposed observations will probe for the first time the rest-frame near-infrared emission of faint cluster galaxies at z~2, allowing us to determine the stellar mass function at a cosmic epoch which is thought to be critical for witnessing ongoing stellar mass assembly in cluster galaxies. These data will be a crucial counterpart of the already available deep HST NICMOS and WFC3 photometry in identifying cluster members. Moreover, the deep rest-frame near-infrared photometry will be a fundamental tool in disentangling the red cluster galaxy population in its two components of truly quiescent objects and heavily reddened star forming sources. The proposed observations will thus allow us to take full advantage of the unique discovery of Cl J1449+0856 to test different scenarios for the evolution of cluster galaxies at a still unprobed epoch.

Spitzer Space Telescope - Snapshot Proposal #11080

Snapshots of Massive Galaxy Clusters at z~1 from the Massive and Distant Clusters of WISE Survey

Principal Investigator: Anthony Gonzalez
Institution: University of Florida

Technical Contact: Anthony Gonzalez, University of Florida

Co-Investigators:
Mark Brodwin, University of Missouri, Kansas City
S. Adam Stanford, UC Davis, IGPP/LLNL
Peter Eisenhardt, JPL/Caltech
Daniel Stern, JPL/Caltech
Daniel Gettings, University of Florida
Dominika Wylezalek, Johns Hopkins
Adam Mantz, University of Chicago
Yen-Ting Lin, ASIAA
Chris Greer, Arizona
Greg Zeimann, Penn State University
Steve Allen, Stanford University

Science Category: galaxy clusters and groups(high-z)
Hours Approved: 346.0
Priority: 2

Abstract:
The Massive and Distant Clusters of WISE Survey (MaDCoWS) is a comprehensive program to detect and characterize the most massive galaxy clusters in the universe at z~1, and is the only all-sky survey sensitive to galaxy clusters at this epoch. We propose a large snapshot program to obtain photometry for clusters drawn from the 2000 highest significance detections in the MaDCoWS catalog. From a previous pilot program and CARMA Sunyaev-Zel’dovich imaging, we have calibrated a low-scatter mass-richness relation. The proposed observations will yield photometric redshifts and richness estimates for the full snapshot sample. The requested observations are designed to be optimal for (1) investigation of the evolution of massive galaxies in the most overdense environments, (2) unbiased calibration of scaling relations for cluster mass observables, and (3) identification of extremely massive clusters that can be used for the fgas cosmological test and as constraints on primordial non-Gaussianity. These observations also have substantial legacy value, providing a fiducial reference sample for the next generation of wide-area cluster surveys. We intend for this survey to be a community resource for years to come.

Spitzer Space Telescope - General Observer Proposal #90177

IRAC Imaging of Clusters from the Massive Distant Clusters of WISE Survey

Principal Investigator: Anthony Gonzalez
Institution: University of Florida

Technical Contact: Anthony Gonzalez, University of Florida

Co-Investigators:
Daniel Gettings, University of Florida
Mark Brodwin, University of Missouri Kansas City
Adam Stanford, LLNL/UC Davis
Peter Eisenhardt, Caltech/JPL
Daniel Stern, Caltech/JPL
Greg Zeimann, Penn State
Dominika Wylezalek, Caltech/JPL

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 37.9

Abstract:
The Massive Distant Clusters of WISE Survey (MaDCoWS) is a comprehensive search of the full extragalactic sky designed to detect and characterize the massive galaxy cluster population at 0.9<z<1.3, with the dual aims of constraining the Gaussianity of the initial density perturbations after inflation and exploring the evolution of the oldest galaxies in the most overdense environments. Our team uses a color selection method that combines the WISE 3.4 and 4.6 micron data with ground-based optical data to isolate z>0.9 galaxies and identify clusters as overdensities of super-L* galaxies at these redshifts. Within the WISE-SDSS overlap region, which is the focus of this proposal, our team has identified approximately 4000 massive galaxy clusters, with follow-up optical imaging and spectroscopy demonstrating the success of our approach. We propose with Spitzer to obtain IRAC imaging of the 200 highest significance detections within the WISE-SDSS overlap region, which requires only 37.9 hrs. These data will be used to identify the most exciting, massive systems for detailed multiwavelength analysis, to calibrate WISE-based mass proxies for the full cluster survey, and to conduct a statistical analysis of the evolution of cluster galaxy properties as a function of cluster mass at this epoch. MaDCoWS provides the first all-sky sample of massive clusters at this epoch, and the results from this program with enhance the legacy value of the survey.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80262

Observations of SN2012cg

Principal Investigator: Ariel Goobar
Institution: Stockholm University

Technical Contact: Ori Fox, NASA/Goddard

Co-Investigators:
Ori Fox, NASA/Goddard
Joel Johansson, Stockholm University

Science Category: evolved stars/pne/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.0

Abstract:
We propose to observe the highly reddened Type Ia supernova SN2012cg in NGC4424 (d=15 Mpc). Given the proximity and high dust extinction of this object, we may detect pre-exisiting dust in the circumstellar environment, heated up by the SN explosion. A detection would have great implications for the understanding of the progenitor system of SNe Ia and for their use as distance indicators in cosmology. The Spitzer data will fill in a very important gap in our multi-wavelength data-set, ranging from UV observations from HST, optical and near-IR observations from ground facilities and HST, to Herschel data at sub-mm wavelengths.

Spitzer Space Telescope - General Observer Proposal #10125

Continuing Ground- and Space-Based Variability Monitoring of Zw 229-015

Principal Investigator: Varoujan Gorjian
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
Aaron Barth, UCI
Joshua Bloom, UC Berkeley
Alex Filippenko, UC Berkeley
Sebstian Hoenig, UCSB
Michael Joner, BYU
Matthew Malkan, UCLA
Liuyi Pei, UCI

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.0
Priority: 2

Abstract:
This proposal is the next step of our successful Cycles 7, 8 and 9 AGN monitoring program conducted at 3.6 microns (and then expanded to 4.5 microns in Cycle 9) complemented by an unprecedented effort of ground- and space-based observatories to study dust reprocessed light within AGN. We detected strong IR variability in Zw 229-015 (a Seyfert 1 at z=0.028), which demonstrated the strongest and most rapid variability in our sample and which yielded the highest S/N light curve due to the large number of comparison stars in the field. This AGN provides a unique opportunity for Spitzer to obtain a multi-year, high-cadence light curve of an AGN with consistently strong optical and IR variability over timescales of days to months to years. Our goal now is to extend this high-cadence monitoring (1 observation per 72 hours) and continue with the expanded wavelength coverage at 4.5 microns. We continue to obtain ground-based optical (V-band) and near-IR (K-band) monitoring data for Zw 229-015 in order to provide unique new constraints on models for the dust distribution in the cores of AGN.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10163

A Coordinated Spitzer and Hubble Space Telescope Study of NGC 5548

Principal Investigator: Varoujan Gorjian
Institution: JPL/Caltech

Technical Contact: Varoujan Gorjian, JPL/Caltech

Co-Investigators:
Aaron Barth, UCI
Alex Filippenko, UC Berkeley
Sebastian Hoenig, Dark Cosmology Center
Mike Joner, BYU
Matt Malkan, UCLA
Liuyi Pei, UCI
Brad Peterson, Ohio State
Jorg-Uwe Pott, MPIA
Kirsten Schnuelle, MPIA

Science Category: AGN
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.8

Abstract:
An unprecedented opportunity has arisen to do simultaneous monitoring of the variability of an active galactic nucleus (AGN) in the UV, the optical, and the IR. NGC 5548 will be spectroscopically monitored daily in the UV for 6 months with the Hubble Space Telescope starting in February 2014. In support of this program, ground based telescopes will monitor NGC 5548 in the optical both photometrically and spectroscopically. The Spitzer Space Telescope is in a unique position to add vital 3.6 and 4.5 micron data by monitoring NGC 5548 for dust reverberation. NearâM-^HM-^Rinfrared reverberation measurements have proven to be a valuable tool for mapping the location of hot dust in AGN, and NGC 5548 is an ideal candidate for dust reverberation mapping since it is a low-luminosity source hence its dust sublimation radius should be measurable within this campaign (Spitzer visibility window March - May 2014). This multi-wavelength campaign can provide a great deal of information about the distribution and temperature profile of the dust around the accretion disk of NGC 5548, and, combined with the spectroscopy, can also provide information about the dust chemistry and the three-dimensional distribution of the dust. If approved, this program would make NGC 5548 the only AGN to have been monitored both photometrically and spectroscopicaly from the UV to the IR creating an exceptional opportunity to study the unresolved core of this AGN.

Spitzer Space Telescope - General Observer Proposal #11065

Infrared Reverberation Mapping of 30 Quasars from the SDSS Reverberation Mapping Project

Principal Investigator: Varoujan Gorjian
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
Aaron Barth, UCI
Niel Brandt, PSU
Kyle Dawson, U. of Utah
Paul Green, CfA
Luis Ho, Peking University
Keith Horne, St. Andrews University
Linhua Jiang, ASU
Ian McGreer, U. of Arizona
Donald Schneider, PSU
Yue Shen, Carnegie Observatories
Charling Tao, Tsinghua Univesrity/CPPM/IN2P3/CNRS

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 200.0
Priority: 1

Abstract:
The potential for Cycle 11 proposals to be observed throughout the 20 month Cycle11/12 period opens up a new window for long term reverberation monitoring of high luminosity active galactic nuclei (AGN). Current Spitzer reverberation monitoring projects looking for UV/optical light absorbed and re-emitted in the IR by dust have been limited to AGN that could potentially show reverberation within a single cycle (~1 year). This has narrowed the sample of sources to low luminosity AGN which would have a small dust sublimation radius thus having their dust close enough so that the light travel time from the UV/optical emitting region of the accretion disk to the IR emitting region of the dust would be on the 1-2 month timescale. With this new opportunity we propose to monitor a sample of 30 quasars chosen from the Sloan Digital Sky Survey Reverberation Mapping (SDSS-RM) project. This sample has photometric monitoring for 849 quasars over a four year span (2010 - 2014) combining data from the Pan-STARRS, CFHT, and Steward Observatory telescopes. Those sources also have a 6 month (Jan-July, 2014) spectroscopic variability monitoring campaign carried out by the SDSS telescope with the aim of detecting broad emission-line reverberation lags and deriving black-hole masses. The SDSS-RM sample is expected to continue to be monitored with optical imaging and SDSS spectroscopy in 2015-2016. From these we have chosen the 30 sources that have shown the most variability in the optical and are also the brightest at 3.6 microns as determined from the WISE all-sky survey (> 45 microJy). We will monitor these quasars on a weekly basis throughout their Cycles 11 and 12 visibility periods allowing for an unprecedented span between optical and near-IR reverberation monitoring.

Spitzer Space Telescope - General Observer Proposal #13118

Long Term Optical and Infrared Reverberation Mapping of High and Low Luminosity Active Galactic Nuclei

Principal Investigator: Varoujan Gorjian
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
Aaron Barth, UCI
Niel Brandt, PSU
Kyle Dawson, U. of Utah
Paul Green, CfA
Luis Ho, Peking University
Keith Horne, St. Andrews University
Linhua Jiang, Peking University
Mike Joner, BYU
John Kenney, Concordia University
Ian McGreer, U. of Arizona
Tyler Nordgren, U. of Redlands
Donald Schneider, PSU
Yue Shen, Carnegie Observatories
Charling Tao, Tsinghua Univesrity/CPPM/IN2P3/CNRS

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 205.0
Priority: 1

Abstract:
Previous Spitzer reverberation monitoring projects looking for UV/optical light absorbed and re-emitted in the IR by dust have been limited to very low luminosity active galactic nuclei (AGN) that could potentially show reverberation within a single cycle (~1 year). Cycle 11-12's two year baseline allowed for the reverberation mapping of 17 high luminosity quasars from the Sloan Digital Sky Survey Reverberation Mapping project. By combining ground based monitoring from Pan-STARRS, CFHT, and Steward Observatory telescopes with Spitzer data we have for the first time detected dust reverberation in quasars. We propose to continue this project to capitalize on the continuing optical motnoring from the ground and to increase the confidence in the detected lags. Additionally, the Call for Proposals asks for up to 1000 hours of observations in the Spitzer CVZ to accommodate battery charging needs. We propose to add to our quasar sample five lower luminosity Seyfert galaxies from the Pan-STARRS ground based optical survey that are in the Spitzer CVZ, which will increase the luminosity range of AGN we are studying and, combined with additional ground based observatories, provide for a continuous monitoring campaign lasting 2 years and thus provide the most detailed study of dust around AGN to date.

Spitzer Space Telescope - General Observer Proposal #14126

Continuing Long Term Optical and Infrared Reverberation Mapping of 17 Sloan Digital Sky Survey Quasars

Principal Investigator: Varoujan Gorjian
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
Aaron Barth, UCI
Niel Brandt, PSU
Kyle Dawson, U. of Utah
Paul Green, CfA
Luis Ho, Peking University
Keith Horne, St. Andrews University
Linhua Jiang, Peking University
Ian McGreer, U. of Arizona
Donald Schneider, PSU
Yue Shen, U. of Illinois
Charling Tao, Tsinghua Univesrity/CPPM/IN2P3/CNRS

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 98.4
Priority: 1

Abstract:
Previous Spitzer reverberation monitoring projects searching for UV/optical light absorbed and re-emitted in the IR by dust have been limited to low luminosity active galactic nuclei (AGN) that could potentially show reverberation within a single cycle (~1 year). Cycle 11-12's two year baseline allowed for the reverberation mapping of 17 high-luminosity quasars from the Sloan Digital Sky Survey Reverberation Mapping project. We continued this monitoring in Cycle 13 and now propose to extend this program in Cycle 14. By combining ground-based monitoring from Pan-STARRS, CFHT, and Steward Observatory telescopes with Spitzer data we have for the first time detected dust reverberation in quasars. By continuing observations with this unqiue combination of resources we should detect reverberation in more objects and reduce the uncertainties for the remaining sources.

Spitzer Space Telescope - General Observer Proposal #70119

Spitzer, Kepler, and Ground Based Reverberation Mapping of 3 Active Galactic Nuclei

Principal Investigator: Varoujan Gorjian
Institution: JPL

Technical Contact: Varoujan Gorjian, JPL

Co-Investigators:
Matthew Malkan, UCLA
Aaron Barth, UCI
Alex Filippenko, UC Berkeley
Joshua Bloom, UC Berkeley

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 27.7

Abstract:
Near-infrared reverberation measurements have proven to be a valuable tool for mapping the location of hot dust in active galactic nuclei (AGNs). Ground-based campaigns have shown that the K-band continuum varies in response to changes in the optical continuum, and measurements of the K-band lag time give the size scale of the hot dust emission region, which likely corresponds to the dust sublimation radius. Reverberation measurements at longer wavelengths can add valuable information on the dust temperature profile in AGNs and the structure of the putative dusty torus, but there have not previously been any definitive measurements of dust reverberation at wavelengths longer than the K band. We propose to conduct a campaign of high-cadence monitoring observations (1 observation per 72 hours) of three bright, low-redshift AGNs in order to detect 3.6 micron variability and to measure the reverberation lag time of the 3.6 micron continuum relative to the optical continuum. This will be accomplished at the previously unprecedented photometric accuracy of 1%. Our sample includes two well-studied and highly variable AGNs, NGC 4051 and Mrk 817. Our third target, the Seyfert 1 galaxy Zw 229-015, is a Kepler monitoring target for Kepler Cycle 2, making it a key target for coordinated, multiwavelength monitoring over the coming year. We will obtain ground-based optical (V-band) and near-IR (JHK) monitoring data for these AGNs in order to compare the near-IR and 3.6 micron variability with the optical light curves, providing unique new constraints on the dust temperature profiles in these AGNs.

Spitzer Space Telescope - General Observer Proposal #80148

Spitzer, Kepler, and Ground Based Reverberation Mapping of 3 Active Galactic Nuclei

Principal Investigator: Varoujan Gorjian
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
Matthew Malkan, UCLA
Aaron Barth, UCI
Alex Filippenko, UC Berkeley
Joshua Bloom, UC Berkeley

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 28.3

Abstract:
Near-infrared reverberation measurements have proven to be a valuable tool for mapping the location of hot dust in active galactic nuclei (AGNs). Ground-based campaigns have shown that the K-band continuum varies in response to changes in the optical continuum, and measurements of the K-band lag time give the size scale of the hot dust emission region. Reverberation measurements at longer wavelengths can add valuable information on the dust temperature profile in AGNs and the structure of the putative dusty torus, but there have not previously been any definitive measurements of dust reverberation at wavelengths longer than the K band. In our Cycle 7 campaign we proposed to conduct a campaign of high-cadence monitoring observations (1 observation per ~72 hours) of three bright, low-redshift AGNs in order to detect 3.6 micron variability and to measure the reverberation lag time of the 3.6 micron continuum relative to the optical continuum. Four obstacles needed to be overcome to do reverberation mapping at 3.6 microns: 1. Could we obtain long and well sampled 3.6 micron light curves with high precision? 2. Would the monitored AGN show significant optical variation? 3. Would IRAC detect significant variations during the observing window? 4. Finally, would there be correlated variability between the IR and the optical light curves? Based on our first observed source, Zw 229-015, the answer to all those questions is YES! In addition to Zw 229-105 which is also a Kepler monitoring target and so it has become a key AGN for coordinated multi-wavelength monitoring; our sample includes two well-studied and highly variable AGNs, NGC 4051 and Mrk 817. We will conitnue to obtain ground-based optical (V-band) and near-IR (JHK) monitoring data for these AGNs in order to compare the near-IR and 3.6 micron variability with the optical light curves, providing unique new constraints on the dust temperature profiles in these AGNs.

Spitzer Space Telescope - General Observer Proposal #90144

Continuing Ground- and Space-Based Variability Monitoring of Zw 229-015

Principal Investigator: Varoujan Gorjian
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
Matthew Malkan, UCLA
Aaron Barth, UCI
Alex Filippenko, UC Berkeley
Joshua Bloom, UC Berkeley
Sebstian Hoenig, UCSB
Michael Joner, BYU

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 19.1

Abstract:
This proposal is the next step of our successful Cycles 7 and 8 AGN monitoring program conducted at 3.6 microns and complemented by an unprecedented effort of ground- and space-based observatories to study dust reprocessed light within AGN. We detected strong IR variability in Zw 229-015 (a Seyfert 1 at z=0.028), which demonstrated the strongest and most rapid variability in our sample and which yielded the highest S/N light curve due to the large number of comparison stars in the field. This AGN provides a unique opportunity for Spitzer to obtain a multi-year, high-cadence light curve of an AGN with consistently strong optical and IR variability over timescales of days to months to years. Our goal now is to extend this high-cadence monitoring (1 observation per 72 hours) and expand the wavelength coverage to 4.5 microns. We will continue to obtain ground-based optical (V-band) and near-IR (K-band) monitoring data for Zw 229-015 and combine with the continuing Kepler Space Telescope data in order to provide unique new constraints on models for the dust distribution in the cores of AGN.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10036

Spitzer Microlens Planets and Parallaxes

Principal Investigator: Andrew Gould
Institution: The Ohio State University

Technical Contact: Sean Carey, SSC

Co-Investigators:
Sean Carey, Spitzer Science Center
Jennifer Yee, Ohio State University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 100.0
Priority: 1

Abstract:
We will measure the "microlens parallaxes" of about 120 microlensing events that peak during Spitzer's "bulge window" (2014 Jun 02 -- Jul 12), by comparing simultaneous Spitzer and ground-based microlensing lightcurves, making use of Spitzer's location about 1 AU from Earth. These measurements will enable mass and distance measurements of about 4 microlensing planets that are detected (from the ground). Microlens planet mass measurements are very rare and have proved extremely interesting in every case. Microlensing identifies planets at and beyond the snowline, probing unique parameter space and providing vital information to constrain planet formation and migration theories. But the sample of ground-based microlens-parallax measurements is highly biased toward special systems. Spitzer would provide the first unbiased study, and would double the number of mass measurements. The same survey would provide a unique probe of brown dwarf binaries, and yield the first mass-based (not light-based) measurement of the stellar mass function (i.e., including dark objects such as black holes). This project can only be carried out by a satellite that is separated from Earth by of order 1 AU and has good resolution.

Spitzer Space Telescope - General Observer Proposal #11006

Galactic Distribution of Planets from Spitzer Microlens Parallaxes

Principal Investigator: Andrew Gould
Institution: The Ohio State University

Technical Contact: Sean Carey, SSC

Co-Investigators:
Sean Carey, Spitzer Science Institution
Jennifer Yee, Harvard-Smithsonian Center for Astrophysics

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 832.0
Priority: 1

Abstract:
We will measure the "microlens parallaxes" of about 120 microlensing events that peak during Spitzer's "bulge window" (2015 Jun 09 - Jul 19), by comparing simultaneous Spitzer and ground-based microlensing lightcurves, making use of Spitzer's location about 1 AU from Earth. These measurements will enable mass and distance measurements of about 4 microlensing planets. The ensemble of planet and non-planet distance measurements will yield the first probe of the Galactic distribution of planets Microlens planet mass measurements are very rare and have proved extremely interesting in every case. Microlensing identifies planets at and beyond the snowline, probing unique parameter space and providing vital information to constrain planet formation and migration theories. But the sample of ground-based microlens-parallax measurements is highly biased toward special systems. Spitzer would provide the first unbiased study. The same survey would provide a unique probe of brown dwarf binaries, and yield the first mass-based (not light-based) measurement of the stellar mass function (i.e., including dark objects such as black holes). A very successful 2014 "Pilot Program" demonstrates that this project is technically and scientifically viable. (As in the previous "Pilot Program", we request zero day proprietary period.)

Spitzer Science Center Note:
For ease of scheduling the observations were split into one pid per week:

11006	Week 706
11190	Week 707
11191	Week 708
11192	Week 709
11193	Week 710
11194	Week 711
11195	Week 712

Spitzer Space Telescope - General Observer Proposal #12013

Galactic Distribution of Planets From High-Magnification Microlensing Events

Principal Investigator: Andrew Gould
Institution: The Ohio State University

Technical Contact: Sean Carey, SSC

Co-Investigators:
Jennifer Yee, Harvard
Sean Carey, IPAC

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 100
Priority: 1

Abstract:
We will use Spitzer to measure microlens parallaxes for ~14 microlensing events that are high-magnification (as seen from Earth), in order to determine the Galactic distribution of planets. Simultaneous observations from Spitzer and Earth yield parallaxes because they are separated by ~1 AU, which is of order the size of the Einstein radius projected on the observer plane. Hence, Earth and Spitzer see substantially different lightcurves for the same event. These Spitzer parallaxes enable measurements of the distances to the lenses (and their masses), which is a crucial element for measuring the Galactic distribution of planets. High-mag events are exceptionally sensitive to planets: Gould+ (2010) detected 6 planets from 13 high-mag events. However, previously it was believed impossible to measure their parallaxes using Spitzer: scheduling constraints imply a 3-10 day delay from event recognition to first observation, while high-mag events are typically recognized only 1-2 days before peak. By combining aggressive observing protocols, a completely new photometry pipeline, and new mathematical techniques, we successfully measured parallaxes for 7 events with peak magnification A>100 and another ~7 with 50<A<100 in 2015, mostly from falling lightcurves which were previously viewed as impossible. Based on this experience, by observing 50 targets with Spitzer, we can measure parallaxes for ~14 high-mag events. From this sample, we expect to detect ~4 planets (the number is smaller than Gould+ 2010 because our Spitzer sample will have lower mean magnification). These ~4 planets represent significant progress toward the ~12 necessary to measure the Galactic distribution. All lightcurves will be reduced using our customized software and then made public (unrestricted use), within 2 months of the completion of observations (as we did for our 2015 observations).

Spitzer Science Center Note:

In Cycle 12 two microlensing programs were approved. They total 100 hours of General Observer time and 200 hours of Director's Discretionary Time:

12013 - Galactic Distribution of Planets From High-Magnification Microlensing Events

and

12015 - Degeneracy Breaking for K2 Microlens Parallaxes

For ease of scheduling the observations for both programs are contained in one program/pid per week.

The total list of pids associated with these two programs are:

PID	Week	observations occurred:
12015	759	(June 8 - 18, 2016)
12013	760	(June 18 - 24 , 2016)
12136	761	(June 25 - July 1, 2016)
12137	762	(July 1 - 8 , 2016)
12138	763	(July 8 - 15, 2016)
12139	764	(July 15 - 22, 2016)
12140	765	(July 22 - 28, 2016)

Spitzer Space Telescope - Directors Discretionary Time Proposal #12015

Degeneracy Breaking for K2 Microlens Parallaxes

Principal Investigator: Andrew Gould
Institution: The Ohio State University

Technical Contact: Sean Carey, SSC

Co-Investigators:
Jennifer Yee, Harvard
Sean Carey, IPAC

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 200
Priority: 1

Abstract:
By adding Spitzer observations to microlensing targets being observed from Kepler and Earth, we will create the first interplanetary network of microlensing observatories. This 3-observatory configuration has the unique potential to break the famous 4-fold degeneracy for space-based microlensing parallaxes. This is crucial both for the interpretation of some individual events and to rigorously validate the statistical methods that are used when (as is usually the case) this special 3-observatory configuration is not possible. The Kepler K2 C9 microlensing campaign will monitor about 4 square degrees of the Bulge from 6 Apr to 29 Jun, with the aim of measuring microlens parallaxes. Spitzer can observe this K2 field from 18 Jun to 26 Jul. The 11-day overlap between the two campaigns will allow us to break the 4-fold degeneracy of about 50 microlensing events. Some of these events will be well-covered over the peak from K2, with Spitzer observations of the falling wing providing the necessary information to break the degeneracy in the K2-Earth parallax. Others will be the reverse, with K2 observations of the rising event breaking the degeneracy in Spitzer-Earth parallaxes (i.e., for events peaking during the Spitzer campaign). Breaking this degeneracy leads to a definitive measurement of the magnitude of the microlens parallax vector, which will enable measurements of the masses and distances of the lens systems, including events with planets that contribute to the ~12 needed to make a first measurement of the Galactic distribution of planets, binaries, and many single-lens events, some of which could be black holes, brown dwarfs, or other interesting objects. The distance distribution of the ensemble of lenses can serve as a probe of Galactic structure. All lightcurves will be reduced using our customized software and then made public (for unrestricted use), within two months of the completion of observations (as we did for our 2015 observations).

Spitzer Science Center Note:

In Cycle 12 two microlensing programs were approved. They total 100 hours of General Observer time and 200 hours of Director's Discretionary Time:

12013 - Galactic Distribution of Planets From High-Magnification Microlensing Events

and

12015 - Degeneracy Breaking for K2 Microlens Parallaxes

For ease of scheduling the observations for both programs are contained in one program/pid per week.

The total list of pids associated with these two programs are:

PID	Week	observations occurred:
12015	759	(June 8 - 18, 2016)
12013	760	(June 18 - 24 , 2016)
12136	761	(June 25 - July 1, 2016)
12137	762	(July 1 - 8 , 2016)
12138	763	(July 8 - 15, 2016)
12139	764	(July 15 - 22, 2016)
12140	765	(July 22 - 28, 2016)

Spitzer Space Telescope - Exploration Science Proposal #13005

Galactic Distribution of Planets Spitzer Microlens Parallaxes

Principal Investigator: Andrew Gould
Institution: The Ohio State University

Technical Contact: Sean Carey, SSC

Co-Investigators:
Sean Carey, SSC
Jennifer Yee, Harvard

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 700.0
Priority: 1

Abstract:
We will measure the Galactic distribution of planets by obtaining "microlens parallaxes" of about 700 events, including 18 planetary events, from the comparison of microlens lightcurves observed from Spitzer and Earth, which are separated by 1 AU in projection. As we have demonstrated in two previous programs, the difference in these lightcurves yields both the "microlens parallax" (ratio of the lens-source relative parallax) to the Einstein radius, and the direction of lens-source relative motion. For planetary events, this measurement directly yields the mass and distance of the planet. For non-planetary events it can be combined with a Galactic model to estimate these quantities with factor 1.4 precision. Hence, the cumulative distributions of planetary events and all events can be compared to determine the relative frequency of planets in the Galactic disk and bulge. The results will be combined with those of current/previous Spitzer campaigns and the current Kepler campaign. This proposal is significantly more sensitive to planets than previous work because it takes advantage of the new KMTNet observing strategy that covers 80 sq.deg at >0.4/hr cadence, 24/7 from 3 southern observatories. This same observing program also provides a unique probe of dark objects. It will yield the first mass-measurement based determination of the isolated-brown-dwarf mass function. Thirteen percent of the observations will specifically target binaries, which will probe systems with dark components (brown dwarfs, neutron stars, black holes) that are difficult or impossible to investigate by other methods. The observations and methods from this work are a test bed for WFIRST microlensing.

Spitzer Science Center Note:
For ease of scheduling the observations were split into one pid per week and observed over two summers:

Summer 2017
13005 Week 813
13169 Week 814
13170 Week 815
13171 Week 816
13172 Week 817
13173 Week 818

Summer 2018
13176 Week 866
13177 Week 867
13178 Week 868
13179 Week 869
13180 Week 870
13181 Week 871

Spitzer Space Telescope - General Observer Proposal #14012

The Galactic Distribution of Planets via Spitzer Microlensing Parallax

Principal Investigator: Andrew Gould
Institution: The Ohio State University

Technical Contact: Sean Carey, SSC

Co-Investigators:
Jennifer Yee, Harvard-Smithsonian Center for Astrophysics
Sean Carey, Caltech/IPAC-Spitzer
Yossi Shvartzvald, Caltech/IPAC

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 350.0
Priority: 2

Abstract:
We will measure the Galactic distribution of planets by obtaining "microlens parallaxes" of about 200 events, including 3 planetary events, from the comparison of microlens lightcurves observed from Spitzer and Earth, which are separated by >1.5 AU in projection. The proposed observations are part of a campaign that we have conducted with Spitzer since 2014. The planets expected to be identified in this campaign when combined with previous work will yield a first statistically significant measurement of the frequency of planets in the Galactic bulge versus the Galactic disk. As we have demonstrated in three previous programs, the difference in these lightcurves yields both the "microlens parallax" (ratio of the lens-source relative parallax) to the Einstein radius, and the direction of lens-source relative motion. For planetary events, this measurement directly yields the mass and distance of the planet. This proposal is significantly more sensitive to planets than previous work because it takes advantage of the KMTNet observing strategy that covers >85 sq.deg t >0.4/hr cadence, 24/7 from 3 southern observatories and a alert system KMTNet is implementing for 2019. This same observing program also provides a unique probe of dark objects. It will yield an improved measurement of the isolated-brown-dwarf mass function. Thirteen percent of the observations will specifically target binaries, which will probe systems with dark components (brown dwarfs, neutron stars, black holes) that are difficult or impossible to investigate by other methods. The observations and methods from this work are a test bed for WFIRST microlensing.

Spitzer Science Center Note:
For ease of scheduling the observations were split into one pid per week:

14012 Week 919
14140 Week 920
14141 Week 921
14142 Week 922
14143 Week 923
14144 Week 924

Spitzer Space Telescope - General Observer Proposal #12076

TRACSSS - Tracing Cold Stellar Streams with Spitzer

Principal Investigator: Carl Grillmair
Institution: Spitzer Science Center

Technical Contact: Carl Grillmair, Spitzer Science Center

Co-Investigators:
Andreas Kupper, Columbia University
Branimir Sesar, Max Planck Insitute for Astronomy
Sarah Pearson, Columbia University
Jeffrey Rich, California Institute of Technology
Vicky Scowcroft, Observatories of the Carnegie Institution of Washi
Adrian Price-Whelan, Columbia University
Kathryn Johnston, Columbia University

Science Category: galactic structure
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 37.9
Priority: 1

Abstract:
Cold stellar streams may be the most sensitive probes we have of the size and shape of the Milky Way's dark matter distribution. Using the remarkably precise infrared period-luminosity relation for RR Lyrae, Spitzer has already demonstrated the ability to measure distances to better than 2% over nearly the entire volume of the Galaxy. By measuring very accurate mean magnitudes for RR Lyrae in the Pal 5, GD-1, and Hermus cold stellar streams, we will immediately be able to put tighter constrains on the mass and shape of the Galactic halo. These measurements will become still more important in a few years, when they can be used to turn Gaia proper motion measurements into accurate transverse space velocities. These measurements are unlikely to be improved upon in the foreseeable future and may ultimately rank among Spitzer's most enduring legacies.

Spitzer Space Telescope - General Observer Proposal #13040

TRACSSS-2: Tracing More Cold Stellar Streams with Spitzer

Principal Investigator: Carl Grillmair
Institution: Spitzer Science Center

Technical Contact: Carl Grillmair, Spitzer Science Center

Co-Investigators:
Andreas Kupper, Columbia University
Branimir Sesar, Max Planck Insitute for Astronomy
Sarah Pearson, Columbia University
Jeffrey Rich, Observatories of the Carnegie Institution of Washi
Vicky Scowcroft, Observatories of the Carnegie Institution of Washi
Adrian Price-Whelan, Columbia University
Kathryn Johnston, Columbia University

Science Category: galactic structure
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 97
Priority: 1

Abstract:
Stellar debris streams may be the most sensitive probes we have of the size and shape of the Milky Way's dark matter distribution. Using the remarkably precise infrared period-luminosity relation for RR Lyrae, Spitzer has already demonstrated the ability to measure distances to better than 2% over nearly the entire volume of the Galaxy. By measuring very accurate mean magnitudes for RR Lyrae in the Anticenter and Styx streams, we will immediately be able to put tighter constrains on the mass and shape of the Galactic halo. These measurements will become still more important in coming years, when they can be used to turn Gaia proper motion measurements into accurate transverse space velocities. These measurements are unlikely to be improved upon in the foreseeable future and may ultimately rank among Spitzer's most enduring legacies.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13237

Measuring Precise Radii of Giants Orbiting Giants to Distinguish Between Planet Evolution Models

Principal Investigator: Samuel Grunblatt
Institution: University of Hawaii

Technical Contact: Samuel Grunblatt, University of Hawaii

Co-Investigators:
Daniel Huber, University of Hawaii
Eric Lopez, NASA Goddard SFC
Eric Gaidos, University of Hawaii
John Livingston, University of Tokyo

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 37.4

Abstract:
Despite more than twenty years since the initial discovery of highly irradiated gas giant planets, the mechanism for planet inflation remains unknown. However, proposed planet inflation mechanisms can now be separated into two general classes: those which allow for post-main sequence planet inflation by direct irradiation from the host star, and those which only allow for slowed cooling of the planet over its lifetime. The recent discovery of two inflated warm Jupiters orbiting red giant stars with the NASA K2 Mission allows distinction between these two classes, but uncertainty in the planet radius blurs this distinction. Observing transits of these planets with the Spitzer Space Telescope would reduce stellar variability and thus planet radius uncertainties by approximately 50% relative to K2, allowing distinction between the two planet inflation model classes at a 3-sigma level. We propose to observe one transit of both known warm Jupiters orbiting red giant stars, K2-97b and EPIC228754001.01, to distinguish between planet model inflation classes and measure the planetary heating efficiency to 3-sigma precision. These systems are benchmarks for the upcoming NASA TESS Mission, which is predicted to discover an order of magnitude more red giant planet systems after launching next year.

Spitzer Space Telescope - General Observer Proposal #90128

Variability in the rho Oph star forming region

Principal Investigator: Hans Guenther
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Hans Guenther, Harvard-Smithsonian Astrophysical Observatory

Co-Investigators:
Scott Wolk, Harvard-Smithsonian Center for Astrophysics
Katja Poppenhaeger, Harvard-Smithsonian Center for Astrophysics
Luisa Rebull, SSC / Caltech
Robert Gutermuth, University of Massachusetts
Peter Plavchan, NExScI

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.7

Abstract:
Young stellar objects (YSOs) are variable on different time scales due to a variety of physical processes: Changes in the accretion rate and accretion geometry, rotational modulation of cool star spots and hot accretion spots, occasional eclipses by the accretion funnel or an inner disk warp, and changes in the disk structure. Observations in the context of the YSOVAR project revealed a surprising range of variability patters in the 3.6 and 4.5 micron channels that are so far largely unexplained. In order to solve this mystery we propose to re-observe the L1688 cloud in the rho Oph star forming region using both IRAC channels. With 10 data points distributed over the summer visibility window in 2013 we can address two scientific aims: (1) The observations will results in new time-baselines of 3 and 9 years to study the long-term variability of YSOs in rho Oph. Variability on this scale is most likely due to changes in the inner disk structure and can only be probed in the IRAC bands. Also, we will see if the short-term variability pattern of any source has changed in the last three years, so we can see if e.g. irregularly variable sources switch over to a state with constant lightcurves on the time scale of years. (2) The proposed observations will form an integral part of a multi-wavelengths campain including spectroscopic Magellan/FIRE observations. Combining both datasets we can calculate the temperature, density and mass flux in the accretion spots from HI lines and obtain the extinction from two very different methods.

Spitzer Space Telescope - General Observer Proposal #80181

Mid-IR Variability of YSOs in the Large, Evolved, Young Cluster, Cep OB3b

Principal Investigator: Robert Gutermuth
Institution: University of Massachusetts

Technical Contact: Robert Gutermuth, University of Massachusetts

Co-Investigators:
Judith Pipher, University of Rochester
Thomas Megeath, University of Toledo
Lori Allen, NOAO
Thomas Allen, University of Toledo
Tim Naylor, University of Exeter
Rob Jeffries, Keele University
James Muzerolle, STScI
Scott Wolk, CfA Harvard

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 69.5

Abstract:
Cep OB3b is a rich young massive cluster similar in size and membership to the ONC, yet more evolved, less obscured, and ~3 Myr older. Cep OB3b and ONC are the only two such massive (> 1000 member) young clusters within 1 kpc of the Sun. Its age range of 3-5 Myr, in contrast to the ONC?s age < 2Myr, places Cep OB3b in the important 2-5 Myr period when disks are beginning to dissipate, dust is beginning to settle to the midplane, disk accretion rates onto the star decrease, and planet formation, especially giant planet formation, begins and may induce asymmetry to the inner disk wall. Throughout pre-main sequence evolution, variability is ubiquitous. These rapid changes to and in the disk during the 2-5 Myr period may result in signatures in both the period and amplitude of the variability. Thus we propose a mid-IR variability study of the Cep OB3b cluster to complement the YSOVAR variability study of the ONC. Because of Cep OB3b?s high ecliptic latitude, continuous monitoring over a 90-day observation window is possible, so that long period variables will not be missed. ONC, on the other hand, is restricted to a 40 day window. We plan to monitor approximately 400 YSOs in the 4-5 Myr population in Cep OB3b using a similar observing strategy to that employed for the ONC to facilitate comparison. Because Cep OB3b is not very obscured, for the most part, we have been able to obtain a vast complementary data set of medium and high resolution spectroscopic observations for over 1000 stars in the cluster, so that accretion rates and mass determinations (from spectral classifications) will be available to aid interpretation. Deep near-IR images, and Xray data on the cluster are also in hand, and Herschel observations are scheduled.

Spitzer Space Telescope - Directors Discretionary Time Proposal #60003

The Spitzer Exoplanetary Atmosphere Survey

Principal Investigator: Joseph Harrington
Institution: University of Central Florida

Technical Contact: Joseph Harrington, University of Central Florida

Co-Investigators:
Drake Deming, NASA's Goddard Space Flight Center
Kevin Stevenson, University of Central Florida
Jonathan Fortney, University of California, Santa Cruz
Nicolas Iro, NASA's Goddard Space Flight Center
Gregory Laughlin, University of California, Santa Cruz
Sara Seager, Massachusetts Institute of Technology
Giovanna Tinetti, University College, London, UK
Andrew Collier Cameron, University of St. Andrews, UK
Coel Hellier, Keele University, UK
Don Pollacco, Queen's University Belfast, UK
Peter Wheatley, University of Warwick, UK
Gaspar Bakos, Harvard Smithsonian Center for Astrophysics
Michael Gillon, Observatoire de Geneve, Switzerland
Didier Queloz, Observatoire de Geneve, Switzerland
Debra Fischer, San Francisco State University
Peter McCullough, Space Telescope Science Institute

Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Approved: 200.0

Abstract:
We propose a Target of Opportunity (ToO) program to observe photometric eclipses and transits of extrasolar planets. Spitzer eclipses are the most fundamental (and in many cases the only) direct exoplanetary measurements possible with current instrumentation; transits measure the radius and eclipses the intrinsic fluxes from these worlds. We will populate a figure of predicted equilibrium vs. observed brightness temperatures, which is starting to show patterns indicating different classes of atmospheric behavior. The observations will constrain models of composition, chemistry, and atmospheric dynamics on each planet. The events will also inform follow-on work with other telescopes for the brightest targets. Based on discovery statistics, 25-35 new, observable, transiting planets will be announced in 2009, and somewhat more in 2010. Also, a number of known planets with good predicted signal have not yet been observed. We will publish digital lightcurves with journal articles and submit them for archiving. No comparable opportunity to observe exoplanets will be available until JWST.

Spitzer Space Telescope - General Observer Proposal #70084

Exoplanet Targets of Opportunity in Cycle 7

Principal Investigator: Joseph Harrington
Institution: University of Central Florida

Technical Contact: Joseph Harrington, University of Central Florida

Co-Investigators:
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Jasmina Blecic, University of Central Florida
Jonathan Fortney, University of California, Santa Cruz
Nicolas Iro, NASA's Goddard Space Flight Center
Gregory Laughlin, University of California, Santa Cruz
Nikku Madhusudhan, Massachusetts Institute of Technology
Sara Seager, Massachusetts Institute of Technology
Giovanna Tinetti, University College, London, UK
Andrew Collier Cameron, University of St. Andrews, UK
Coel Hellier, Keele University, UK
Don Pollacco, Queen's University Belfast, UK
Peter Wheatley, University of Warwick, UK
Gaspar Bakos, Harvard Smithsonian Center for Astrophysics
Michael Gillon, Universite de Liege, Belgium
Didier Queloz, Observatoire de Geneve, Switzerland
Debra Fischer, Yale University
Peter McCullough, Space Telescope Science Institute

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 49.9

Abstract:
We propose a Target of Opportunity (ToO) program to observe photometric eclipses and transits of new extrasolar planets. Spitzer eclipses are the most fundamental (and in many cases the only) direct exoplanetary measurements possible with current instrumentation; transits measure the radius and eclipses the intrinsic fluxes from these worlds. We will populate a figure of predicted equilibrium vs. observed brightness temperatures, which is starting to show patterns indicating different classes of atmospheric behavior. The observations will constrain models of composition, chemistry, and atmospheric dynamics on each planet. The events will also inform follow-on work with other telescopes for the brightest targets. Based on discovery statistics, 25-35 new, observable, transiting planets will be announced in the next year. We will publish digital lightcurves with journal articles and submit them for archiving. No comparable opportunity to observe exoplanets will be available until JWST.

Spitzer Space Telescope - General Observer Proposal #60086

Characterizing the Periodic Infrared Brightening Events of GX17+2: A Precessing Synchrotron Jet?

Principal Investigator: Thomas Harrison
Institution: New Mexico State University

Technical Contact: Thomas Harrison, New Mexico State University

Co-Investigators:
Jillian Bornak, New Mexico State University
Bernie McNamara, New Mexico State University
Dawn Gelino, NExScI
Michael Rupen, NRAO

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.6

Abstract:
GX17+2 is a low mass X-ray binary, and one of the brightest X-ray sources in the sky. It is also a "Z Source" so named by the path this small family of objects traces out in the X-ray color-color diagram. This Z-pattern is believed to occur due to the changing rate of accretion, which is normally quite close to the Eddington limit for a neutron star. GX17+2 seems to be a normal member of this class of object, with stochastic X-ray and radio variations. The one exception to this is that the infrared counterpart shows four magnitude variations in the K-band. Even more peculiar is that these "outbursts" are periodic and recur every 3.01 days! Unfortunately, GX17+2 is highly reddened (Av > 19) and is not detectable at other ground-based wavelengths. Thus, we cannot conclusively identify the nature of these outbursts, but our radio observations show that it is radio loud during these infrared events. This suggests that we are seeing a precessing synchrotron jet. While there is evidence for precessing jets in other X-ray binaries, such a short precession period is unprecedented. We propose to obtain simultaneous K-band and IRAC 3.6 and 4.5 micron observations of GX17+2 during two IR bright phases to allow us to deconvolve the reddening and spectrum of the source to allow us to confirm whether these outbursts are from optically thin synchrotron emission. Such jets are expected to be highly variable, and the short exposure times offered by Spitzer will allow us to characterize this variability. The proposed program requires 3.6 hr.

Spitzer Space Telescope - General Observer Proposal #13054

The progenitors of the most massive galaxy clusters at 1 < z < 3

Principal Investigator: Nina Hatch
Institution: Nottingham University

Technical Contact: Nina Hatch, Nottingham University

Co-Investigators:
Mark Brodwin, University of Missouri
Elizabeth Cooke, University of Nottingham
Audrey Galametz, MPE
Anthony Gonzalez, University of Florida
Stuart Muldrew, University of Leicester
Gael Noirot, ESO
Daniel Smith, University of Hertfordshire
Daniel Stern, JPL
Joel Vernet, ESO
Dominika Wylezalek, JHU

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 119.1
Priority: 1

Abstract:
This project will locate and characterize the progenitors of the most massive galaxy clusters in our Universe at z ~ 2. These rare, massive objects are cosmological probes that test the validity of Lambda-CDM, and open a window into the early formation of the oldest and most massive galaxies in the most extreme overdensities in the Universe. Searching across 10,000 square degrees of the SDSS BOSS survey we have located 27 spectroscopically confirmed groups of radio-loud quasars at 1.3 < z < 3.2. Radio-loud quasars are preferentially located in high-redshift clusters and protoclusters (Wylezalek et al. 2013; Hatch et al. 2014), but the association of several radio-loud quasars implies the presence of an agglomeration of several >10^13 solar mass dark matter haloes that will eventually combine to form some of the most massive clusters in the Universe (Orsi et al. 2016; see Fig. 1). In this proposal we request 119.1 hours to observe all 27 radio-loud quasar groups in order to identify the associated galaxy overdensities that makes up the collapsing clusters.

Spitzer Space Telescope - General Observer Proposal #60112

A SURVEY OF CLUSTER-GROWTH AT EARLY EPOCHS

Principal Investigator: Nina Hatch
Institution: Universiteit Leiden

Technical Contact: Nina Hatch, Universiteit Leiden

Co-Investigators:
Nick Seymour, MSSL, UCL, UK
George Miley, Leiden Observatory, NL
Carlos De Breuck, ESO
Tadayuki Kodama, Nat Astro Obs Japan
Joel Vernet, ESO
Huub Rottgering, Leiden Observatory
Audrey Galametz, ESO
Bram Venemans, ESO
Jaron Kurk, MPIA, Germany
Alessandro Rettura, University of California, Davis
Masayuki Tanaka, ESO
Michelle Doherty, ESO

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 28.9

Abstract:
Forming clusters of galaxies, protoclusters, are unique laboratories for studying galaxy evolution as they contain large numbers of galaxies in the same rich environment. We propose to use Spitzer to study galaxy and cluster evolution during the formative epoch of dense structures (1.7 < z < 3) by observing a well-defined sample of 10 protocluster fields. These fields have already been observed at shorter wavelengths (Y, J, H, K) using the new HAWK-I wide-field imager on the VLT and form the first statistically significant sample of evolved protocluster galaxies (~ 800 protocluster galaxy candidates). We propose to obtain 3.6 and 4.5 micron data on the 10 fields in order to: (i) distinguish between dusty starbursts and passively evolving galaxies; and (ii) measure the masses of the protocluster galaxies. The Spitzer data will facilitate population studies of high density environments, enabling us to create the first mass-selected samples of galaxies in protoclusters at 1.7 < z < 3, and select H-alpha emitting starburst galaxies for spectroscopic follow-up.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14271

Unveiling the stellar mass of Darth Vader

Principal Investigator: Natsuki Hayatsu
Institution: The University of Tokyo

Technical Contact: Chao-Wei Tsai, University of California, Los Angeles

Co-Investigators:
Zhu-Yu Zhang, ESO
Chao-Wei Tsai, University of California
Rob Ivison, ESO
Chentao Yang, ESO
Katsuya Okoshi, Tokyo University of Science
Nobunari Kashikawa, The University of Tokyo
Ping Zhou, University of Arizona
Kotaro Kohno, The University of Tokyo
Yuri Nishimura, The University of Tokyo

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.7
Priority: 1

Abstract:
We have serendipitously discovered, a strong millimetre line emitter at 5" from Cloverleaf (a quadruply- lensed QSO at z = 2.55). Several features (from Herschel and ALMA) indicate that this new galaxy is at z = 2.29, consistent with an intervening HI absorber in the line of sight of Cloverleaf. SED fitting also allows solutions of z = 5.58, 4.49, and 3.39. However, Chandra detected hard X-rays, suggesting an AGN-host in a transit stage from starburst to QSO. Here, we apply for new Spitzer IRAC observations, for this mysterious galaxy named 'Darth Vader', which is optically/near-IR dark (i.e. no detections down to 27 mAB at HST), yet hosts a colossal starburst also a powerful AGN, aiming to detect or obtain deep upper limits of the near-IR continuum flux to estimate its stellar mass.

Spitzer Space Telescope - Directors Discretionary Time Proposal #540

First complete transit observation of the 111-day-period planet HD80606b

Principal Investigator: Guillaume Hebrard
Institution: IAP

Technical Contact: Guillaume Hebrard, IAP

Co-Investigators:
Jean-Michel Desert, IAP
Claire Moutou, OAMP
Xavier Bonfils, LAOG
David Ehrenreich, LAOG
Thierry Forveille, LAOG
Alfred Vidal-Madjar, IAP
Frederic Pont, University of Exeter
Nuno Santos, Univ. do Porto

Science Category: extrasolar planets
Observing Modes: IracPost-Cryo Mapping
Hours Approved: 19.0

Abstract:
Due to its high-eccentricity 111-day-period orbit, HD80606b is an extreme planet, going from hot-Jupiters mode to a much cooler regime near the habitable zone. Its transiting nature was recently established by ground observations, including the photometric and spectroscopic data we secured at Haute-Provence Observatory, covering a part of this extremely long-duration transit (about 12 hours). The fortunate properties of HD80606b provides an amazing opportunity to challenge the field of exoplanets characterization. There is intense interest in obtaining a first complete transit of HD80606b with Spitzer. However, the end of the "Cold Spitzer" made impossible its scheduled observation. We thus propose to observe with IRAC onboard the "Warm Spitzer" the complete transit of HD80606b expected on January 13-14, 2010 which will produce the best-quality transit light curve ever obtained from any extrasolar planet. We will simultaneously conduct a photometric and spectroscopic campaign from ground, at that date and the weeks around. This full dataset will allow system parameters to be accurately measured, including stellar and planetary masses, radii and densities, orbit inclination and eccentricity, or spin-orbit misalignment angle. They are fundamental parameters to understand the origin and the evolution of this system. Such well-observable transits of HD80606b are extremely rare, and opportunities should not be missed. Together with complementary ground observations, the Spitzer January 2010 complete transit light curve of this exceptional object will provide a long-term legacy value.

Spitzer Space Telescope - Directors Discretionary Time Proposal #70031

Search for rings and satellites around the temperate exoplanet CoRoT-9b (continued)

Principal Investigator: Guillaume Hebrard
Institution: IAP

Technical Contact: Guillaume Hebrard, IAP

Co-Investigators:
Alain Lecavelier des Etangs, IAP
Jean-Michel Desert, CFA
David Ehrenreich, LAOG
Rodrigo Diaz, IAP
Claire Moutou, OAMP
Hans Deeg, IAC
Francois Bouchy, IAP/OHP
Magali Deleuil, OAMP
Alfred Vidal-Madjar, IAP

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 29.0

Abstract:
CoRoT-9b is the first temperate transiting exoplanet. With a semi-major axis of 0.41 AU on a quasi-circular orbit, this is the first transiting planet far enough from its parent star to have an extended Hill sphere (3.5 million kilometers in radius), as needed to form and sustain rings and satellites. CoRoT-9b is thus the most promising planet known to date to probe its nearby environment with an accurate transit light curve. Up to 2014, there will be only two opportunities to observe a transit of CoRoT-9b with Spitzer. We will observe the first one in June 2010 with Spitzer. Here we propose to observe the second one, that will occur in July 2011 during the Cycle 7. This new observation will increase the probability for satellite detection and allow any detection of rings based on the June-2010 transit to be confirmed. The Spitzer/IRAC light curve will also allow the search for Transit Timing Variations potentially due to additional bodies in this planetary system, as well as a significant refinement of the system parameters together with the photometric and spectroscopic ground-based campaign that we will simultaneously conduct in July 2011. Observable CoRoT-9b transits being extremely rare, opportunities should not be missed. The program we propose here is the last chance to secure this transit observation before year 2014.

Spitzer Space Telescope - Directors Discretionary Time Proposal #70207

The young nearby supernova PTF11eon/2011dh: Mid-IR followup to an evolving puzzle

Principal Investigator: George Helou
Institution: IPAC

Technical Contact: George Helou, IPAC

Co-Investigators:
E. Ofek, Caltech
J. Surace, SSC
M. Kasliwal, Caltech
I. Arcavi, Weizmann Inst. of Science
A. Gal-Yam, Caltech
S.R. Kulkarni, Caltech

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.4

Abstract:
On May 31 2011 a new supernova exploded in the nearby (8 Mpc) spiral galaxy M51. Such a nearby event occurs only once every few years. Following its discovery by the Palomar Transient Factory1, we spectroscopically confirmed this was a type II SN, triggering a world-wide multiwavelength follow-up campaign. Including X-ray and UV observations from Swift, CARMA and eVLA in the radio regime, and multitude of visible light and near-IR ground based telescopes. An unprecedented radio spectrum peaked around 1 mm wavelength has been observed. It is unclear at this stage whether the data can be explained using standard circumstellar material (CSM) interaction models, or whether we are seeing a yet unexplained phenomenon (possibly analogous to the unique, bright, short-lived flare detected from SN 1987A). Here we proposed for Spitzer observations of PTF 11eon. Spaced based IR observations are required in order to establish evidence for thermal emission from circumstellar matter around the SN and provide insight regarding dust formation.

Spitzer Space Telescope - General Observer Proposal #90154

Planet Formation in the Circumbinary Disk of KH 15D

Principal Investigator: William Herbst
Institution: Wesleyan University

Technical Contact: William Herbst, Wesleyan University

Co-Investigators:
Catrina Hamilton, Dickinson College
Reinhard Mundt, Max Planck Institute for Astronomy - Heidelberg
Diana Windemuth, Wesleyan University
Christopher Johns-Krull, Rice University
Joshua Winn, MIT
Ann Marie Cody, IPAC
John Stauffer, IPAC
John Johnson, California Institute of Technology
Peter Plavchan, IPAC
Sean Carey, IPAC
Geoff Marcy, Berkeley
Sandy Leggett, Gemini

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4

Abstract:
We propose to measure the brightness of the T Tauri binary system KH 15D in IRAC channels 1 and 2 at eight epochs, covering several important missing orbital phases around minimum light and one near maximum. The data are crucial to understanding the mechanisms behind the observed reddening in the system, which has implications for planet formation and disk evolution. We wish to test the hypothesis that, near minimum light of the system, i.e. near periastron of the orbit, we are detecting infrared radiation from a third luminous object, likely a 3 Myr old giant planet. Discovery of a luminous giant planet in this system would provide a real challenge to planet formation theories. Alternatively, the reddening of the system observed at deepest minimum may arise from selective extinction of infrared radiation penetrating the occulting ring. In that case we will gain valuable information on the grain size distribution in a pre-planetesimal ring of evolved solids within the terrestrial planet formation zone of a circumbinary disk. Either result is scientifically valuable and the window of time to obtain these observations is closing fast. Precession of the disk is already revealing more and more of the binary orbit, a process that will soon overwhelm the spectral signature of any luminous giant planet with the direct and scattered light of its stars.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10165

Caught in the Act: An FU Orionis Outburst from a Previously Uncatalogued Star

Principal Investigator: Lynne Hillenbrand
Institution: Caltech

Technical Contact: Mansi Kasliwal, OCIW

Co-Investigators:
Mansi Kasliwal, OCIW
Adam Miller, Caltech

Science Category: YSOs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0

Abstract:
We propose follow-up of a newly discovered probable FU Ori star near the W4 HII region. This is a rare opportunity to catch at mid-infrared wavelengths an object of this class.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14211

Followup of an Interesting NEOWISE + Gaia Source

Principal Investigator: Lynne Hillenbrand
Institution: California Institute of Technology

Technical Contact: Luisa Rebull, IPAC

Co-Investigators:
Luisa Rebull, IPAC
Roc Cutri, IPAC
Michael Kuhn, California Institute of Technology
Carlos Contreras Pena, Exeter
Tim Naylor, Exeter

Science Category: Star Formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.1

Abstract:
While variability of young stellar objects is ubiquitous, FU Ori type outbursts are rare, with only about 25 known members of the class. We have recently identified a new, ongoing outburst, and request Spitzer monitoring to continue the NEOWISE monitoring that has traced the lightcurve to date, notably the source rise to near-peak brightness. The pre- and post-peak brightness of an FU Ori event has never been measured before, presenting a unique opportunity for Spitzer.

Spitzer Space Telescope - General Observer Proposal #90134

Jet-Like Structures in NGC 1097

Principal Investigator: Joannah Hinz
Institution: University of Arizona

Technical Contact: Joannah Hinz, University of Arizona

Co-Investigators:
Debra Elmegreen, Vassar College
Sebastien Comeron, Univ of Oulu
Seppo Laine, Spitzer Science Center
Benne Holwerda, ESA
Juan Carlos Munoz-Mateos, NRAO
Luis Ho, Carnegie Observatories
Bruce Elmegreen, IBM
Eva Schinnerer, MPIA
Kartik Sheth, NRAO
Johan Knapen, IAC

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.7

Abstract:
NGC 1097 has an extensive, unique network of jet-like extended structures that stretch out for dozens of kiloparsecs. Their origin has remained a mystery for decades. The evidence for their association with the AGN is weak, and the lack of HI emission in the vicinity makes it unlikely that they are the product of tidal interactions or streams off the main disk of the galaxy. Recent modeling has shown that the structures may be the remnants of a dwarf galaxy, though the type of dwarf remains unclear, and such interactions are complicated by the fact that the main spiral has a large bar. We propose Spitzer observations of these features to determine the streams' true extent, to age-date individual structures by focusing on the old stellar population, estimate their masses, and calculate their metallicities. We will use Spitzer's sensitivity and the degeneracy-breaking IRAC colors to unravel the history of this unusual object. This proposal is part of broader studies by members of this team on galaxy outskirts and interactions, including mergers, streams, shells, asymmetries and lopsidedness, all of which contribute to our understanding of galaxy evolution in the nearby Universe.

Spitzer Space Telescope - General Observer Proposal #10052

Deep Imaging and Structure Decomposition of Nearby Elliptical Galaxies

Principal Investigator: Luis Ho
Institution: Carnegie Institution of Washington

Technical Contact: Luis Ho, Carnegie Institution of Washington

Co-Investigators:
Song Huang, Observatories of Carnegie Institute of Washington

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 29.8
Priority: 2

Abstract:
The formation and evolution of massive elliptical (E) galaxies still present unresolved puzzles. Recent observations show that high-z early-type galaxies (ETGs) are more compact than local galaxies of the same mass. This structural difference indicates gradual inside-out build-up of an extended outer envelope, most likely via dissipationless processes. Under this picture, the envelope of nearby massive Es records the fossil evidence of the late-stage growth. Yet, these structures have not been reliably explored using Spitzer IRAC imaging except for a small number of Es in extreme, dense environments. As the most common environment for $>L^{ast}$ galaxies and where the late-stage, minor-merger driven evolution first started, the group environment is a very efficient place for the growth of massive Es. In this proposal, we request 29.8 hours of IRAC imaging of five massive Es in different group environments. The sample has been carefully studied using optical images from the Carnegie-Irvine Galaxy Survey, and all have additional optical, high-resolution images from {\\emph HST}. With a careful mapping design and 1680 s on-source integration, we can achieve a sensitivity of at least 26.6 (AB) mag arcsec^{-2} in the 3.6 micron band. This senstivity will allow us to get good constraints on the outer stellar density profiles and explore their extended, low-surface brightness structures in great detail.

Spitzer Space Telescope - General Observer Proposal #10008

As the Disk Turns... Monitoring the Azimuthal Thermal Gradient of the Irradiated Dust Disk in Epsilon Aurigae

Principal Investigator: Donald Hoard
Institution: Eureka Scientific Inc.

Technical Contact: Donald Hoard, Eureka Scientific Inc.

Co-Investigators:
Steve Howell, NASA-Ames
Robert Stencel, University of Denver

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.8
Priority: 1

Abstract:
Epsilon Aurigae is the eclipsing binary star with the longest known orbital period, showing a single long (~2 yr) eclipse every 27.1 yr. For the last ~200 years, the nature of the eclipsing object defied explanation. We recently showed that epsilon Aur most likely consists of a high luminosity F0 post-AGB star, and a B5 V star surrounded by a solar system size (~8 AU diameter) disk of dusty material. We propose to continue our IRAC monitoring of epsilon Aur, to characterize the disk's azimuthal thermal variation as its irradiated, warm (1150 K) portion increasingly comes into view. We request 0.2 hr to obtain 2 IRAC observations. If Cycle 10 is extended through Jan 2015, we request another 6 visits (0.6 hr) in Dec 2014, coinciding with the predicted start of coherent pulsations of the F star, which occur every ~3000 days. The most recent eclipse was in Aug 2009-Jul 2011; we are now in the post-eclipse phase, when the heated side of the disk begins rotating into view. During the majority of our past IRAC observations (starting a few months prior to the eclipse ingress), only the cool (550 K) side of the disk was visible. In 2014-2015, as we move toward quadrature, the effect of heating due to the F star will increase the IRAC ch1/ch2 flux ratio. The eclipse of epsilon Aur is a rare event and a unique astrophysical opportunity, since backlighting of the disk by the luminous eclipsed star reveals details that cannot be detected in similar disks around single stars. This is one of the very few astrophysical disks where azimuthal thermal gradients can be mapped and interpreted. Observations of the warm side of the disk are crucial to test and constrain new models of disk structure. As part of our overall monitoring campaign with Spitzer, Hubble, Herschel, and numerous ground-based facilities, the proposed observations will make an important contribution to the understanding of binary stars, including mass transfer and evolution, along with new insights into astrophysical disks and post-AGB star evolution.

Spitzer Space Telescope - General Observer Proposal #80017

Epsilon Aurigae at the End of Eclipse

Principal Investigator: Donald Hoard
Institution: Spitzer Science Center

Technical Contact: Donald Hoard, Spitzer Science Center

Co-Investigators:
R. Stencel, University of Denver
S. Howell, NOAO

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
We request a small investment of 24 minutes of Spitzer time, to obtain four IRAC observations of epsilon Aurigae. A naked eye object located near Capella, epsilon Aurigae is the eclipsing binary star with the longest known orbital period, showing a single long duration (~2 yr) eclipse every 27.1 yr. For much of the last 150 years, the nature of the eclipsing object defied explanation. We recently demonstrated that epsilon Aurigae consists of a high luminosity F0 post-AGB star in orbit with a B5 V star surrounded by a solar system sized (~8 AU diameter) disk of cool, dust-dominated material. The eclipse of epsilon Aurigae is a rare event; moreover, it is a unique astrophysical opportunity, since the backlighting of the disk by the high luminosity eclipsed star reveals details that cannot be detected in similar dusty disks around single stars. The current eclipse started in August 2009 and is expected to reach its photometric conclusion in May 2011 (with the spectroscopic conclusion as late as December 2011). The goals for these observations include: (1) extend our ongoing IRAC monitoring campaign covering the current eclipse to late-phase and post-eclipse visits; (2) provide a consistent, well-calibrated space-based set of IR photometry for comparison with ongoing ground-based work; and (3) use the composite results to constrain the thermal profile of the disk. A key expectation of these particular observations is to reveal the irradiation-heated portion of the disk, which will be visible on its trailing side following eclipse. Observations of this side of the disk will be crucial to test and constrain new models of disk structure. As part of our overall monitoring campaign with Spitzer, Hubble, Herschel, and numerous ground-based facilities, these proposed observations will make an important contribution to the understanding of stellar evolution in binary stars, including mass transfer and evolution studies, along with new insights into astrophysical disks and post-AGB star evolution.

Spitzer Space Telescope - General Observer Proposal #90097

Revealing the Hot Side of Epsilon Aurigae

Principal Investigator: Donald Hoard
Institution: Eureka Scientific Inc.

Technical Contact: Donald Hoard, Eureka Scientific Inc.

Co-Investigators:
Robert Stencel, University of Denver
Steve Howell, NASA-Ames

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
We request a small investment of 24 minutes of Spitzer time, to obtain four IRAC observations of epsilon Aurigae. A naked eye object located near Capella, epsilon Aurigae is the eclipsing binary star with the longest known orbital period, showing a single long duration (~2 yr) eclipse every 27.1 yr. For much of the last 200 years, the nature of the eclipsing object defied explanation. We recently demonstrated that epsilon Aurigae consists of a high luminosity F0 post-AGB star in orbit with a B5 V star surrounded by a solar system sized (~8 AU diameter) disk of cool, dust-dominated material. The eclipse of epsilon Aurigae is a rare event; moreover, it is a unique astrophysical opportunity, since the backlighting of the disk by the high luminosity eclipsed star reveals details that cannot be detected in similar dusty disks around single stars. The current eclipse started in August 2009 and ended in July 2011; we are now in the post-eclipse phase, when the irradiation-heated side of the disk will begin rotating into view. The goals for these observations include: (1) extend our ongoing IRAC monitoring campaign covering the current eclipse to post-eclipse visits; (2) provide a consistent, well-calibrated space-based set of IR photometry for comparison with ongoing ground-based work; and (3) use the composite results to constrain the thermal profile of the disk. A key expectation of these particular observations is to reveal the irradiation-heated portion of the disk, which will be visible on its trailing side following eclipse. Observations of this side of the disk will be crucial to test and constrain new models of disk structure. As part of our overall monitoring campaign with Spitzer, Hubble, Herschel, and numerous ground-based facilities, these proposed observations will make an important contribution to the understanding of stellar evolution in binary stars, including mass transfer and evolution studies, along with new insights into astrophysical disks and post-AGB star evolution.

Spitzer Space Telescope - General Observer Proposal #90105

Illuminating the Process of Dust Accretion on a White Dwarf

Principal Investigator: Donald Hoard
Institution: Eureka Scientific Inc.

Technical Contact: Donald Hoard, Eureka Scientific Inc.

Co-Investigators:
Steve Howell, NASA-Ames

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.8

Abstract:
KIC 9535405 is a white dwarf identified as a blue variable object in the Burrell Optical Kepler Survey. Our time-resolved optical spectra of KIC 9535405 show accreted metals in its photosphere, indicating ongoing accretion from a previously undetected circumstellar dust disk (KIC 9535405 is too faint to have been detected by both 2MASS and WISE). Our Kepler time series observations have revealed a photometric period of 6.138 hr. The variability is non-sinusoidal and we have modelled it as due to a cooler (30,000 K) region on the hot (34,000 K) WD photosphere. This cool spot likely maps the zone of accreting metals on the WD surface. We propose here to (1) obtain precise IRAC ch 1 and ch 2 flux density measurements in order to characterize the IR excess due to circumstellar dust, and (2) obtain IRAC ch 1 and ch 2 light curves for comparison with the extant and ongoing Kepler and ground-based monitoring. Despite the causal connection between the presence of a dust disk and metal enrichment of the WD, little is known about the actual mechanism through which matter transits from the dust disk to the WD surface. In that regard, KIC 9535405 is a unique target that can address this gap in our understanding. It is the first dusty WD for which observational information at optical wavelengths shows the non-uniform geographic distribution of accreted material over the surface of the WD, providing an invaluable look at the intermediate steps of the process that starts with the IR excess observational signature of a dusty disk around a WD and ends with the observational signature of metal-enrichment in the optical-UV spectrum of the WD.

Spitzer Space Telescope - General Observer Proposal #11028

Deep Extinction Mapping in Molecular Cores

Principal Investigator: Klaus Hodapp
Institution: Institute for Astronomy, University of Hawaii

Technical Contact: Klaus Hodapp, Institute for Astronomy, University of Hawaii

Co-Investigators:
Laurie Urban, Institute for Astronomy
Marcia Rieke, University of Arizona

Science Category: ISM
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.2
Priority: 2

Abstract:
This proposal is for preparatory observations of the targets selected for a future James Webb Space Telescope (JWST) Near-Infrared Camera (NIRCam) guaranteed time project, as well as for a more general preparation for the science of this project. Our JWST project with NIRCam, NIRSpec, and MIRI is aimed at obtaining the deepest, and therefore best sampled, extinction maps of a sample of molecular cores, selected to contain quiescent, collapsing, and star-forming cores. We will also obtain spectroscopy of suitable, selected background stars for a detailed study of both the continuum extinction law and the ice feature absorption. The proposed Spitzer IRAC observations are aimed at identifying specific background stars for these future spectroscopic observations with JWST NIRSpec or NIRCam (grism), and with MIRI. For detailed planning of the JWST observations, we need to know how many suitable background stars are available, how many NIRSpec multi-slit pointing will be required, or whether slitless NIRCam grism spectroscopy is feasible. In addition to their role in preparing future JWST observations, the proposed Spitzer observations will immediately be used, together with UKIRT data we have already obtained and together with archival imaging data from other ground-based telescopes, to compute column density maps of the target objects and compare those with JCMT continuum and CO line emission maps to study the temperature distribution and gas freeze-out effects in those dense molecular cores. This work will form the main part of L. Urban’s Ph.D. thesis project.

Spitzer Space Telescope - General Observer Proposal #70063

Observing Stellar Mass Assembly at Half of a Hubble time in
the Environs of Two Massive Clusters of Galaxies

Principal Investigator: Bradford Holden
Institution: University of California Obs/Lick Obs

Technical Contact: Bradford Holden, UCO/Lick Obs.

Co-Investigators:

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.0

Abstract:
It is now well-established that mass-selected samples are crucial to understanding the evolution of galaxies at intermediate-high redshift as they transform from starforming galaxies to more quiescent galaxies. Spitzer plays a crucial role in the derivation of such samples. We propose to use IRAC to measure accurate stellar masses of galaxies in our unique spectroscopic and imaging survey of the environs of two forming clusters of galaxies at z~0.8. The evolution of the galaxy stellar mass function is a key prediction of many models of galaxy formation, and various models make different predictions on how much mass assembly occurs for cluster galaxies during the cluster formation process. Our large, low dispersion spectroscopic survey has already yielded a remarkable 20,000 redshifts between z~0 and z~1, including over 2400 at the redshift of our clusters. The proposed IRAC data will provide a measure of the rest-frame, near-infrared flux, and therefore provide accurate stellar mass estimates with which we can study the evolution of the stellar mass function. The proposed wide area will provide us with a field sample at the redshift of the clusters, which will allow us to compare mass functions in different environments. A key aspect of our study is to derive and compare the cluster and group galaxy mass function with the mass function of the field. This very important test will investigate whether the growth of dark matter halos directly influences the growth of the stellar mass of the galaxies in those halos.

Spitzer Space Telescope - General Observer Proposal #10059

The Effective Extinction Law in Overlapping Galaxy Pairs

Principal Investigator: Benne Holwerda
Institution: ESTEC, European Space Agency

Technical Contact: Benne Holwerda, ESTEC, European Space Agency

Co-Investigators:
Joannah Hinz, MMT
William Keel, University of Alabama

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0
Priority: 2

Abstract:
Dust extinction plays a crucial role in understanding fundamental cosmological parameters, in everything from determining the mass density and the cosmological constant from type IA supernovae observations to understanding the measured star-formation rates of the highest redshift proto-galaxies in the early Universe. Currently, very little is known about dust masses or the effects of dust at these cosmic distances. However, an effective dust extinction law can be measured successfully in the nearby Universe from pairs of overlapping star-forming galaxies. Assuming symmetry of both galaxy pair members, the dust extinction can be derived by measuring the light missing from the background galaxy disk. We have used this technique successfully in the optical, but to apply it to the few pairs observed and resolved at UV and optical wavelengths, an accurate measure of the intrinsic symmetry of the galaxies in the pair is needed. Only Spitzer can measure this galactic symmetry free of extinction from dust and at a level sensitive enough to detect any faint asymmetries in outer disks. However, only one overlapping pairs of galaxies with existing UV observations has been observed previously with Spitzer, and this is not enough to understand how dust extinction might change with morphological type, galaxy mass, and other parameters. Therefore, we ask for Spitzer/IRAC observations of four additional pairs of overlapping galaxies to measure the intrinsic asymmetry of galaxies in each pair and, thus, calibrate the observed effective extinction law in the overlap regions. Understanding local dust extinction in star-forming galaxies will be of tremendous value to unraveling the role of dust at higher redshifts.

Spitzer Space Telescope - General Observer Proposal #13148

Super-Eight: The brightest z~8 Galaxies

Principal Investigator: Benne Holwerda
Institution: Sterrewacht Leiden

Technical Contact: Benne Holwerda, Sterrewacht Leiden

Co-Investigators:
R. Bouwens, Universiteit Leiden
L. Bradley, Space Telescope Science Institute
V. Calvi, Space Telescope Science Institute
G. Illingworth, University of California - Santa Cruz
I. Labbe, Universiteit Leiden
D. Magee, University of California - Santa Cruz
P. Oesch, Yale University
G. Roberts-Borsani, University College London
R. Smit, Durham Univ.

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.0
Priority: 1

Abstract:
What are the properties of the most massive z~8 galaxies ("Super-Eights") and how luminous can these galaxies become at that epoch? Answering these questions is challenging due to the rarity of luminous z~8 galaxies and the large field-to-field variations in their volume densities. Indeed, the full wide-area CANDELS program only shows 3 z~8 galaxy candidates brighter than 25.5 mag and all of these candidates conspicuously lie in the same CANDELS field (EGS). One of our strongest new probes for particularly luminous z~8 galaxies are the WFC3 Pure-Parallel (PP) programs. Particularly intriguing are 8 bright z~8 candidates in these observations. These candidates have similar luminosities as the 3 brightest z~8 candidates from CANDELS (all spectroscopically confirmed). However, the uncertain contamination levels at extreme bright end of z~8 selection mean that follow-up observations are critical. We propose highly-efficient pointed HST and Spitzer/IRAC observations to determine if these candidates are indeed at z~8. We estimate that anywhere from 50 to 100% of the targeted sources will be confirmed to be at z~8 based on our results from CANDELS. The estimate is very uncertain due to very large cosmic variance in the CANDELS result and contamination from rare low-redshift sources. When combined with CANDELS, our observations would provide us the strongest current constraints on the volume density of bright, massive galaxies in the early Universe (serving as a guide to models of their build-up) and also provide valuable targets for future spectroscopy (e.g. with JWST), useful for probing the ionization state of the IGM.

Spitzer Space Telescope - General Observer Proposal #14049

Nebular Line Emission and Stellar Mass of Bright z~8 Galaxies ‘‘Super-Eights’’

Principal Investigator: Benne Holwerda
Institution: Leiden University

Technical Contact: Benne Holwerda, Leiden University

Co-Investigators:
Rychard Bouwens, University of Leiden
Michele Trenti, University of Melbourne
Pascal Oesch, Yale
Ivo Labbe, University of Leiden
Renske Smit, Durham University, Department of Physics
Guido Roberts-Borsani, University College London
Stephanie Bernard, University of Melbourne
Joanna Bridge, University of Louisville

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 31.9
Priority: 1

Abstract:
Searches for the Lyman-alpha emission from the very first galaxies ionizing the Universe have proved to be extremely difficult with limited success beyond z~7 (<3% detections). However, a search of all CANDELS yielded four bright z~8 sources with associated strong Lyman-alpha lines, despite the Universe expected to be ~70% neutral at this time. The key to their selection is an extremely red IRAC color ([3.6]-[4.5]> 0.5, Roberts-Borsani+ 2016), indicative of very strong nebular line emission. Do such extreme line emitting galaxies produce most of the photons to reionize the Universe? We propose to expand the sample of bright z~8 galaxies with reliable IRAC colors with seven more Y-band dropouts found with HST and confirmed through HST/Spitzer. The Spitzer observations will test how many of bright z~8 galaxies are IRAC-red and measure both their stellar mass and [OIII]+Hbeta line strength. Together with Keck/VLT spectroscopy, they will address these questions: I) Do all luminous z~8 galaxies show such red IRAC colors ([OIII] emission / hard spectra)? II) Is luminosity or a red IRAC color the dominant predictor for Lyman-alpha emission? III) Or are these sources found along exceptionally transparent sightlines into the early Universe? With 11 bright z~8 sources along different lines-of-sight, all prime targets for JWST, we will aim to determine which of the considered factors (luminosity, color, sight-line) drives the high Lyman-alpha prevalence (100%) and insight into the sources reionizing the Universe.

Spitzer Space Telescope - General Observer Proposal #10012

A Survey for Outflows in Infrared Dark Clouds

Principal Investigator: Joseph L Hora
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Joseph L Hora, Harvard-Smithsonian Astrophysical Observatory

Co-Investigators:
Claudia Cyganowski, Harvard-Smithsonian CfA
Howard Smith, Harvard-Smithsonian CfA
Jonathan Foster, Yale University
Matthew Povich, California State Polytechnic University, Pomona
Susanna Finn, unaffiliated
James Jackson, Boston University

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 107.4

Abstract:
We propose deep IRAC observations of a sample of IRDCs, selected to have ancillary data available and to contain cores spanning a range of evolutionary states. The star formation activity of the sample ranges from candidate starless cores to IR-bright massive YSOs, based on current data. The primary goals of the proposed IRAC observations are (1) to detect additional 4.5 micron outflows and (2) to study the low-mass YSO population associated with the IRDCs. By concentrating our mapping on previously identified IRDCs, we can quickly obtain images that improve by an order of magnitude on the sensitivity to extended emission from outflows and to point sources (YSOs) of the original GLIMPSE survey data. These deeper data will allow us to address several questions important to understanding star and cluster formation in IRDCs and the meaning of extended 4.5 micron emission as a star-formation tracer.

Spitzer Space Telescope - General Observer Proposal #14005

Investigating Massive Star Formation in the Cep OB4 Association

Principal Investigator: Joseph Hora
Institution: Harvard/Smithsonian Center for Astrophysics

Technical Contact: Joseph Hora, Harvard/Smithsonian Center for Astrophysics

Co-Investigators:
Howard Smith, CfA
Elaine Winston, CfA
Volker Tolls, CfA

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.6
Priority: 2

Abstract:
We propose to map the OB association Cep OB4 to perform a census of the young stellar objects (YSOs) in the association and its surrounding bright-rimmed cloud. This association is one of the closest massive star-forming regions and has a favorable location and viewing geometry for study, but has never been fully mapped by Spitzer/IRAC. We will identify the Class I, II and III YSOs in the region and determine their properties, which we will use to analyze the population and test aspects of star formation models in OB associations. The data will provide a legacy for future studies of this region, including source identifications and followups with JWST.

Spitzer Space Telescope - General Observer Proposal #80058

W43 - Extreme Star Formation in the Galactic Bar

Principal Investigator: Joseph Hora
Institution: Harvard/Smithsonian Center for Astrophysics

Technical Contact: Joseph Hora, Harvard/Smithsonian Center for Astrophysics

Co-Investigators:
Frederique Motte, CEA/Saclay
Quang Nguyen-Luong, CEA/Saclay
Tom Megeath, University of Toledo
Peter Schilke, University of Cologne
Nicola Schneider, CEA/Saclay
Sylvain Bontemps, Observatoire de Bordeaux
Rob Gutermuth, Smith College
Howard Smith, CfA
Kathleen Kraemer, AFRL
Sean Carey, Spitzer Science Center
Eric Keto, CfA
Xavier Koenig, GSFC
Giovanni Fazio, CfA
Robert Simon, University of Cologne
Lori Allen, CfA/NOAO
Don Mizuno, AFRL
Stephan Price, AFRL
Joseph Adams, Cornell University

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.0

Abstract:
We propose to extend Spitzer's study of massive star formation to the W43 massive star-forming complex, located in the 5 kpc molecular ring, which is the most active region of star formation in our Galaxy. Star formation may be different in this region due to a higher overall density of massive molecular clouds and star formation, higher radiation fields and supernova rates, and a higher metallicity. Thus, the proposed observations will allow us to compare star formation in this massive inner Galaxy region to star formation near the Sun, and in the outer Galaxy (coming from the studies of W5, the Cycle-5 SMOG project, and GLIMPSE360), and therefore to complete a more representative view of star formation in the Galaxy.

Spitzer Space Telescope - General Observer Proposal #80088

YSO variability in Massive Star-forming Regions

Principal Investigator: Joseph Hora
Institution: Harvard/Smithsonian Center for Astrophysics

Technical Contact: Joseph Hora, Harvard/Smithsonian Center for Astrophysics

Co-Investigators:
Tom Megeath, University of Toledo
John Stauffer, Spitzer Science Center
Rob Gutermuth, Smith College
Maria Morales-Calderon, SSC/Caltech
Kevin Flaherty, University of Arizona
Jan Forbrich, Harvard-Smithsonian Center for Astrophysics
Peter Plavchan, NExtSci/IPAC/Caltech
Luisa Rebull, SSC/Caltech
Barb Whitney, Space Science Institute
Elaine Winston, ESTEC
Howard Smith, Harvard-Smithsonian Center for Astrophysics

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 115.0

Abstract:
We propose to obtain multi-epoch observations of two fields in the Cygnus-X massive star-forming complex to determine the variability characteristics of intermediate- to high-mass young stellar objects (YSOs). This program is complementary to the YSOVAR exploration science program which obtained lightcurves for a sample of low- mass YSOs in nearby star forming regions. We propose monitoring two fields in Cygnus-X, which in total contain at least 140 Class I and 900 Class II YSOs. This will provide a significant sample of objects and allow us to constrain models of variability in young stars, particularly in the phase of evolution where they have massive disks and circumstellar envelopes and are accreting mass at a rapid rate.

Spitzer Space Telescope - General Observer Proposal #90187

Extreme Star Formation in the Massive Young Cluster Westerlund 1

Principal Investigator: Joseph Hora
Institution: Harvard/Smithsonian Center for Astrophysics

Technical Contact: Joseph Hora, Harvard/Smithsonian Center for Astrophysics

Co-Investigators:
Kathleen Kraemer, Boston College
Tom Megeath, University of Toledo
Rob Gutermuth, Smith College
Howard Smith, CfA
Juan Rafael Martinez Galarza, CfA
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Nicola Schneider, CEA/Saclay
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Sylvain Bontemps, Observatoire de Bordeaux
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Quang Nguyen-Luong, CEA/Saclay
Peter Schilke, University of Cologne
Eric Keto, CfA
Giovanni Fazio, CfA
Lori Allen, NOAO

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.2

Abstract:
We propose to extend Spitzer's study of massive star formation to the massive cluster Westerlund 1, which at ~4 kpc is the closest and most massive "Super Star Cluster" known in the Galaxy. Star formation may have proceeded differently in this region, having created a higher overall density of coeval massive stars. The proposed observations will allow us to compare star formation in this region to that seen near the Sun, in the massive Cygnus-X complex, and in the outer Galaxy (coming from the studies of W5, the Cycle-5 SMOG project, and GLIMPSE360), and therefore to complete a more representative view of star formation in the Galaxy.

Spitzer Space Telescope - General Observer Proposal #90168

Old Stars in the Massive, Gas-Rich HIgh Mass Galaxies

Principal Investigator: Shan Huang
Institution: Cornell University

Technical Contact: Shan Huang, Cornell University

Co-Investigators:
Martha Haynes, Cornell U.
Leslie Hunt, Oss. Astrof. Arecetri
Riccardo Giovanelli, Cornell U.
Elizabeth Adams, Cornell U.
Jarle Brinchmann, U. Leiden
John Carpenter, Caltech
Gregory Hallenbeck, Cornell U.
Karen Masters, U. Portsmouth
Emmanouil Papastergis, Cornell U.
Amelie Saintonge, Max Planck Inst. extra. Physik
Kristine Spekkens, Royal Military College Canada
Sabrina Stierwalt, U. Virginia

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.4

Abstract:
We propose to obtain IRAC maps (at 3.6 and 4.5 micron) of a sample of 32 exceptionally gas-rich galaxies extracted from the ALFALFA extragalactic HI survey. These very HIgh HI Mass (HIghMass) galaxies have HI masses > 10^10 Msun and are also very gas-rich for their stellar masses. Are they in an arrested stage of evolution or do their huge HI disks, evident in our HI synthesis maps, result from recent baryon accretion? The current proposal builds on a coordinated multiwavelength program already underway which includes HI synthesis mapping (JVLA, GMRT, WSRT), UV imaging (GALEX), Halpha imaging (KPNO), optical spectroscopy (INT), CO mapping (CARMA), CO line observation (IRAM), and FIR/submm mapping (Herschel). The proposed observations will allow us to probe the underlying older stellar population in the HIghMass galaxies, yielding insight into how many stars were formed at early times and where within their disks that early star formation took place. The additional NIR data will substantially improve the stellar mass estimates relative to our SDSS- only estimates. In combination with the other data, we will determine their star formation histories and disentangle the possible evolutionary scenarios. In particular, the unique combination of sensitivity and angular resolution of Spitzer in this wavelength range is critical to study the substructures of the old stellar population at a resolution that can be easily compared with our UV/optical images and to trace the mass and color profiles into the outer disks of faint surface brightness. The HIghMass galaxies identified by ALFALFA represent the local counterparts of the populations which are likely to dominate future studies of HI at higher redshift with the Square Kilometre Array.

Spitzer Space Telescope - General Observer Proposal #90243

Confirmation of T Dwarf Candidate Companions of Radial Velocity Planet Systems

Principal Investigator: Alan Hulsebus
Institution: Iowa State University

Technical Contact: Alan Hulsebus, Iowa State University

Co-Investigators:
Joe Carson, College of Charleston
Massimo Marengo, Iowa State University

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.2

Abstract:
We propose to carry out second epoch IRAC observations in order to confirm common proper motion of two T-dwarf companion candidates identified at 2.3 and 2.2 arcmin separation from high-eccentricity, radial velocity (RV) planet systems. The candidates were identified with Spitzer IRAC 3.6 and 4.5 micron observations, along with follow-up photometry in J (1.25 micron) band using the Calar Alto 3.5m Omega2000 instrument. One solar-type RV host star has a 1.8 MJ planet at 1.9 AU, with orbital eccentricity 0.8; the second has an 8.1 MJ planet at 2.9 AU with an orbital eccentricity of 0.3. Through the "Kozai Mechanism", a wide-separation brown dwarf companion could explain the unusually high eccentricity of the gas giant planets in these systems.

Spitzer Space Telescope - General Observer Proposal #90180

Probing the Extremes of the Stellar Mass-Metallicity Relation with IRAC

Principal Investigator: Leslie Hunt
Institution: INAF - Istituto di Radioastronomia/Firenze

Technical Contact: Leslie Hunt, INAF - Istituto di Radioastronomia/Firenze

Co-Investigators:
Simone Bianchi, INAF-Osservatorio Astrofisico di Arcetri, Firenze
Martha P. Haynes, Cornell University
Laura Magrini, INAF-Osservatorio Astrofisico di Arcetri
Sandra Savaglio, Max-Planck-Institut fur Extraterrestrische Physik
Stefano Zibetti, INAF-Osservatorio Astrofisico di Arcetri

Science Category: starburst galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.6

Abstract:
The relation between metallicity and stellar mass (MZR) among galaxies is one of the fundamental relations in astronomy, key to understanding galaxy mass assembly and evolution. In the Local Universe the MZR has been extensively studied using the SDSS survey, and extended, with IRAC, to low surface-brightness dwarf galaxies with low star-formation rates (SFRs). Although quite tight for the original sample, the IRAC MZR breaks down when applied to metal-poor low-mass galaxies with high SFRs - i.e., the types of galaxies expected to be abundant in the early universe. Our new formulation of the MZR, which encompasses both the quiescent mode of star formation (SF, the main sequence) and the starburst SF mode, better predicts the position of metal-deficient starbursts in the MZR. However, it is based on a very small number of these metal-poor galaxies which occupy a key position in the MZR. To fill this gap, we propose IRAC imaging of 45 extremely metal-deficient star-forming dwarf galaxies. Our proposed observations will be combined with data for existing (higher-metallicity) dwarf galaxies already in the archive in order to: (1) assess gas and hot dust contamination to the IRAC colors as a function of SFR, age, and metallicity; (2) infer stellar mass from corrected IRAC fluxes, combined with optical photometry, and re-assess the MZR down to the lowest abundances known for star-forming galaxies; (3) investigate trends with specific SFR locally and compare with those at high-redshift; (4) examine the various hypotheses possibly underlying the MZR, including outflow in low-mass galaxies, inflow of pristine gas, and chemical downsizing. Ultimately, our proposed observations will enable a more reliable assessment of fundamental scaling relations among stellar mass, metallicity, and SFR, and help constrain mass assembly over cosmic epochs.

Spitzer Space Telescope - General Observer Proposal #11029

Follow-up of Candidate Companions to Vega

Principal Investigator: Markus Janson
Institution: Stockholm University

Technical Contact: Markus Janson, Stockholm University

Co-Investigators:
Sascha Quanz, ETH Zurich
Joseph Carson, College of Charleston
Christian Thalmann, ETH Zurich
David Lafreniere, University of Montreal
Adam Amara, ETH Zurich

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 7.2
Priority: 1

Abstract:
Vega hosts one of the most nearby massive debris disks, with a morphology that may be indicative of wide giant planetary companions. Its proximity and relatively young age also make it an attractive target for direct imaging searches for such companions. We therefore observed Vega with Spitzer during cycle 9, which provides the best sensitivity to planets in wide orbits that is available with any existing facility. Three candidates were discovered in the data which are substantially brighter at 4.5 micron than at 3.6 micron, while typical background sources have much smaller brightness differences between these bands. We now propose to follow the system up in a second epoch to test the three candidates for common proper motion with the primary star. If real, physical companions, the candidates have separations of 265-335 AU and masses of 2-3 Mjup according to evolutionary models (regardless of initial entropy conditions), and would therefore constitute the coldest and lowest-mass planets ever imaged outside of the Solar System.

Spitzer Space Telescope - General Observer Proposal #70009

Improved Search for Thermal Emission from Fomalhaut b

Principal Investigator: Markus Janson
Institution: University of Toronto

Technical Contact: Markus Janson, University of Toronto

Co-Investigators:
Joe Carson, College of Charleston
David Lafreniere, University of Montreal

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.1

Abstract:
Fomalhaut is a young, nearby, and massive star hosting a circumstellar debris disk. The disk consists primarily of a ring with a sharp inner edge, which is eccentric and offset from the photocenter of the star. This characteristic morphology is believed to be caused by dynamical sculpting by a planetary companion. Coronagraphic imaging of the system has revealed a co-moving point-source, which has been interpreted as being a signature of this companion. However, subsequent imaging attempts at longer wavelengths have failed to detect this candidate. We show that due to the large separation between the star and candidate planet, Spitzer imaging with an improved high-contrast method provides the best opportunity for detecting thermal emission corresponding to masses approaching the lower limit of 0.5 Mjup for the expected companion, derived from dynamical models at the age of the Fomalhaut system. Our proposed observations could therefore provide the first definite thermal image of the candidate, which is necessary to unambiguously confirm its existence and constrain its physical properties.

Spitzer Space Telescope - General Observer Proposal #90170

Imaging Search for Dynamically Inferred Planets in Nearby Debris Disk Systems

Principal Investigator: Markus Janson
Institution: Princeton University

Technical Contact: Markus Janson, Princeton University

Co-Investigators:
Joe Carson, College of Charleston
David Lafreniere, University of Montreal
Dave Spiegel, Institute for Advanced Study
Sascha Quanz, ETH Zurich
Christian Thalmann, University of Amsterdam
Adam Amara, ETH Zurich

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 11.0

Abstract:
The nearby stars Eps Eri, Vega, and Fomalhaut all host large debris disks with morphological structures that can be interpreted as being due to dynamical influence from unseen giant planets residing in the systems. At the ages of the systems of a few hundred Myrs, such planets are expected to have cooled down to temperatures of ~200 K, which makes them unreachable from the ground due to their faintness at JHKL wavelengths and the prohibitively large thermal background at longer wavelengths. Spitzer, however, has the sensitivity required at 4.5 micron to detect such objects. As we have shown previously (Janson et al. 2012), a dedicated observing strategy and data reduction scheme can be used to improve the Spitzer contrast performance by more than an order of magnitude compared to conventional methods, which enables this degree of sensitivity down to separations of ~10". The corresponding detection space provides an excellent match to the predicted properties of inferred companions in the three systems. Here, we propose to re-observe Fomalhaut to follow up a candidate companion detected in our previous image, and to observe Vega and Eps Eri to search for their inferred companions. In each case we will be sensitive to Jovian or sub-Jovian companions in the primary separation regions of interest, which is a factor 3 better mass sensitivity than previously achieved. These observations provide a unique opportunity to study far colder and more Jupiter-like planets than previously imaged.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13155

Search for Transits by the Earth Analogue around Proxima Centauri

Principal Investigator: James Jenkins
Institution: Universidad de Chile

Technical Contact: Joseph Harrington, University of Central Florida

Co-Investigators:
Joseph Harrington, University of Central Florida
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Patricio Rojo, Universidad de Chile
Eliza Kempton, Grinnell College
Ricardo Ramirez, Universidad de Chile
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Ignasi Ribas, Institut dEstudis Espacials de Catalunya
David Kipping, Columbia University
Cristina Rodriguez-Lopez, Instituto Astrofisica de Andalucia
Stefan Dreizler, University of Gottingen
Jantje Freudenthal, University of Gottingen
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Guillem Anglada-Escude, Queen Mary University of London

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 49.0

Abstract:
We will search for transits of the recently discovered Proxima Centauri b. Radial-velocity (RV) data indicate a planet with >1.5 Me (Earth masses) and an equilibrium temperature of 230 K (assuming 0.3 albedo and complete heat redistribution). Comparing to Earth's 255 K equilibrium temperature, the planet may be an excellent candidate to host life, and its proximity, at just 1.3 pc, makes it particularly favorable for observation, compared to more distant planets. It is thus the exoplanet with the highest priority for characterization. Due to the red-dwarf star's high activity level, the small size of the planet, and the orbital period, optical ground-based transit surveys have not achieved the sensitivity needed to detect the transit, but Spitzer easily can. The Pale Red Dot project, the planet's discoverers, thus request observations that should find any transit with 99% confidence, and that will characterise the atmosphere with transits at both Spitzer wavelengths.

An additional 37.5hr was awarded to this program to do further observations in 2017.

Spitzer Space Telescope - General Observer Proposal #10055

Deep Spitzer/IRAC Imaging of the Subaru Deep Field

Principal Investigator: Linhua Jiang
Institution: Arizona State University

Technical Contact: Linhua Jiang, Arizona State University

Co-Investigators:
Eiichi Egami, University of Arizona
Seth Cohen, Arizona State University
Xiaohui Fan, University of Arizona
Chun Ly, STScI
Matthew Mechtley, Arizona State University
Rogier Windhorst, Arizona State University

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 132.2
Priority: 2

Abstract:
The last decade saw great progress in our understanding of the distant Universe as a number of objects at z > 6 were discovered. The Subaru Deep Field (SDF) project has played an important role on study of high-z galaxies. The SDF is unique: it covers a large area of 850 sq arcmin; it has extremely deep optical images in a series of broad and narrow bands; it has the largest sample of spectroscopically-confirmed galaxies known at z >= 6, including ~100 Lyman alpha emitters (LAEs) and ~50 Lyman break galaxies (LBGs). Here we propose to carry out deep IRAC imaging observations of the central 75% of the SDF. The proposed observations together with those from our previous Spitzer programs will reach a depth of ~10 hours, and enable the first complete census of physical properties and stellar populations of spectroscopically-confirmed galaxies at the end of cosmic reionization. IRAC data is the key to measure stellar masses and constrain stellar populations in high-z galaxies. From SED modeling with secure redshifts, we will characterize the physical properties of these galaxies, and trace their mass assembly and star formation history. In particular, it allows us, for the first time, to study stellar populations in a large sample of z >=6 LAEs. We will also address some critical questions, such as whether LAEs and LBGs represent physically different galaxy populations. All these will help us to understand the earliest galaxy formation and evolution, and better constrain the galaxy contribution to reionization. The IRAC data will also cover 10,000 emission-line selected galaxies at z < 1.5, 50,000 UV and mass selected LBGs at 1.5 < z < 3, and more than 5,000 LBGs at 3 < z < 6. It will have a legacy value for SDF-related programs.

Spitzer Space Telescope - General Observer Proposal #70094

Physical Properties of Spectroscopically Confirmed Galaxies at 5.7<z<7 in the Subaru Deep Field

Principal Investigator: Linhua Jiang
Institution: University of Arizona

Technical Contact: Linhua Jiang, University of Arizona

Co-Investigators:
Eiichi Egami, University of Arizona
Nobunari Kashikawa, NAOJ, Japan

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 49.5

Abstract:
The last few years have seen a number of discoveries that provided the first glimpse of the universe at z > 6 using both space and ground-based telescopes. The Subaru Deep Field (SDF) project has been very successful in searching for high-redshift galaxies. It has spectroscopically identified more than 100 galaxies at z > 5.7 (i.e., the majority of the currently confirmed galaxies at z > 5.7 are in this field), and thus is an ideal field to study physical properties of distant galaxies. Here we propose to carry out deep IRAC imaging of SDF with 12 telescope pointings. When combined with the existing data from our previous program, the new data will cover 90% of the known SDF galaxies at z > 5.7 to a depth of 5-6 hours or 0.12 uJy (3 sigma). As joint Spitzer/HST observations, we also propose to obtain deep HST WFC3 F125W- and F160W-band images of a representative sample of galaxies. The WFC3 data provides rest-frame UV photometry to decipher the properties of young stellar populations, while the IRAC data measure the amplitude of the Balmer break and constrain the properties of mature populations. With the proposed observations we will be able to characterize the physical properties of these highest-redshift galaxies known so far, and obtain accurate information of stellar masses, ages, star formation histories, etc. This helps us to understand the earliest galaxy formation and evolution and the galaxy contribution to cosmic reionization. We will also specifically address the following questions: (1) Do Lyman alpha emitters and Lyman break galaxies represent physically two different galaxy populations at z > 6; (2) Is the Lyman alpha emission systematically suppressed at z > 6 with respect to the continuum emission, or, are we reaching the epoch of cosmic reionization; (3) Do we see any sign of abnormally young stellar population at z > 6. The data obtained through this program will have a legacy value for high-redshift studies in general.

Spitzer Space Telescope - General Observer Proposal #10015

SMASH: Spitzer Merger History and Shape of the Galactic Halo

Principal Investigator: Kathryn Johnston
Institution: Columbia University

Technical Contact: Vicky Scowcroft, Carnegie Institution of Washington

Co-Investigators:
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Maria-Rosa Cioni, University of Hertfordshire
Roeland van der Marel, Space Telescope Science Institute
Andrzej Udalski, Warsaw University Observatory
Grzegorz Pietrzynski, Warsaw University Observatory
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David Nidever, University of Virginia
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Andy Monson, Carnegie Observatories
Mark Seibert, Carnegie Observatories
Horace Smith, Michigan State University
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Giuseppe Bono, Universit'a di Roma Tor Vergata, Roma, Italy
Massimo Marengo, Iowa State University
Eric Persson, Carnegie Observatories
David Law, University of Toronto
Carl Grillmair, California Institute of Technology
Judy Cohen, California Institute of Technology
Branimir Sesar, California Institute of Technology
Adrian Price-Whelan, Columbia
Michele Fabrizio, Astronomical Observatory of Teramo

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 646.0
Priority: 1

Abstract:
The existence of a period-luminosity relation for RR Lyrae variables as measured at IRAC mid-infrared wavelengths allows Spitzer to estimate distances to individual stars with 2% errors. The SMASH program will exploit this unprecedented opportunity to precisely map structures throughout the halo of our Galaxy. SMASH will construct the first 3-D map of one of the larger satellites of the Milky Way (Sagittarius), it will determine precise distances to four more satellites (Ursa Minor, Carina, Sculptor & Bootes) and make the only measurements of stars in tidal streams accurate enough to determine their individual positions within the debris. This proposal describes some of the ground-breaking science enabled by this program, from increased accuracy in determining the orbits of satellite galaxies, to revolutionary constraints on the mass, shape and orientation of our Milky Way's dark matter halo. The foundational importance of these data sets cannot be overstated. These Milky Way structures lie far beyond the reach of any current or proposed future direct parallax measurements. Moreover, the combination of the SMASH results with proper motions from ESA's upcoming astrometric mission, Gaia, can effectively stretch Gaia's horizon for full 6D phase-space maps of our Galaxy by nearly four orders of magnitude in volume! These data and the resulting distance measurements will become Spitzer's legacy to the Galactic Astronomy community for years to come.

Data from this program was split into multiple PIDs. You can find the data in program IDs 10015, 10160, 10161

Spitzer Space Telescope - General Observer Proposal #11103

Infrared Variable Stars in M32

Principal Investigator: Olivia Jones
Institution: Space Telescope Science Institute

Technical Contact: Olivia Jones, Space Telescope Science Institute

Co-Investigators:
Margaret Meixner, STScI
Iain McDonald, JBCA
Martha Boyer, NASA Goddard Space Flight Center
Mike Rich, UCLA
Ciska Kemper, ASIAA

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.9
Priority: 1

Abstract:
Asymptotic Giant Branch (AGB) stars are important contributors to enrichment of the interstellar medium. Their total dust contribution relative to supernovae, and how it changes with metallicity, is less certain. This uncertainty is largely due to the poorly determined dust-production rates. With Spitzer, we have identified 110 extremely dusty point sources within the Local Group dwarf elliptical galaxy M32, and estimated their total dust-input rate. To isolate the fainter evolved stars in M32, confirm their membership of the galaxy, better constrain their spectral energy distributions, pulsation properties, and dust-production rates, we require multi-epoch observations to identify their variability. From this, we can calculate the dust budget of the galaxy. We propose four additional epochs of data at both 3.6 and 4.5 microns which will detect over 1000 point sources, enabling identification of long-period, large-amplitude infrared variability among stars in our closest dwarf elliptical galaxy. Comparison to complementary studies at low metallicity will provide a critical test on how metallicity influences dust production in this metal-rich environment.

Spitzer Space Telescope - General Observer Proposal #10032

Infrared Variability of Dusty White Dwarfs?

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Siyi Xu, University of California, Los Angeles

Co-Investigators:
Siyi Xu, University of California, Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.7
Priority: 1

Abstract:
To date, 30 white dwarfs with excess infrared radiation have been discovered. It is still a mystery why there is a dramatic spread in their inner disk temperatures, ranging from 500 K to 1800 K. There are two leading theories. (i) This range represents different evolutionary stages and the infrared flux changes very slowly over the entire disk lifetime of 1 Myr. (ii) There are major fluctuations at the disk inner boundary, which cause the flux to be variable on a timescale of a few years. Comparing photometry from the newly released WISE data with Spitzer/IRAC, which were typically taken five years apart, we have found that the fluxes of 5 white dwarfs show differences larger than 3 sigma. We propose to reobserve these 5 targets to test whether there is true infrared variability to put better constraints on the inner disk regions around white dwarfs.

Spitzer Space Telescope - General Observer Proposal #70055

A Search for Circumstellar Dust Disks Around DBZ and DZ White Dwarfs

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Michael Jura, University of California - Los Angeles

Co-Investigators:
Jay Farihi, University of Leicester
Carl Melis, University of California, San Diego
Siyi Xu, University of California, Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10.3

Abstract:
We propose to observe 14 heavily polluted helium white dwarfs (DBZs and DZs) to search for dust disks. With current data, it appears that even when controlled for the same amount of accreted mass, cooler stars do not possess circumstellar dust. Is this an artifact of small number statistics or is there a real variation in the physical composition of parent bodies that white dwarfs accrete? Perhaps younger white dwarfs are contaminated by robust asteroid analogues while older white dwarfs accrete fragile materials from Kuiper Belt-like objects.

Spitzer Space Telescope - General Observer Proposal #80003

How Frequently Do Warm White Dwarfs Possess Dust Disks?

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Siyi Xu, University of California, Los Angeles

Co-Investigators:
Jay Farihi, University of Leicester
Siyi Xu, University of California, Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 28.4

Abstract:
Polluted white dwarfs with dust disks are proving to be uniquely powerful tools to study the elemental composition of extrasolar minor planets. We request IRAC observations of 39 warm white dwarfs to search for infrared excesses. These data will allow us to test the hypothesis that warm white dwarfs are more frequently polluted than cool white dwarfs. If so, then we may be able to indirectly reconstruct the orbital and compositional architectures of extrasolar planetary systems.

Spitzer Space Telescope - General Observer Proposal #90102

A Search for Dust Orbiting Highly-Polluted DBZ and DZ White Dwarfs

Principal Investigator: Michael Jura
Institution: University of California - Los Angeles

Technical Contact: Siyi Xu, University of California, Los Angeles

Co-Investigators:
Siyi Xu, University of California, Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5.1

Abstract:
We propose to observe seven heavily-polluted white dwarf stars to search for excess infrared radiation created by the debris from the tidal-disruption of a planetesimal. Our central science question is why do only some highly-polluted white dwarfs have circumstellar dust disks. We expect to use these results to better constrain the formation and evolution of extrasolar planetary systems.

Spitzer Space Telescope - General Observer Proposal #80132

Detecting the Signature of Eccentric Exoplanets During Periastron Passage

Principal Investigator: Stephen Kane
Institution: California Institute of Technology

Technical Contact: Stephen Kane, California Institute of Technology

Co-Investigators:
Dawn Gelino, NASA Exoplanet Science Institute, Caltech
Diana Dragomir, NASA Exoplanet Science Institute, Caltech
Andrew Howard, UC Berkeley
Heather Knutson, UC Berkeley
Jessica Krick, Spitzer Science Center, Caltech
Gregory Laughlin, UC Santa Cruz
Suvrath Mahadevan, Pennsylvania State University
Kaspar von Braun, NASA Exoplanet Science Institute, Caltech
Jason Wright, Pennsylvania State University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 50.0

Abstract:
Characterization of exoplanets has matured in recent years, particularly through studies of exoplanetary atmospheres of transiting planets at infra-red wavelenegths. A relatively unexplored region of exoplanet parameter space is the thermal detection of long-period eccentric planets during periastron passage. Detection of these signatures reveals important information on the albedo, radiative time constant, and heat redistribution efficiency of giant planetary atmospheres under these extreme conditions. Here we propose to monitor three such exoplanets whose orbital parameters have already been refined to great precision. The results of this study will constrain heat signatures from these planets and be used in building atmospheric models for planets which undergo large changes in flux.

Spitzer Space Telescope - General Observer Proposal #90207

A Mid-Infrared Search for the Outer Companion in a Millisecond Pulsar Triple System

Principal Investigator: David Kaplan
Institution: University of Wisconsin - Milwaukee

Technical Contact: David Kaplan, University of Wisconsin - Milwaukee

Co-Investigators:
Scott Ransom, NRAO
Ingrid Stairs, UBC
Jason Hessels, ASTRON/UvA

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.1

Abstract:
Only two systems with pulsars and multiple companions are known, but they offer a wealth of information about dynamics, binary evolution, and the pulsars themselves. We have recently discovered a bright new millisecond pulsar in a very exotic stellar system: a hierarchical triple system with a low-mass He-core white dwarf in a relatively compact 1.6-day orbit and an as-yet-undetermined outer star in a orbit of roughly 327 days. This is a unique system with incredible long-term potential to tell us about detailed Newtonian dynamics and stellar evolution, and it can also provide high-precision pulsar and white dwarf masses. However, our lack of knowledge about the outer companion significantly limits our understanding about the evolution of this system. Evolutionary models suggest a low-mass stellar companion, but current near-infrared data rule out anything earlier than M5. Here we request modest Spitzer/IRAC observations of this system: with 1.1 hours we can obtain precise photometry in the mid-infrared and detect or constrain any cool companion, thus establishing whether the system contains a low-mass star or a white dwarf and helping us unravel its complex evolutionary history.

Spitzer Space Telescope - Directors Discretionary Time Proposal #547

PTF10fqs: A Luminous Red Nova in the Spiral Messier 99

Principal Investigator: Mansi Kasliwal
Institution: Caltech

Technical Contact: Mansi Kasliwal, Caltech

Co-Investigators:
George Helou, Caltech
Jason Surace, Caltech
Shri Kulkarni, Caltech

Science Category: nearby galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0

Abstract:
On April 16, we discovered a rare transient (PTF10fqs) in the luminosity gap between novae and supernovae with the Palomar Transient Factory. PTF10fqs is located on a spiral arm in M99, a member of the Virgo Cluster. The explosion signature resembles that of a class of "Luminous Red Novae"; only two other such transients are known. Here, we propose MIR photometry to determine the total energetics of the event and trace the circumstellar dust. Together with our ongoing optical, NIR, radio, UV and X-ray follow-up of PTF10fqs, we hope to make progress in deciphering the nature of this class.

Spitzer Space Telescope - General Observer Proposal #10136

SPIRITS: SPitzer InfraRed Intensive Transients Survey

Principal Investigator: Mansi Kasliwal
Institution: Carnegie Institution of Washington

Technical Contact: Mansi Kasliwal, Carnegie Institution of Washington

Co-Investigators:
Yi Cao, California Institute of Technology
Jason Surace, IPAC, Caltech
George Helou, Infrared Processing and Analysis Center, Caltech
Robert Williams, Space Telescope Science Institute
Shri Kulkarni, California Institute of Technology
Nathan Smith, University of Arizona Tucson
Lee Armus, Spitzer Science Center, Caltech
Howard Bond, Penn State University
Matteo Cantiello, University of California Santa Barbara
Robert Gehrz, University of Minnesota
Chip Kobulnicky, University of Wyoming
Norbert Langer, Argelander Institute, Universitat Bonn Germany
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Eran Ofek, Weizmann Institute of Science
Mudumba Parthasarathy, Indian Institute of Astrophysics
Sumin Tang, Caltech
Schuyler van Dyk, Infrared Processing and Analysis Center, Caltech
Patricia Whitelock, South African Astronomical Observatory

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 338.0
Priority: 1

Abstract:
The dynamic mid-infrared sky is hitherto largely unexplored. We propose the SPitzer InfraRed Intensive Transients Survey (SPIRITS) --- a systematic search of 242 nearby galaxies within 20 Mpc, on timescales ranging between a day to a year, to a depth of 20 mag. In preparation for SPIRITS, we undertook three pilot programs: searching the WISE data stream for variables in nearby galaxies, mining the Spitzer Heritage Archive, and Spitzer follow-up of optically discovered transients. Our results are encouraging and motivate our design of SPIRITS to fill in missing pieces in our understanding of the end points of stellar evolution. We expect to discover explosive transients (ILRT, LRN, CNe, SNe), eruptive variables (LBV, RSG, YSG, AGB, RSG) and possibly new phenomena. SPIRITS will be the definitive study to ascertain the rate and origin of two new classes of red gap transients, quantify the contribution of classical novae to galactic chemical evolution and uncover supernovae buried in starbursts. SPIRITS will also systematically probe mass loss rates and dust formation in the most massive stars. SPIRITS will yield a census of supergiant variability and asymptotic giant branch variability in diverse galaxy environments. SPIRITS will likely discover the first extragalactic "Born Again Giant" stars. The SPIRITS team is committed to a concomitant ground-based NIR and optical survey and extensive, panchromatic follow-up: 110 nights of near-IR imaging, 66 nights of optical imaging and 60 nights of spectroscopy annually. Follow-up will serve to maximize the discovery potential of our requested 994 hrs of Spitzer/IRAC observing time. We believe it is time that the Spitzer Great Observatory add another time-domain jewel in its crown.

Data from this program was split into multiple PIDs. You can find the data in program IDs 10136, 11063

Spitzer Space Telescope - General Observer Proposal #10152

Spitzer Characterization of Transients from the Palomar Transient Factory

Principal Investigator: Mansi Kasliwal
Institution: Carnegie Institution of Washington

Technical Contact: Mansi Kasliwal, Carnegie Institution of Washington

Co-Investigators:
Ariel Goobar, Oskar Klein Center, Sweden
Joel Johansson, Oskar Klein Center, Sweden
Brad Cenko, NASA/Goddard
Eran Ofek, Weizmann Institute of Science
Peter Nugent, Lawrence Berkeley National Labs
Shri Kulkarni, Caltech
Yi Cao, Caltech
George Helou, IPAC Caltech
Avishay Gal-Yam, Weizmann Institute of Science
Iair Arcavi, Weizmann Institute of Science
Sagi Ben-Ami, Weizmann Institute of Science

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 16.8
Priority: 2

Abstract:
We propose to continue Spitzer/IRAC follow-up of optical transients discovered by the Palomar Transient Factory. Our goals are: (i) probe the mass loss history and characterize the circumstellar environment of supernovae. (ii) construct a late-time bolometric light curve; the mid-infrared observations complement our ground-based optical and near-infrared data and (iii) understand the physical origin of new classes of transients (specifically, intermediate luminosity red transients) where the mystery is literally enshrouded in dust. We select extremely nearby supernovae, both thermonuclear and core-collapse, where the thermal echo is easily detectable in the mid-infrared. We also select peculiar supernovae that show tell-tale signs of circumstellar interaction. We also select rare and red gap transients in the local universe. Additionally, we request low-impact target of opportunity observations for new discoveries in 2014. Our total request is 17 hrs.

Spitzer Space Telescope - General Observer Proposal #11063

SPIRITS: SPitzer InfraRed Intensive Transients Survey

Principal Investigator: Mansi Kasliwal
Institution: Carnegie Institution of Washington

Technical Contact: Mansi Kasliwal, Carnegie Institution of Washington

Co-Investigators:
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George Helou, Infrared Processing and Analysis Center, Caltech
Robert Williams, Space Telescope Science Institute
John Bally, University of Colorado Boulder
Howard Bond, Pennsylvania State University
Patricia Whitelock, South African Astronomical Observatory & Universit
Ann Marie Cody, NASA Ames
Robert Gehrz, University of Minnesota
Jacob Jencson, California Institute of Technology
Samaporn Tinyanont, Harvey Mudd College
Nathan Smith, University of Arizona Tucson
Jason Surace, IPAC, Caltech
Lee Armus, Spitzer Science Center, Caltech
Matteo Cantiello, University of California Santa Barbara
Norbert Langer, Argelander Institute, Universitat Bonn Germany
Emily Levesque, University of Colorado Boulder
Shazrene Mohamed, South African Astronomical Observatory
Eran Ofek, Weizmann Institute of Science
Parthasarathy Mudumba, Indian Institute of Astrophysics
Schuyler van Dyk, Infrared Processing and Analysis Center, Caltech
Martha Boyer, NASA GSFC
Mark Phillips, Carnegie Institution for Science
Eric Hsiao, Aarhus University, Denmark
Nidia Morrell, Las Campanas Observatory
Dan Perley, California Institute of Technology
Consuelo Gonzalez, Las Campanas Observatory
Carlos Contreras, Las Campanas Observatory

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 791.9
Priority: 1

Abstract:
The exploration of the dynamic mid-infrared sky has just begun. We propose to continue the SPitzer InfraRed Intensive Transients Survey (SPIRITS) --- a systematic search of 194 nearby galaxies within 20 Mpc, on timescales ranging between a week to a year, to a depth of 20 mag. During Cycle 10, SPIRITS has discovered over 40 infrared transients and over 1200 infrared variables. We are discovering explosive transients (ILRT, LRN, CNe, SNe), eruptive variables (LBV, RSG, YSG, AGB), and mysterious new infrared events devoid of optical counterparts (e.g. possible birth of a massive star system). Our Cycle 10 discoveries motivate our experiment design for Cycle 11 and 12. In particular, we request additional shorter cadence baselines to fill in missing pieces in our understanding of the end points of stellar evolution. Three years of SPIRITS will constitute the definitive study to ascertain the rate and origin of new classes of infrared transients, quantify the contribution of classical novae to galactic chemical evolution, and uncover supernovae buried in starbursts. We are also systematically probing mass-loss rates and dust formation in the most massive stars. SPIRITS yields a census of supergiant variability and asymptotic giant branch variability in diverse galaxy environments. The SPIRITS team continues to be committed to a concomitant ground-based NIR and optical survey and extensive spectroscopic follow-up: 308 nights of near-IR imaging, 135 nights of optical imaging and 34 nights of spectroscopy in Cycle 11 and 12. Follow-up will serve to maximize the discovery potential of our requested 795.3 hrs of Spitzer/IRAC and 10 orbits of HST/WFC3 observing time.

Spitzer Space Telescope - General Observer Proposal #13053

SPIRITS: SPitzer InfraRed Intensive Transients Survey

Principal Investigator: Mansi Kasliwal
Institution: Caltech

Technical Contact: Ryan Lau, Caltech

Co-Investigators:
Ryan Lau, California Institute of Technology
Yi Cao, California Institute of Technology
Frank Masci, Infrared Processing and Analysis Center, Caltech
George Helou, Infrared Processing and Analysis Center, Caltech
Robert Williams, Space Telescope Science Institute
John Bally, University of Colorado Boulder
Howard Bond, Pennsylvania State University
Patricia Whitelock, SAAO & University of Cape Town
Ann Marie Cody, NASA Ames
Robert Gehrz, University of Minnesota
Jacob Jencson, California Institute of Technology
Samaporn Tinyanont, California Institute of Technology
Nathan Smith, University of Arizona Tucson
Jason Surace, IPAC, Caltech
Lee Armus, Spitzer Science Center, Caltech
Matteo Cantiello, University of California Santa Barbara
Norbert Langer, Argelander Institute, Universitat Bonn Germany
Emily Levesque, University of Colorado Boulder
Shazrene Mohamed, South African Astronomical Observatory
Eran Ofek, Weizmann Institute of Science
Parthasarathy Mudumba, Indian Institute of Astrophysics
Schuyler van Dyk, Infrared Processing and Analysis Center
Martha Boyer, NASA GSFC
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Eric Hsiao, Florida State University
Nidia Morrell, Las Campanas Observatory
Dan Perley, California Institute of Technology
Consuelo Gonzalez, Las Campanas Observatory
Carlos Contreras, Las Campanas Observatory
Olivia Jones, Space Telescope Science Institute
Michael Ressler, Jet Propulsion Laboratory
Scott Adams, California Institute of Technology
Anna Moore, California Institute of Technology
David Cook, California Institute of Technology
Ori Fox, Space Telescope Science Institute
Joel Johansson, Weizmann Institute for Science
Rubab Khan, NASA GSFC
Andy Monson, Pennsylvania State University

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 285.7
Priority: 1

Abstract:
Spitzer is pioneering a systematic exploration of the dynamic infrared sky. Our SPitzer InfraRed Intensive Transients Survey (SPIRITS) has already discovered 147 explosive transients and 1948 eruptive variables. Of these 147 infrared transients, 35 are so red that they are devoid of optical counterparts and we call them SPRITEs (eSPecially Red Intermediate-luminosity Transient Events). The nature of SPRITEs is unknown and progress on deciphering the explosion physics depends on mid-IR spectroscopy. Multiple physical origins have been proposed including stellar merger, birth of a massive binary, electron capture supernova and stellar black-hole formation. Hence, we propose a modest continuation of SPIRITS, focusing on discovering and monitoring SPRITEs, in preparation for follow-up with the James Webb Space Telescope (JWST). As the SPRITEs evolve and cool, the bulk of the emission shifts to longer wavelengths. MIRI aboard JWST will be the only available platform in the near future capable

of characterizing SPRITEs out to 28um. Specifically, the low resolution spectrometer would determine dust mass, grain chemistry, ice abundance and energetics to disentangle the proposed origins. The re-focused SPIRITS program consists of continued Spitzer monitoring of only those 104 luminous galaxies that are known SPRITE hosts or are most likely to host new SPRITEa. Scaling from the SPIRITS discovery rate, we estimate finding 22 new SPRITEs and 6 new supernovae over the next two years. The SPIRITS team remains committed to extensive ground-based follow-up. The Spitzer observations proposed here are essential for determining the final fates of active SPRITEs as well as bridging the time lag between the current SPIRITS survey and JWST launch.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13202

Hunt for infrared photons from the first binary neutron star merger

Principal Investigator: Mansi Kasliwal
Institution: Caltech

Technical Contact: Mansi Kasliwal, Caltech

Co-Investigators:
The GROWTH Collaboration
[Global Relay of Observatories Watching Transients Happen]

Science Category: GRBs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30.0

Abstract:
Yesterday, within two seconds of 2017 August 17 12:41:04 GMT, both LIGO interferometers and the Fermi satellite detected gravitational waves from a neutron star merger and a short contemporaneous gamma ray burst! We now have a promising optical and infrared counterpart. This may very well be a historic moment in multi-messenger astronomy, and may even prove to be of the same league as neutrinos from SN,1987A. Here, we request the Spitzer Space Telescope to engage in the hunt for infrared photons.

Spitzer Space Telescope - General Observer Proposal #14046

Understanding Nucleosynthesis in Neutron Star Mergers with Spitzer Observations

Principal Investigator: Mansi Kasliwal
Institution: California Institute of Technology

Technical Contact: Mansi Kasliwal, California Institute of Technology

Co-Investigators:
Ryan Lau, Caltech
Brad Cenko, NASA/GSFC
Leo Singer, NASA/GSFC
Ariel Goobar, Stockholm University, Sweden
Eran Ofek, Weizmann Institute of Science, Israel
David Kaplan, University of Wisconsin Milwaukee
Igor Andreoni, Caltech
Scott Adams, Caltech
Daniel Perley, LJMU, UK

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30.0
Priority: 1

Abstract:
The discovery of the first electromagnetic counterpart to gravitational waves from merging neutron stars opened a new chapter in multi-messenger astrophysics. The infrared signature was key to unraveling the prolific production of heavy elements by r-process nucleosynthesis. Understanding the nuclear physics in the heavy element production requires observations a few weeks after the merger at longer wavelengths that are only accessible by Spitzer. In particular, Spitzer can address the question of whether or not the heaviest elements in the third abundance peak (such as gold and platinum) were synthesized. Here, we request 30 hours of Target of Opportunity time to undertake Spitzer follow-up of two neutron star mergers.

Spitzer Space Telescope - General Observer Proposal #14089

SPIRITS: SPitzer InfraRed Intensive Transients Survey

Principal Investigator: Mansi Kasliwal
Institution: California Institute of Technology

Technical Contact: Jacob Jencson, California Institute of Technology

Co-Investigators:
Ryan Lau, California Institute of Technology
Frank Masci, Infrared Processing and Analysis Center, Caltech
George Helou, Infrared Processing and Analysis Center, Caltech
Robert Williams, Space Telescope Science Institute
John Bally, University of Colorado Boulder
Howard Bond, Pennsylvania State University
Patricia Whitelock, SAAO & University of Cape Town
Ann Marie Cody, NASA Ames
Robert Gehrz, University of Minnesota
Samaporn Tinyanont, California Institute of Technology
Nathan Smith, University of Arizona Tucson
Jason Surace, IPAC, Caltech
Lee Armus, Spitzer Science Center, Caltech
Matteo Cantiello, University of California Santa Barbara
Norbert Langer, Argelander Institute, Universitat Bonn Germany
Emily Levesque, University of Colorado Boulder
Shazrene Mohamed, South African Astronomical Observatory
Eran Ofek, Weizmann Institute of Science
Parthasarathy Mudumba, Indian Institute of Astrophysics
Schuyler van Dyk, Infrared Processing and Analysis Center
Martha Boyer, Space Telescope Science Institute
Mark Phillips, Carnegie Institution for Science
Eric Hsiao, Florida State University
Nidia Morrell, Las Campanas Observatory
Dan Perley, Liverpool John Moores University
Consuelo Gonzalez, Las Campanas Observatory
Carlos Contreras, Las Campanas Observatory
Olivia Jones, Space Telescope Science Institute
Michael Ressler, Jet Propulsion Laboratory
Scott Adams, California Institute of Technology
Anna Moore, Australian National University
David Cook, California Institute of Technology
Ori Fox, Space Telescope Science Institute
Joel Johansson, Uppsala University
Rubab Khan, University of Washington
Andrew Monson, Pennsylvania State University
Matthew Hankins, Cornell University
Steven Goldman, Space Telescope Science Institute
Jencson Jacob, California Institute of Technology

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 276.6
Priority: 2

Abstract:
Spitzer is pioneering a systematic exploration of the dynamic infrared sky. Our SPitzer InfraRed Intensive Transients Survey (SPIRITS) has already discovered 78 explosive transients and 2457 eruptive variables. Of these 78 infrared transients, 60 are so red that they are devoid of optical counterparts and we call them SPRITEs (eSPecially Red Intermediate-luminosity Transient Events). The nature of SPRITEs is unknown and progress on deciphering the explosion physics depends on mid-IR spectroscopy. Multiple physical origins have been proposed including stellar merger, birth of a massive binary, electron capture supernova and stellar black hole formation. Hence, we propose a modest continuation of SPIRITS, focusing on discovering and monitoring SPRITEs, in preparation for follow-up with the James Webb Space Telescope (JWST). As the SPRITEs evolve and cool, the bulk of the emission shifts to longer wavelengths.

MIRI aboard JWST will be the only available platform in the near future capable of characterizing SPRITEs out to 28 um. Specifically, the low resolution spectrometer would determine dust mass, grain chemistry, ice abundance and energetics to disentangle the proposed origins. The re-focused SPIRITS program consists of continued Spitzer monitoring of those 106 luminous galaxies that are known SPRITE hosts or are most likely to host new SPRITEs. Scaling from the SPIRITS discovery rate, we estimate finding 10 new SPRITEs and 2-3 new supernovae in Cycle 14. The SPIRITS team remains committed to extensive ground-based follow-up. The Spitzer observations proposed here are essential for determining the final fates of active SPRITEs as well as bridging the time lag between the current SPIRITS survey and JWST launch.

Spitzer Space Telescope - General Observer Proposal #70110

PTF10fqs: A Luminous Red Nova in the Spiral Messier 99

Principal Investigator: Mansi Kasliwal
Institution: Caltech

Technical Contact: Mansi Kasliwal, Caltech

Co-Investigators:
George Helou, Caltech
Jason Surace, Caltech
Shri Kulkarni, Caltech

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.8

Abstract:
On April 16, 2010 we discovered a rare transient (PTF10fqs) in the luminosity gap between novae and supernovae with the Palomar Transient Factory. PTF10fqs is located on a spiral arm in M99, a member of the Virgo Cluster. On April 18, we obtained a Gemini spectrum and on April 20, multi-color photometry with the Palomar 60-inch. The explosion signature resembles that of a class of "Luminous Red Novae"; only two other such transients are known. A plethora of models have been proposed: stellar merger, e-capture on AGB star, weird nova and weird supernova. Here, we propose MIR photometry to determine the total energetics of the event and as a unique tracer of the circumstellar dust. Together with our ongoing multi-wavelength (optical, NIR, radio, UV and X-ray) follow-up of PTF10fqs, we hope to make progress in deciphering the nature of this class.

Spitzer Space Telescope - Directors Discretionary Time Proposal #70202

PTF10acbp: A Luminous Red Nova in the Spiral UGC11973

Principal Investigator: Mansi Kasliwal
Institution: Caltech

Technical Contact: Mansi Kasliwal, Caltech

Co-Investigators:
George Helou, Caltech
Roc Cutri, Caltech
Shri Kulkarni, Caltech
Jason Surace, Caltech
Douglas Hoffman, Caltech
Frank Masci, Caltech

Science Category: nearby galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0

Abstract:
The Palomar Transient Factory recently discovered a rare extragalactic transient, PTF10abcp, in the luminosity gap between novae and supernovae. Serendipitous detection of this transient with the WISE Observatory in the mid-infrared, combined with our ground-based follow-up, shows that PTF10acbp is a new member of the emerging class of Luminous Red Novae. To disentangle the large number of proposed theories in the literature, the mid-infrared is a vital diagnostic. Hence, we propose Spitzer/DDT observations.

Spitzer Space Telescope - General Observer Proposal #80196

Infrared Signature: The Key to Deciphering Luminous Red Novae

Principal Investigator: Mansi Kasliwal
Institution: California Institute of Technology

Technical Contact: Mansi Kasliwal, California Institute of Technology

Co-Investigators:
Shri Kulkarni, Caltech
George Helou, Caltech
Doug Hoffman, Caltech
Roc Cutri, Caltech
Jason Surace, Caltech
Frank Masci, Caltech
Eran Ofek, Caltech
Brad Cenko, UC Berkeley
Robert Quimby, Caltech

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 31.4

Abstract:
We propose a comprehensive campaign to characterize the mid-infrared explosion signature of luminous red novae using Spitzer/IRAC. The first member of this rare, new class of transients was discovered in 2006 and the population today stands at six. These events are notable for their mid-IR brilliance and longevity (over two years). Our plan of action is three-fold: six-monthly monitoring of known luminous red novae, follow-up of new luminous red novae discovered by the WISE observatory and new discoveries by the Palomar Transient Factory. These observations are essential to infer two physical parameters: the total energy release and the event rate.

Spitzer Space Telescope - General Observer Proposal #90240

Spitzer Characterization of Transients from the Palomar Transient Factory

Principal Investigator: Mansi Kasliwal
Institution: Carnegie Institution of Washington

Technical Contact: Mansi Kasliwal, Carnegie Institution of Washington

Co-Investigators:
Eran Ofek, Weizmann Institute of Science
Alessandra Corsi, George Washington University
Peter Nugent, Lawrence Berkeley National Labs
Shri Kulkarni, Caltech
Yi Cao, Caltech
George Helou, IPAC Caltech
Avishay Gal-Yam, Weizmann Institute of Science
Iair Arcavi, Weizmann Institute of Science
Sagi Ben-Ami, Weizmann Institute of Science

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.4

Abstract:
We propose to continue Spitzer/IRAC follow-up of optical transients discovered by the Palomar Transient Factory. Our goals are: (i) probe the mass loss history and characterize the circumstellar environment of supernovae. (ii) construct a late-time bolometric light curve; the mid-infrared observations complement our ground-based optical and near-infrared data and (iii) understand the physical origin of new classes of transients (specifically, intermediate luminosity red transients) where the mystery is literally enshrouded in dust. We select extremely nearby supernovae, both thermonuclear and core-collapse, where the thermal echo is easily detectable in the mid-infrared. We also select peculiar supernovae that show tell-tale signs of circumstellar interaction. We also select rare and red gap transients in the local universe for IRAC follow-up. Additionally, we request low-impact target of opportunity observations for new discoveries in 2013. Our total request is 24 hrs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #544

The Peculiar Object P/2010 A2 (LINEAR)

Principal Investigator: Michael Kelley
Institution: University of Maryland

Technical Contact: Michael Kelley

Co-Investigators:
William Reach, IPAC
David Trilling, NAU
Jeremie Vaubaillon, IMCCE/Paris
Michael Mueller, Obs. Cote dAzure
Josh Emery, Univ. Tennessee Knoxville

Science Category: asteroids
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.3

Abstract:
We propose an 8.3 hr low-impact Target of Opportunity DDT proposal to assess the nature of the newly discovered comet P/2010 A2 (LINEAR) and the associated asteroid 2010 AA15 with Spitzer/IRAC. The orbital elements of comet A2 and asteroid AA15 securely place them in the inner-asteroid belt and close to the Flora family of asteroids. The existence of cometary objects within the asteroid belt is a hot topic in planetary science because it blurs the distinction between the comets and asteroids and opens the possibility of significant volatile content in asteroids. However, comet A2 may instead be the result of a never before seen collision between two asteroids. This provides us with a unique opportunity to measure the amount of dust produced in sub-km asteroid collisions and to provide "ground-truth" measurements of the dust observed in debris disks around main sequence stars. Our proposed program will measure the optical depth and color of the dust, allow us to search for thermal emission from the asteroid as well as molecular emission from CO or CO2 gas.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10164

The Siding Spring Hazard at Mars

Principal Investigator: Michael Kelley
Institution: Maryland

Technical Contact: Michael Kelley, Maryland

Co-Investigators:
James Bauer, NASA JPL
Dennis Bodewits, Univ. Maryland
Tony Farnham, Univ. Maryland
Jian-Yang Li, Planet. Sci. Inst.
Nalin Samarasinha, Planet. Sci. Inst.
Rachel Stevenson, NASA JPL
Pasquale Tricarico, Planet. Sci. Inst.

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.5

Abstract:
Comet C/2013 A1 (Siding Spring) will pass Mars at the extremely close distance of 136,000 km in Oct 2014, giving Mars orbiting spacecraft an up-close and unprecedented view of this dynamically new comet. However, 100 minutes after the closest approach to the nucleus, Mars passes within 30,000 km of the comet’s orbit. Here, large dust grains may be found on impacting trajectories, potentially posing a fatal hazard to the spacecraft. Such large grains must be ejected from the comet nucleus well before the time of encounter. Therefore, we propose IRAC imaging of this comet to assess the present-day gas production rate, which will aid dust impact hazard assessment.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10173

CO2 Impacts on the Martian Atmosphere

Principal Investigator: Michael Kelley
Institution: Univ. Maryland

Technical Contact: Michael Kelley, Univ. Maryland

Co-Investigators:
James Bauer, NASA JPL
Dennis Bodewits, Univ. Maryland
Tony Farnham, Univ. Maryland
Rachel Stevenson, NASA JPL
Roger Yelle, Univ. Arizona

Science Category: Comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.6

Abstract:
The dynamically new comet C/2013 A1 (Siding Spring) will pass Mars at the extremely close distance of 140,000 km on 2014 Oct 19. This encounter is unique---a record close approach to a planet with spacecraft that can observe its passage---and currently, all 5 Mars orbiters have plans to observe the comet and/or its effects on the planet. Gas from the comet's coma is expected to collide with the Martian atmosphere, altering the abundances of some species and producing significant heating, inflating the upper atmosphere. We propose DDT observations with Spitzer/IRAC to measure the comet's CO2+CO coma (observing window Oct 30 - Nov 20), to use these measurements to derive the coma's CO2 density at Mars during the closest approach, and to aid the interpretation of any observed effects or changes in the Martian atmosphere.

Spitzer Space Telescope - General Observer Proposal #11106

CO2 Orbital Trends in Comets

Principal Investigator: Michael Kelley
Institution: University of Maryland

Technical Contact: Michael Kelley, University of Maryland

Co-Investigators:
Lori Feaga, University of Maryland, College Park
Dennis Bodewits, University of Maryland, College Park
Adam McKay, University of Texas at Austin
Colin Snodgrass, The Open University, UK
Diane Wooden, NASA Ames Research Center

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 237.6
Priority: 1

Abstract:
Spacecraft missions to comets return a treasure trove of details of their targets, e.g., the Rosetta mission to comet 67P/Churyumov-Gerasimenko, the Deep Impact experiment at comet 9P/Tempel 1, or even the flyby of C/2013 A1 (Siding Spring) at Mars. Yet, missions are rare, the diversity of comets is large, few comets are easily accessible, and comet flybys essentially return snapshots of their target nuclei. Thus, telescopic observations are necessary to place the mission data within the context of each comet's long-term behavior, and to further connect mission results to the comet population as a whole. We propose a large Cycle 11 project to study the long-term activity of past and potential future mission targets, and select bright Oort cloud comets to infer comet nucleus properties, which would otherwise require flyby missions. In the classical comet model, cometary mass loss is driven by the sublimation of water ice. However, recent discoveries suggest that the more volatile CO and CO2 ices are the likely drivers of some comet active regions. Surprisingly, CO2 drove most of the activity of comet Hartley 2 at only 1 AU from the Sun where vigorous water ice sublimation would be expected to dominate. Currently, little is known about the role of CO2 in comet activity because telluric absorptions prohibit monitoring from the ground. In our Cycle 11 project, we will study the CO2 activity of our targets through IRAC photometry. In conjunction with prior observations of CO2 and CO, as well as future data sets (JWST) and ongoing Earth-based projects led by members of our team, we will investigate both long-term activity trends in our target comets, with a particular goal to ascertain the connections between each comet's coma and nucleus.

Spitzer Space Telescope - General Observer Proposal #13116

CO2 Orbital Trends in Comets

Principal Investigator: Michael Kelley
Institution: University of Maryland

Technical Contact: Michael Kelley, University of Maryland

Co-Investigators:
Dennis Bodewits, University of Maryland
Lori Feaga, University of Maryland
Matthew Knight, University of Maryland
Adam McKay, University of Texas, Austin
Colin Snodgrass, Open University, UK
Diane Wooden, NASA Ames Research Center

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 268.7
Priority: 1

Abstract:
Carbon dioxide is a primary volatile in comet nuclei, and potentially a major contributor to comet activity (i.e., the process of mass loss). However, CO2 cannot be observed directly from the ground, and past surveys of this molecule in comets were limited to space-borne snapshot observations. This situation limits our understanding of the behavior of CO2 in comets, and its role in driving comet mass loss. To address this deficiency, we were awarded a Cy11 Spitzer program designed to quantify the production rate of CO2 on >month-long timescales for 21 comets. We request an additional 269~hr in Cy13 to complete the Spitzer portion of our survey, and to add three more comets (46P/Wirtanen and 2 Target of Opportunity Oort cloud comets). Our survey is designed to probe the orbital trends of CO2 production in the comet population. We aim to: 1) examine the role of CO2 in the persistent post-perihelion activity observed in Jupiter-family comets; 2) measure the seasonal variations of CO2/H2O as a proxy for nucleus heterogeneity, when possible; 3) search for orbital trends sensitive to cumulative insolation as a proxy for nucleus layering; and 4) examine how Oort cloud comets evolve by comparing dynamically new and old targets. The final data set will allow us to investigate the effects of heating on the evolution of comets, if nucleus structures can be inferred through activity, and set the stage for JWST investigations into comet activity and composition.

Spitzer Space Telescope - General Observer Proposal #70023

Detecting a Debris Disk Around the Most Metal-Rich White Dwarf

Principal Investigator: Mukremin Kilic
Institution: Harvard-Smithsonian Center for Astrophysics

Technical Contact: Mukremin Kilic, Harvard-Smithsonian Center for Astrophysics

Co-Investigators:
Patrick Dufour, Universite de Montreal

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.3

Abstract:
We recently discovered the most metal-rich white dwarf currently known. Our follow-up MMT spectroscopy shows that SDSS J0738+18 has a helium dominated atmosphere polluted with significant amounts of O, Mg, Si, Ca, and Fe. Our model atmosphere analysis shows that SDSS J0738+18 has an amount of metals similar to the mass of the dwarf planet Ceres. With this mass of metals, SDSS J0738+18 is even more metal-rich than the Sun. The large amounts of oxygen present in the photosphere of this star indicates that the accreted object was similar to Earth. Our follow-up near-infrared observations at Gemini reveal H- and K-band flux excesses most likely due to a dust disk. We propose to obtain IRAC imaging of this star to confirm the presence and to constrain the physical parameters of the disk. Confirmation of such an IR excess from this disk will reveal the source of the material. If the disk is confirmed, our abundance analysis can be used to study the composition of the accreted matter and therefore the dust disk itself. In addition to this star, we recently discovered 11 more white dwarfs with K-band excesses revealed in our PAIRITEL (the old 2MASS telescope) observations. Here, we propose to obtain IRAC imaging of these 11 additional white dwarfs to confirm the presence of disks. If confirmed, these disks would imply that the fraction of white dwarfs with debris disks (and remnant planetary systems) may be as high as 15%.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14288

Constraining the Final Decline of the Kilonova AT 2017gfo

Principal Investigator: Charles Kilpatrick
Institution: UC Santa Cruz

Technical Contact:Charles Kilpatrick, UC Santa Cruz

Co-Investigators:
Ryan Foley, UC Santa Cruz

Science Category: GRBs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10.0
Priority: 1

Abstract:
Spitzer observations of the neutron star merger GW170817 provide the only infrared constraints on its electromagnetic counterpart (a kilonova called AT 2017gfo) between 25 and 110 days after merger. Indeed, the decline rate of this emission in two epochs of IRAC Channel 2 observations 43 and 74 days after merger is consistent with the decay of some long-lived radioisotopes in the ejecta, perhaps providing the first smoking gun evidence for third peak r-process material synthesized in the merger. However, analysis of these data is severely limited by 1) the current depth of template observations obtained 264 days after merger, which is comparable to the original observations, 2) the possibility that the kilonova emission is blended with non-thermal synchrotron emission from a jet launched by the merger, and 3) the non-detection of any emission in contemporaneous Channel 1 data. We can address all of these issues by obtaining a fourth epoch of observations, providing an independent template, which will enable cleaner subtractions and detection of fainter sources in the early time imaging.

Spitzer Space Telescope - General Observer Proposal #11059

Understanding the Diversity of Y Dwarfs

Principal Investigator: J.Davy Kirkpatrick
Institution: IPAC

Technical Contact: Christopher Gelino, California Institute of Technology

Co-Investigators:
Christopher Gelino, IPAC/Caltech
Michael Cushing, University of Toledo
Adam Schneider, University of Toledo
Edward Wright, University of California at Los Angeles
Michael Skrutskie, University of Virginia

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.2
Priority: 1

Abstract:
Y dwarfs are the coldest class of brown dwarfs (temperatures < 450K), excellent exoplanet analogs, and prime targets for follow-up with JWST. The 23 examples known show a striking variety of inferred atmospheric properties, and spectroscopic models fail to adequately match their observed features. For one of these Y dwarfs, the disagreement is alarming. To better understand the trends and diversity across the Y spectral sequence, more examples are badly needed. In this proposal, we request IRAC imaging observations of high probability Y dwarf candidates, selected from WISE using their colors and proper motions. The resulting IRAC colors will enable us to better constrain the properties of these new Y dwarfs and prioritize them for further follow-up.

Spitzer Space Telescope - General Observer Proposal #13012

Spitzer Trigonometric Parallaxes of the Solar Neighborhood's Coldest Brown Dwarfs, Part 2

Principal Investigator: J.Davy Kirkpatrick
Institution: IPAC

Technical Contact: J.Davy Kirkpatrick, IPAC

Co-Investigators:
Christopher Gelino, California Institute of Technology
Charles Beichman, California Institute of Technology
Emily Martin, University of California at Los Angeles
Richard Smart, Osservatorio Astronomica di Torino
Jacqueline Faherty, Carnegie Institution of Washington
Christopher Tinney, University of New South Wales
Michael Cushing, University of Toledo
Adam Schneider, University of Toledo
Edward Wright, University of California at Los Angeles
Patrick Lowrance, Spitzer Science Center

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 276.0
Priority: 1

Abstract:
Objects in the immediate solar neighborhood serve as touchstones of stellar populations throughout the rest of the Milky Way and the Universe in general. A detailed accounting and characterization of these objects is therefore of fundamental importance to many fields of astrophysics. One of the most fundamental properties is distance, which directly determines absolute luminosity and space density and aids in the decipherment of radius, kinematics, age, the mass function, etc. The Gaia mission is soon poised to revolutionize our understanding of the solar neighborhood through micro-arcsecond astrometric monitoring. Its sensitivity, however, is limited to objects that emit strongly at wavelengths shorter than 1 micron; Gaia will be unable to detect any objects as cool as late-T and Y dwarfs (250-1100K). Nevertheless, these very cold objects are critically important not only to our understanding of the star formation process at the lowest masses, but also in our comprehension of the physical mechanisms present in cold, exoplanet-like atmospheres. In this proposal, we extend our distance determinations to objects colder than those Gaia can probe by continuing to measure parallaxes, as begun in our Cycle 9-10 program 90007, for all T6 and later brown dwarfs within 20 pc of the Sun.

Spitzer Space Telescope - General Observer Proposal #14000

Spitzer Trigonometric Parallaxes of L, T, and Y Dwarfs: Complementing Gaia's Optically-selected Census of Nearby Stars

Principal Investigator: J.Davy Kirkpatrick
Institution: IPAC

Technical Contact: J.Davy Kirkpatrick, IPAC

Co-Investigators:
Richard Smart, Osservatorio Astronomica di Torino
Federico Marocco, JPL and Caltech/IPAC
Emily Martin, University of California at Los Angeles
Jacqueline Faherty, American Museum of Natural History
Christopher Tinney, University of New South Wales
Michael Cushing, University of Toledo
Charles Beichman, JPL and Caltech/IPAC-NExScI
Christopher Gelino, Caltech/IPAC-NExScI
Adam Schneider, Arizona State University
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Patrick Lowrance, Caltech/IPAC-Spitzer
James Ingalls, Caltech/IPAC-Spitzer

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 230.2
Priority: 3

Abstract:
We now find ourselves at a moment in history where a parallax-selected census of nearby objects from the hottest A stars to the coldest Y dwarfs is almost a reality. With the release of Gaia DR2 in April of this year, we will be able to extract a volume-limited sample of stars out to 20 pc down to a spectral type of ~L5. Extending the census to colder types is much more difficult but nonetheless possible and essential. Ground-based astrometric monitoring of some of these colder dwarfs can be done with deep infrared detections on moderate to large (4+ meter) telescopes, but given the amount of time needed, only a portion of the colder objects believed to lie within 20 pc has been monitored. Our prior Spitzer observations have already enabled direct distance measures for T6 through Y dwarfs, but many 20-pc objects with spectral types between ~L5 and T5.5 have still not been astrometrically monitored, leaving a hole in our knowledge of this important all-sky sample. Spitzer Cycle 14 observations of modest time expenditure can rectify this problem by providing parallaxes for the 150+ objects remaining. Analysis of the brown dwarfs targeted by Spitzer is particularly important because it will provide insight into the low-mass cutoff of star formation, the shape of the mass function as inferred from the observed temperature distribution, the binary fraction of near-equal mass doubles, and the prevalence of extremely young (low-gravity) and extremely old (low metallicity) objects within the sample -- all of which can be used to test and further refine model predictions of the underlying mass function.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14224

Spitzer Parallaxes of Missing Members of the 20-pc Sample: Cold Brown Dwarfs Discovered by Backyard Worlds and CatWISE

Principal Investigator: J.Davy Kirkpatrick
Institution: California Institute of Technology

Technical Contact: J.Davy Kirkpatrick, California Institute of Technology

Co-Investigators:
Daniella Bardalez Gagliuffi, AMNH
Dan Caselden,
Michael Cushing, U. Toledo
Peter Eisenhardt, JPL
Jacqueline Faherty, AMNH
Jonathan Gagne, U. Montreal
Christopher Gelino, Caltech/IPAC
Marc Kuchner, GSFC
Sarah Logsdon, GSFC
Federico Marocco, JPL
Aaron Meisner, NOAO
Adam Schneider, Arizona State U.
Edward Wright, UCLA

Science Category: BD/low mass
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 246.5
Priority: 2

Abstract:
A parallax-selected census of nearby objects from the hottest A stars to the coldest Y dwarfs is almost a reality.Future Gaia releases will enable us to extract a volume-limited sample of stars out to 20 pc down to a spectral type of ~L5. Extending the census to colder types, while difficult, is also possible and essential. Although obtaining a parallax for a 450K dwarf at 20 pc requires a minimum of 20 hr of Keck time and a 250K dwarf dwarf at 2.3 pc would be impossible from any ground-based facility, these objects require only 0.7-2.3 hr with Spitzer/IRAC. Prior and ongoing Spitzer observations by the PI are enabling direct distance measures for dwarfs colder than L5, although at types later than ~T5, that sample is still magnitude limited and not complete to 20 pc. Fortunately, the citizen science project "Backyard Worlds: Planet 9" and the ADAP-funded project CatWISE are leveraging the 6-yr time baseline afforded by the WISE + NEOWISE data to perform motion-based searches for fainter, colder objects still missing from the sample. Since the Cycle 14 call, and partly due to follow-up Cycle 14 observations acquired so far, these efforts have revealed another 132 dwarfs of type T5+ believed to fall within the 20-pc census, including 6 newly discovered objects of type Y0.5 or later. Astrometric monitoring of these 132 objects is still possible using Spitzer DDT time, and such data are crucial because they will enable measurement of the low-mass cutoff of star formation and better test and further refine model predictions of the underlying mass function. Observations of a sample this size and this faint will not be possible after Spitzer is retired.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14326

Finalizing Spitzer Parallaxes for a Volume-limited Sample of Brown Dwarfs

Principal Investigator: J. Davy Kirkpatrick
Institution: Caltech/IPAC

Technical Contact: J. Davy Kirkpatrick

Co-Investigators:
Richard Smart, Osservatorio Astronomica di Torino
Federico Marocco, JPL
Emily Martin, UC Santa Cruz
Jacqueline Faherty, AMNH
Michael Cushing, U Toledo
Charles Beichman, Caltech/IPAC
Christopher Gelino, Caltech/IPAC
Adam Schneider, Arizona State
Edward Wright, UCLA
Patrick Lowrance, Caltech/IPAC-Spitzer
James Ingalls, Caltech/IPAC-Spitzer

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 21.5
Priority: 2

Abstract:
Most brown dwarfs are invisible to Gaia, but by using Spitzer/IRAC ch2 observations we can obtain accurate trigonometric parallaxes for all known brown dwarfs within 20 pc of the Sun. In our Cycle 14 program 14000, we aimed to measure distances to all objects in the 20-pc sample between spectral types ~L5 to T5.5. To obtain full astrometric solutions, Spitzer observations at three maximum parallax factors (i.e., three Spitzer visibility windows) are needed so that the degeneracy between parallax and proper motion can be removed. For ~60 of the ~150 objects in program 14000, however, only two visibility windows were available during the time span covered by the original Cycle 14 call. Now, we can obtain observations of these objects in the final month of Spitzer operations and thereby complete their full astrometric solutions. Combining these data with distance measurements of the other ~90 objects in program 14000, we can test (a) whether our volume-limited sample shows an overabundance of binaries at early-T types, as has been seen in less statistically rigorous samples and (b) whether the non-monotonicity in brown dwarf cooling rates, as predicted by some evolutionary models across the 1500K to 1000K zone, is confirmed or refuted.

Spitzer Space Telescope - General Observer Proposal #70062

Spitzer Verification of the Coldest WISE-selected Brown Dwarfs

Principal Investigator: J.Davy Kirkpatrick
Institution: Infrared Processing and Analysis Center

Technical Contact: Christopher Gelino, California Institute of Technology

Co-Investigators:
Christopher Gelino, IPAC/Caltech
Michael Cushing, JPL
Amanda Mainzer, JPL
Michael Skrutskie, University of Virginia
Roger Griffith, IPAC/Caltech
Edward Wright, UCLA
Peter Eisenhardt, JPL

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 212.4

Abstract:
We will use data from WISE to search for brown dwarfs colder than those currently known. The discovery and subsequent study of low-temperature brown dwarfs will expand our knowledge of the low-mass end of the "stellar" mass function and of the physics of low-Teff, high-pressure atmospheres, the latter of which is important in characterizing exoplanets. Spitzer is an important component in the WISE discovery process because it is the only observatory capable of providing deeper imaging in the same wavelength range used by WISE to select candidates (3-5 um). Our WISE selection process uses the W1 (3.4 um) and W2 (4.6 um) color to identify brown dwarf candidates; the resulting, red W1-W2 colors are indicative of deep methane absorption at 3.3 um. For our coldest sources, which are the most important for deciphering the low-mass cutoff of star formation, these will be color limits because the candidate is undetected in W1. Spitzer can easily provide much deeper imaging and measure robust ch1-ch2 colors, which are complementary to W1-W2. The reddest of these sources will also be the faintest since they are expected to be the coldest ones in the list. For these, near-infrared spectroscopy will be impossible from the ground, so we also ask for HST time with WFC3 to obtain low-resolution grism spectra over the 1.1-1.7 um range to confirm these as brown dwarfs.

Spitzer Space Telescope - General Observer Proposal #80109

Spitzer Verification of the Coldest WISE-selected Brown Dwarfs. II.

Principal Investigator: J.Davy Kirkpatrick
Institution: California Institute of Technology

Technical Contact: Christopher Gelino, California Institute of Technology

Co-Investigators:
Christopher Gelino, IPAC/Caltech
Roger Griffith, IPAC/Caltech
Michael Cushing, JPL
Michael Skrutskie, University of Virginia
Amanda Mainzer, JPL
Kenneth Marsh, IPAC/Caltech
Edward Wright, UCLA
Peter Eisenhardt, JPL

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 171.7

Abstract:
We will use data from WISE to search for brown dwarfs colder than those currently known. The discovery and subsequent study of low-temperature brown dwarfs will expand our knowledge of the low-mass end of the "stellar" mass function and of the physics of low-Teff, high-pressure atmospheres, the latter of which is important in characterizing exoplanets. Spitzer is an important component in the WISE discovery process because it is the only observatory capable of providing deeper imaging in the same wavelength range used by WISE to select candidates (3 to 5 um). Our WISE selection process uses the W1 (3.4 um) and W2 (4.6 um) color to identify brown dwarf candidates; the resulting, red W1-W2 colors are indicative of deep methane absorption at 3.3 um. For our coldest sources, which are the most important for deciphering the low-mass cutoff of star formation, these will be color limits because the candidate is undetected in W1. Spitzer can easily provide much deeper imaging and measure robust ch1-ch2 colors, which are complementary to W1-W2. The reddest of these sources will also be the faintest since they are expected to be the coldest ones in the list.

Spitzer Space Telescope - General Observer Proposal #90007

Spitzer Trigonometric Parallaxes of the Solar Neighborhood's Coldest Brown Dwarfs

Principal Investigator: J.Davy Kirkpatrick
Institution: IPAC

Technical Contact: Christopher Gelino, California Institute of Technology

Co-Investigators:
Christopher Gelino, IPAC/Caltech
Charles Beichman, IPAC/Caltech and NASA/JPL
Christopher Tinney, University of New South Wales
Richard Smart, Osservatorio Astronomico di Torino
Jacqueline Faherty, Universidad de Chile
Michael Cushing, University of Toledo
Edward Wright, University of California at Los Angeles
Patrick Lowrance, Spitzer Science Center/Caltech

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 141.5

Abstract:
There are rare times in astronomy when - by fortuitous circumstances, careful planning, or both - giant leaps forward in our understanding can be made within a very short time. The combination of WISE, Spitzer, and HST is now capable of fast forwarding our knowledge of the immediate Solar Neighborhood. With just six months of survey operations, WISE was able to give us an unprecedented view of the entire sky that revealed the positions of the coldest brown dwarfs with effective temperatures as cold as ~300K (i.e., room temperature). With the investment of two years of Spitzer follow-up, we are capable of having distances measured for all of them. In this proposal, we consider a volume-limited (d < 20 pc) sample of the coldest known spectral types, T6 through early Y. These are the objects that give us the most leverage in discerning the shape of the low-mass end of the field mass function as well as defining the low-mass cutoff itself. Although on-going ground-based programs will provide astrometric monitoring of about half of the sample, Spitzer Cycle 9+10 is needed to measure trigonometric parallaxes for the other half (79 objects), which include the faintest and coldest objects and hence those most difficult to monitor. A combination of current ground-based and HST Cycle 20 spectroscopy will complete the picture by providing the spectral classfications needed for temperature determination on this sample. Having distances and temperature determinations for all of the coldest objects in the the Sun's environs allows us an unprecedented look at the modern-day products of past star formation and our most comprehensive, three-dimensional view to date of the Solar Neighborhood.

Spitzer Space Telescope - General Observer Proposal #11104

P/1999 R1: Sunskirting comet or asteroid?

Principal Investigator: Matthew Knight
Institution: Lowell Observatory

Technical Contact: Matthew Knight, Lowell Observatory

Co-Investigators:
Michael Kelley, University of Maryland
Colin Snodgrass, The Open University
Alan Fitzsimmons, Queen's University Belfast

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.6
Priority: 1

Abstract:
A population of short-period sunskirting comets has recently been discovered in space-based coronagraphic images. These objects reach perihelion well inside the orbit of Mercury where equilibrium temperatures exceed 1000 K, so it is unclear if their cometary behavior is driven by the sublimation of volatile ices or refractory materials. Their extreme orbits likely accelerate evolutionary processes; thus sunskirters provide unique insight into the end states of small bodies in the solar system. The best observed sunskirting comet is P/1999 R1, which has been seen four times by SOHO and STEREO when near the Sun, but by no other astronomical facility. P/1999 R1 is well placed for observations by Spitzer in late-July 2015 and we propose a short program to image it at 3.6 and 4.5 microns. Our primary goal is to constrain the nucleus size and albedo of a sunskirting comet for the first time by combining Spitzer and ground-based observations (we have requested optical time on Gemini and VLT). We will also search for activity and use Spitzer's unique sensitivity to CO/CO2 gas at 4.5 microns to probe the mechanism driving this activity. These observations will allow comparison with the physical properties of other comets and asteroids on small-perihelion orbits to understand the effects of repeated low-perihelion passages and improve our knowledge of the evolutionary processes at work in the solar system.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80237

The First Detailed IR Observations of a Sungrazing Comet: C/2011 W3 Lovejoy

Principal Investigator: Matthew Knight
Institution: Lowell Observatory

Technical Contact: Matthew Knight, Lowell Observatory

Co-Investigators:
Yanga Fernandez, University of Central Florida
Carey Lisse, Johns Hopkins
David Osip, Las Campanas Observatory

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.0

Abstract:
We propose to observe the newly discovered comet C/2011 W3 Lovejoy in February 2012 at 3.6 and 4.5 microns. Lovejoy is a member of the Kreutz group of sungrazing comets and is the first sungrazing comet known to have survived perihelion during the era of modern observations (since 1970). The size of its nucleus is currently unconstrained but is critical for understanding Lovejoy's place in the Kreutz group hierarchy (either as one of the 1600+ known "pygmy" fragments or one of a handful of major fragments of the parent body, which created the rest). Spitzer observations of the nucleus's thermal emission, when combined with planned optical observations (we have an approved HST DDT proposal and plan to obtain concurrent observations from Las Campanas Observatory), would let us definitively measure the size of a Kreutz nucleus for the first time, thereby giving us confidence in estimating sizes of other Kreutz fragments from visible data alone. The observations would also let us constrain the Kreutz nucleus's thermal properties and compare them to other comets that do not suffer such extreme heating. Kreutz comets are known to fragment frequently, and we expect to be sensitive down to fragments ~40 m in radius at 4.5 microns. The imaging of the dust, combined with other visible-wavelength imaging, will let us constrain dust grain sizes (via dynamical [Finson-Probstein] modeling) and grain albedos (via photometry). We would also be able to measure the dust production rate and thus constrain fragment lifetimes. These Spitzer observations would be the first infrared observations of a sungrazing comet since Comet Ikeya-Seki in 1965, and the first in the modern infrared era with sensitive, space-based detectors.

Spitzer Space Telescope - General Observer Proposal #10054

Exploring the Relationship Between Planet Mass and Atmospheric Metallicity

Principal Investigator: Heather Knutson
Institution: Caltech

Technical Contact: Heather Knutson, Caltech

Co-Investigators:
Drake Deming, University of Maryland
Jean-Michel Desert, California Institute of Technology
Jonathan Fortney, University of California, Santa Cruz
Caroline Morley, University of California, Santa Cruz
Julianne Moses, Space Science Institute
Joshua Kammer, California Institute of Technology
Michael Line, California Institute of Technology

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 449.4
Priority: 1

Abstract:
Observations of transiting planets provide an invaluable window into the processes of planet formation and evolution. By measuring the masses and radii of these planets, we can calculate their average densities and constrain their bulk compositions, which presumably vary depending on their formation locations and accretionary histories. Results from large surveys such as Kepler indicate that the average densities of planets tend to increase with decreasing mass, suggesting that low-mass planets have comparatively large rocky or icy cores. In this proposal we will test a fundamental finding of planetary science over the past few decades: the correlation between core mass fraction and atmospheric metallicity. In our own solar system, Neptune and Uranus have both a larger percentage of their masses tied up in solid cores and more metal-rich atmospheres as compared to Jupiter and Saturn. However, with a sample size of just four planets it is difficult to know whether or not this relation holds for all exoplanets, or just for systems that meet particular conditions. Our program focuses on secondary eclipse observations of cool planets, where the relative abundances of methane and CO provide a sensitive tracer of atmospheric metallicity. We select a sample of planets with masses ranging from sub-Neptune to super-Jupiter sizes and temperatures cooler than 1100 K; these systems offer the first opportunity to confront this fundamental question prior to the launch of JWST.

Spitzer Space Telescope - General Observer Proposal #60021

Dynamic Studies of Exoplanet Atmospheres: From Global Properties to Local Physics

Principal Investigator: Heather A. Knutson
Institution: Harvard University

Technical Contact: Heather A. Knutson, Harvard University

Co-Investigators:
David Charbonneau, Harvard University
Jonathan Fortney, University of California, Santa Cruz
Adam Showman, University of Arizona
Nikole Lewis, University of Arizona
Eric Agol, University of Washington
Nicolas Cowan, University of Washington
Drake Deming, NASA Goddard
Adam Burrows, Princeton University
Greg Laughlin, University of California, Santa Cruz
Jonathan Langton, University of California, Santa Cruz

Science Category: extrasolar planets
Observing Modes: IracPostCryoMap
Hours Approved: 1138.0

Abstract:
Spitzer's two-year warm mission represents a unique opportunity to build on its already-substantial legacy in the area of exoplanetary science with a comprehensive set of observations that would directly address fundamental questions about the physical processes that shape exoplanet atmospheres. In our proposal we outline an exciting two-pronged approach that would combine a survey of the secondary eclipses for all of the known transiting planets not already observed during the cryogenic mission with a set of phase curve observations targeting five of the most interesting objects. The first part of our study would more than double the number of systems with secondary eclipse observations and provide the statistical leverage needed to characterize the nature of the high-altitude absorber responsible for the presence of temperature inversions in the atmospheres of HD 209458b, TrES-2, TrES-4, and XO-1b. Secondary eclipse observations alone are not enough, however, as we expect the properties of these tidally-locked planets may vary substantially between the permanent day and night sides. Phase curve observations of select systems at several wavelengths allow us to map out longitudinal variations in the pressure-temperature profiles, chemistry, clouds, and circulation patterns of these highly-irradiated atmospheres, and such spatially resolved information will be absolutely critical in interpreting the results of the broader, low-resolution survey. Comparisons between the two benchmark systems HD 209458b and HD 189733b as well as a carefully-selected set of additional planets will allow us to investigate the importance of irradiation, rotation rate, surface gravity, eccentricity, and stellar metallicity in determining the pressure-temperature structure and dynamic meteorology of these atmospheres. We are requesting a total of 1138 hours for these observations.

Spitzer Space Telescope - General Observer Proposal #80073

Life on the Edge: Planetary Atmospheres in Extreme Environments

Principal Investigator: Heather Knutson
Institution: UC Berkeley

Technical Contact: Heather Knutson, UC Berkeley

Co-Investigators:
Drake Deming, NASA Goddard
Kamen Todorov, Penn State University
Jean-Michel Desert, Harvard University
Eric Agol, University of Washington
Nicolas Cowan, Northwestern University
Adam Burrows, Princeton University
Jonathan Fortney, University of California, Santa Cruz
Andrew Howard, University of California, Berkeley
Gregory Laughlin, University of California, Santa Cruz
Jonathan Langton, Principia College
Adam Showman, University of Arizona
Nikole Lewis, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 596.4

Abstract:
Studies of extrasolar planets have been moving at an ever-accelerating pace, with more than one hundred known transiting planet systems and hundreds of new planet candidates from missions such as Kepler and CoRoT waiting in the wings. Ongoing efforts with the Hubble and Spitzer Space Telescopes, as well as from the ground, have allowed us to characterize the atmospheres of these planets in unprecedented detail and have revealed a surprisingly diverse array of atmosphere properties. We propose to address some of the most hotly debated questions in the field using a subset of bright, recently discovered transiting planet systems, which provide the most optimal targets for detailed characterization. These questions include: What is the mechanism responsible for maintaining the large day-night temperature gradients observed for some tidally locked hot Jupiters? Are MHD effects such as Lorentz braking and Ohmic dissipation important in the hottest planetary atmospheres? What sets the balance between methane and CO in cooler atmospheres, and how important is photochemistry and other non-equilibrium processes? Although it would be natural to extend these same studies down into the super-Earth (< 10 M_earth) mass range, there is currently only one system (GJ 1214) that is suitable for detailed characterization. We therefore propose to carry out a search for transits of known, low-mass radial velocity planets orbiting bright stars, with a 52% probability of finding a new transiting super-Earth. Because the vast majority of Kepler- and CoRoT-detected planets in this mass range are too faint for detailed atmosphere studies, such systems will be crucial in allowing us to characterize the atmospheres of smaller and more earth-like worlds.

Data from this program was split into multiple PIDs. You can find the data in program IDs 80073, 80219, 80220

Spitzer Space Telescope - General Observer Proposal #90032

The Eccentric Exoplanets: A Survey of Atmospheric Heating and Variability

Principal Investigator: Heather Knutson
Institution: Caltech

Technical Contact: Heather Knutson, Caltech

Co-Investigators:
Nicolas Cowan, Northwestern
Nikole Lewis, MIT
Eric Agol, University of Washington
Adam Showman, University of Arizona
Drake Deming, University of Maryland
Adam Burrows, Princeton
Jonathan Fortney, University of California, Santa Cruz
Greg Laughlin, University of California, Santa Cruz
Jonathan Langton, Principia College
Sara Rastegar, Northwestern

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 508.0

Abstract:
Observations of short-period gas giant planets on eccentric orbits provide a unique test of atmospheric circulation theories. Eccentric planets are qualitatively different for two reasons: 1) they cannot be synchronously rotating, so they experience diurnal forcing, and 2) the incident stellar flux changes throughout an orbit, constituting a time-variable atmospheric forcing. These differences cause large variations in planetary temperature and wind speeds as a function of time. We propose to compare thermal phase variations and instantaneous eclipse maps for two benchmark eccentric transiting planets, XO-3b and HAT-P-2b. The mirrored viewing geometry of these two systems and the close similarities in their stellar and planetary properties makes them ideal cases for comparison, as we can observe the same heating and cooling processes from opposite hemispheres. By measuring the heating responses of the two planets during periastron passage, we can determine the radiative time scales of their atmospheres independent of other parameters. The flux that we measure at a given orbital phase will be a function of both the viewing geometry and the heating history of the planet; we break this degeneracy by mapping the instantaneous dayside brightness distribution using the shape of the secondary eclipse ingress and egress. The existence of a large set of secondary eclipse measurements in the same band will also allow us to place strict limits on orbit-to-orbit variability in the planet's dayside emission. Together these data will provide a uniquely detailed picture of the atmospheres of two complementary worlds, and motivate the development of increasingly sophisticated atmospheric circulation models that can be applied to a wide range of planets.

Spitzer Space Telescope - General Observer Proposal #10081

Dust to Dust: Monitoring the Evolution of the New Class of Self-Obscured Transients

Principal Investigator: Christopher Kochanek
Institution: The Ohio State University

Technical Contact: Christopher Kochanek, The Ohio State University

Co-Investigators:
Krzysztof Stanek, Ohio State University
Jose Prieto, Princeton University

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.4
Priority: 1

Abstract:
The goal of this proposal is to understand a new class of explosive transients associated with the most massive AGB stars. Today these sources are true creatures of the mid-IR, being optically invisible and very faint in the near-IR. By coarsely monitoring them with Spitzer and HST we can examine the evolution of the luminosity, dust optical depth and dust radius/temperature at a key time when their observed fluxes are approaching those of the two known progenitors. At its very simplest, they must stop fading in the next ~year or they are the theoretically expected but observationally missing electron capture supernovae (ecSNe). The only way to find out is to continue monitoring the evolution of the four closest examples.

Spitzer Space Telescope - General Observer Proposal #11084

Dust to Dust: Monitoring the Evolution of the New Class of Self-Obscured Transient

Principal Investigator: Christopher Kochanek
Institution: The Ohio State University

Technical Contact: Christopher Kochanek, The Ohio State University

Co-Investigators:
Scott Adams, The Ohio State University

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.4
Priority: 1

Abstract:
The goal of this proposal is to understand a new class of explosive transients associated with the most massive AGB stars. Today these sources are true creatures of the mid-IR, being optically invisible and very faint in the near-IR. By coarsely monitoring them with Spitzer and HST we can examine the evolution of the luminosity, dust optical depth and dust radius/temperature at a key time when their observed fluxes are approaching those of the two known progenitors. At its very simplest, if they do not stop fading in the mid-IR or start to brighten in the near-IR, then they are almost certainly examples of the theoretically expected but observationally missing electron capture supernovae (ecSNe). The exciting result from Cycle 10 is that the sources continued to fade and two are becoming substantially fainter than their progenitors. If this continues in Cycle 11, the ecSNe interpretation becomes increasingly probable.

Spitzer Space Telescope - Directors Discretionary Time Proposal #11181

A Steller Merger In Andromeda

Principal Investigator: Christopher Kochanek
Institution: The Ohio State University

Technical Contact: Christopher Kochanek

Co-Investigators:
Subo Dong, KIAA
Jose Prieto, Diego Portales University

Science Category: Local Group Galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.3

Abstract:

Stellar mergers are common, yet rarely discovered or well-observed. We propose Spitzer 3.6/4.5 micron monitoring of the newly discovered merger event in M31 in order to follow the mass loss process and dust formation. We propose roughly weekly observations in the Mar/Apr and Oct/Nov 2015 visibility windows. These will be the first mid-IR observations of these rare transients in these early phases. We expect to detect the onset of dust formation and track its optical depth, temperature and formation radius.

Spitzer Space Telescope - General Observer Proposal #12000

Confirming the Birth of a New Black Hole

Principal Investigator: Christopher S Kochanek
Institution: Ohio State University

Technical Contact: Christopher S Kochanek, OSU

Co-Investigators:
Xinyu Dai, Oklahoma
Scott Adams, Ohio State
Jill Gerke, Ohio State
Krztsztof Stanek, Ohio State

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.75
Priority: 1

Abstract:
We have carried out a systematic search for failed supernovae, stars forming black holes without a supernova. Several strong arguments suggest that 10-30% of core collapses should fail and the most likely progenitor mass range is 18-25 Msun. Our survey has yielded one excellent candidate, and, based on its luminosity, it lies exactly in this mass range. If the failed supernova fraction is 10-30%, it is statistically reasonable that we should have found one in our survey. We propose CXO, HST and SST observations to confirm this candidate. Discovering a new X-ray source would be the ultimate confirmation, while HST and SST can confirm the vanishing of the progenitor star better than our ground-based data. A successful outcome for these observations would be revolutionary.

Spitzer Space Telescope - General Observer Proposal #12063

Monitoring the M31 Stellar Merger Transient

Principal Investigator: Christopher Kochanek
Institution: The Ohio State University

Technical Contact: Christopher Kochanek, The Ohio State University

Co-Investigators:
Scott Adams, Ohio State University

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4
Priority: 1

Abstract:
We propose two new epochs of Spitzer observations of the stellar merger transient occurring in M31. While initially dust free, the systems clearly underwent a major dust formation episode in May 2015. Supplemented by ground based optical and near-IR observations, the new Spitzer data should allow us to estimate the dust optical depth, radius, temperature and mass, along with the underlying luminosity and temperature of the merger remnant. This is a relatively rare opportunity to study the evolution of an ongoing merger, and the first to be studied by Spitzer from its earliest phases.

Spitzer Space Telescope - General Observer Proposal #13022

Dust to Dust: Monitoring the Evolution of a New Class of Self-Obscured Transients

Principal Investigator: Christopher Kochanek
Institution: The Ohio State University

Technical Contact: Christopher Kochanek, The Ohio State University

Co-Investigators:
Scott Adams, Ohio State University

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.7
Priority: 1

Abstract:
The goal of this proposal is to understand a new class of explosive transients associated with the most massive AGB stars. Today these sources are true creatures of the mid-IR, being optically invisible and very faint in the near-IR. By coarsely monitoring them with Spitzer and HST we can examine the evolution of the luminosity, dust optical depth and dust radius/temperature at a key time when their observed fluxes are approaching those of the two known progenitors. At its very simplest, if they do not stop fading in the mid-IR or start to brighten in the near-IR, then they are almost certainly examples of the theoretically expected but observationally missing electron capture supernovae (ecSNe). The exciting result from Cycle 11 is that the sources continued to fade and two are clearly substantially fainter than their progenitors. If this continues in Cycle 13, the ecSNe interpretation becomes far stronger.

Spitzer Space Telescope - General Observer Proposal #70040

Massive Star CSI: Has The Progenitor of SN2008S Vanished?

Principal Investigator: Christopher Kochanek
Institution: The Ohio State University

Technical Contact: Christopher Kochanek, The Ohio State University

Co-Investigators:
Kris Stanek, Ohio State University
Jose Prieto, Carnegie Obseratories
Todd Thompson, Ohio State University

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.5

Abstract:
SN2008S in NGC6946 is the prototype of a new class of optical transients. Its luminosity was low for a Type II supernova, and the progenitor star was identified as a completely dust obscured log(L/Lsun)=4.5, T=440K massive star (~10 Msun) in archival Spitzer data. It is uncertain whether this is a new class of low-luminosity supernova (e.g. an electron capture supernova) or a new class of massive star outburst. The transient has now faded to the point where the source is again invisible in the optical. Near-IR detections are consistent with a somewhat hotter source, T~1200K, somewhat brighter than the progenitor and still fading at ~3 mag/year. Using two epochs of IRAC observations to constrain the mid-IR emission, and two epochs of HST H-band observations to constrain emission from cool stars, we will solve this mystery by either identifying and characterizing the surviving progenitor or ruling out its survival.

Spitzer Space Telescope - General Observer Proposal #80015

Understanding A New Class of Mid-IR Transients

Principal Investigator: Christopher Kochanek
Institution: The Ohio State University

Technical Contact: Christopher Kochanek, The Ohio State University

Co-Investigators:
Krzysztof Stanek, Ohio State University
Jose Prieto, Carnegie Observatories
Dorota Szczygiel, Ohio State University
Xinyu Dai, Oklahoma University

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5.0

Abstract:
There is a new class of stellar transients whose progenitors are completely obscured (probably) extreme AGB stars, where the dust in the surviving wind appears to reform after the transient and again cloak the system. Whether these are true supernovae or a new class of stellar eruption is unclear, so the key question is whether or not the star survived. However, their present day emission appears to be due to optically thick dust (shock) heated by the ejecta from the transient, so we must understand the evolution of this emission and the dust optical depths before we can determine the survival of the stars. We propose a combination of Spitzer, Hubble and Chandra observations to characterize 6 of the new transients and a comparison sample of 5 supernovae with late time emission due to shocks and 3 luminous variable outbursts with late time emission due to a surviving star surrounded by ejected matter. The SST data will characterize the shock luminosity and its rate of decay, both exploring the physics of dusty shocks and setting limits on the flux from any surviving star. The near-IR HST data will tightly constrain the optical depth of the dust and potentially allow us to see through it to any surviving star. If the emission is from a dusty shock, there must be X-ray emission, and the amount of soft X-ray absorption will determine the the absorbing column densities.

Spitzer Space Telescope - General Observer Proposal #90124

Dust to Dust: The Mysterious SN2008S Class of Stellar Eruptions

Principal Investigator: Christopher Kochanek
Institution: The Ohio State University

Technical Contact: Christopher Kochanek, The Ohio State University

Co-Investigators:
Krzystof Stanek, Department of Astronomy, The Ohio State University
Todd Thompson, Department of Astronomy, The Ohio State University
Jose Prieto, Department of Astrophysical Sciences, Princeton University
Dorota Szczygiel, Department of Astronomy, The Ohio State University

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0

Abstract:
The SN2008S class of stellar transients appear to be explosions of (or on) extreme AGB stars completely obscured by dust formed in their dense winds. The explosive transient briefly destroys almost all the dust, but the dust then reforms and again cloaks the systems from view except in the mid-IR. We have been monitoring these systems, and they have been slowly fading. They are approaching the point where they must either level out near the luminosity of their progenitor stars or fade away. In the latter case, these events are almost certainly the predicted but previously unobserved class of electron capture supernovae. The only way to find out is to continue monitoring these systems, and only Spitzer has the necessary sensitivity -- they are optically invisible, and barely detectable with HST in the near-IR. We will obtain one new epoch for each of the four systems close enough to follow their evolution in luminosity to levels well below the progenitor luminosities.

Spitzer Space Telescope - Directors Discretionary Time Proposal #90255

Spitzer observations of a possible supernova in the making

Principal Investigator: Rubina Kotak
Institution: Queens University

Technical Contact: Rubina Kotak, Queens U.

Co-Investigators:
Seppo Mattila, Tuorla Observatory

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.0

Abstract:
We request urgent observations of a unique transient event: SN 2009ip. Although this transient was identified as a luminous blue variable star soon after its discovery, a recent giant outburst / explosion has led to the suggestion that we may be witnessing the transition from an eruption to a genuine supernova explosion -- a truly remarkable possibility! Although it is being well-observed at most other wavelengths, mid-infrared observations are non-existent. Yet, our request here, will allow us to estimate the total bolometric output, ascertain the presence of new or old circumstellar dust, and monitor the evolution of the spectral energy distribution.

Spitzer Space Telescope - General Observer Proposal #12059

Tying the IRS to IRAC

Principal Investigator: Kathleen Kraemer
Institution: Boston College

Technical Contact: Kathleen Kraemer, Boston College

Co-Investigators:
Greg Sloan, Cornell University

Science Category: stellar populations
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.7
Priority: 2

Abstract:
To enhance the utility of the Spitzer data archive and enable better support of JWST, we propose to observe with IRAC a set of the stars that were used to calibrate the IRS. The IRS calibration was tied to MIPS, but the consistency with IRAC has yet to be examined. That is, the short wavelength ends of the IRS spectra are not independently pinned down to measured photometry. Also, an issue with flux lost from the finite-sized slits, particularly at the short-wavelength end, was never fully resolved. We will address these issues with IRAC observations at 3.6 and 4.5 micron. Most of these sources saturated WISE and are too faint for SOFIA, so IRAC is the only instrument capable of observing them at these bands. We request 4.5 hours to complete this project.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14221

Observing IRS Standards with IRAC

Principal Investigator: Kathleen Kraemer
Institution: Boston College

Technical Contact: Kathleen Kraemer, Boston College

Co-Investigators:
G. Sloan, Space Telescope Science Institute
C. Engelke, Boston College

Science Category: Stellar populations
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.1

Abstract:
We request 1.1 hours to observe ten spectrophotometric standard stars with Spitzer's IRAC at 3.6 and 4.5 um. The calibration of Spitzer's IRS was tied to the 24 um calibration of MIPS, but the short-wavelength end of the spectral range was never formally pinned photometrically. We have undertaken a project to observe the IRS standards with IRAC. The proposed targets have IRAC observations in the archive, but they were obtained with different integration times and dither patterns from our IRAC observations of other standards. We have found that these differences lead to significantly larger uncertainties than for data taken with a uniform strategy. Since the affected stars include some of the most frequently observed IRS standards, we must observe them in the same uniform manner as the rest of the IRS standard stars to properly compare the calibrations of the two instruments and enable improvements to their respective calibrations. Additionally, one of our targets is an important transfer standard that will help connect the Spitzer calibration to that of JWST.

Spitzer Space Telescope - General Observer Proposal #12084

Continuous Dust Formation in Type II SNe

Principal Investigator: Kelsie Krafton
Institution: Louisiana State University

Technical Contact: Kelsie Krafton, Louisiana State University

Co-Investigators:
Jennifer Andrews, University of Arizona
Geoffrey Clayton, Louisiana State University
Michael Barlow, University College London
Antonia Bevan, University College London

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.4
Priority: 2

Abstract:
Studies in the last 10 years of dust formation in core-collapse supernovae (CCSNe) have found only small amounts, ~0.001 solar masses. This is far less than the amount needed to account for the large masses of dust seen in some high redshift galaxies. However, the recent discovery of ~1 solar mass of cold dust in the ejecta of SN 1987A has has caused a complete re-evaluation of dust formation in CCSNe. It has been suggested that the CCSNe are continuously forming dust so that by the time they are about 25 years old they will have dust masses similar to SN 1987A. However, there is a wide time gap between the CCSNe that have been studied recently and SN 1987A. We plan to use the sensitivity of Spitzer to detect dust emission from CCSNe between 4 and 50 yr after explosion. Radiative transfer models will be used to estimate the dust masses. These observations are part of a long term study requiring multiple epochs of Spitzer observations to look for evidence of continuous dust formation. These observations will help shed light on the mystery of dust in SN 1987A.

Spitzer Space Telescope - General Observer Proposal #13063

Continuous Dust Formation in SNe 2010jl and 2011ja

Principal Investigator: Kelsie Krafton
Institution: Louisiana State University

Technical Contact: Kelsie Krafton, Louisiana State University

Co-Investigators:
Geoffrey Clayton, Louisiana State University
Jennifer Andrews, University of Arizona
Michael Barlow, University College London
Ilse De Looze, University College London

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.6
Priority: 1

Abstract:
Studies in the last 10 years of dust formation in core-collapse supernovae (CCSNe) have found only small amounts, ~0.001 solar masses. This is far less than the amount needed to account for the large masses of dust seen in some high redshift galaxies. However, the recent discovery of ~1 solar mass of cold dust in the ejecta of SN 1987A has has caused a complete re-evaluation of dust formation in CCSNe. It has been suggested that the CCSNe are continuously forming dust so that by the time they are about 25 years old they will have dust masses similar to SN 1987A. However, there is a wide time gap between the CCSNe that have been studied recently and SN 1987A. We plan to use the sensitivity of Spitzer to detect dust emission from CCSNe 5 or more years after explosion. Radiative transfer models will be used to estimate the dust masses. This proposal is to continue our study of two interesting SNe 2010jl and 2011ja. These observations are part of a long term study requiring multiple epochs of Spitzer observations to look for evidence of continuous dust formation. These observations will help shed light on the mystery of dust in SN 1987A.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13239

Early Observations of the Dust in the New CCSN 2017eaw

Principal Investigator: Kelsie Krafton
Institution: Louisiana State University

Technical Contact: Kelsie Krafton, Louisiana State University

Co-Investigators:
Geoffrey Clayton, Louisiana State University
Jennifer Andrews, University of Arizona
Ori Fox, Space Telescope Science Institute

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.0

Abstract:
Studies in the last 10 years of dust formation in core-collapse supernovae (CCSNe) have found only small amounts, ~0.001 solar masses. This is far less than the amount needed to account for the large masses of dust seen in some high redshift galaxies. However, the recent discovery of ~1 solar mass of cold dust in the ejecta of SN 1987A has has caused a complete re-evaluation of dust formation in CCSNe. It has been suggested that the CCSNe are continuously forming dust so that by the time they are about 25 years old they will have dust masses similar to SN 1987A. However, there is a wide time gap between the CCSNe that have been studied recently and SN 1987A. We plan to use the sensitivity of Spitzer to detect dust emission from SN 2017eaw at two epochs less than a year after explosion. Radiative transfer models will be used to estimate the dust masses. These observations will provide a necessary baseline for our proposed JWST DD ERS observations. This is part of a long term study to look for evidence of continuous dust formation in CCSNe. These observations will help shed light on the mystery of dust in the early universe.
SSC Note: A 2019 epoch was added by the TAC.

Spitzer Space Telescope - General Observer Proposal #80190

A Spitzer Proper Motion Survey of the Pleiades

Principal Investigator: Adam Kraus
Institution: University of Hawaii

Technical Contact: Adam Kraus, University of Hawaii

Co-Investigators:
John Stauffer, Caltech/IPAC
Michael Liu, University of Hawaii - IfA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 19.5

Abstract:
The Pleiades is a landmark open cluster that has had a profound impact on our understanding of stellar astronomy. The stellar member census of the Pleiades has been intensely studied since the beginnings of modern astronomy, and the high-mass substellar membership has been filled in by a number of advances over the past decade. However, the lowest-mass brown dwarfs have remained elusive. We propose to search for these cool, faint brown dwarfs using a high-precision proper motion survey with Spitzer. This survey exploits archival first-epoch astrometry from shortly after launch, in combination with our proposed observations in Cycle 8, to measure proper motions with a precision of 2--3 mas at 30 M_Jup and ~12 mas even at masses as low as 10 M_Jup. This type of study has previously been infeasible, but as we describe, our new characterization of the IRAC optical distortion improves the astrometric noise floor from 150 mas down to 10--20 mas. Our new census will reveal the shape and slope of the bottom of the Pleiades mass function and establish a new set of benchmark brown dwarfs in an unexplored range of mass and age that is directly comparable to exoplanets like HR 8799bcde. In summary, this novel and efficient survey will cast new light on the last unidentified members in the prototype for all young open clusters.

Spitzer Space Telescope - General Observer Proposal #90071

A Proper-Motion Census of Star-Forming Regions in the Solar Neighborhood

Principal Investigator: Adam Kraus
Institution: University of Hawaii

Technical Contact: Adam Kraus, University of Hawaii

Co-Investigators:
John Stauffer, Caltech/IPAC
Neal Evans, University of Texas at Austin
Katelyn Allers, Bucknell University
Michael Dunham, Yale University
Jessica Lu, University of Hawaii - IfA
Daniel Jaffe, University of Texas at Austin

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 559.2

Abstract:
Over the past decade, Spitzer has revolutionized our understanding of the membership, mass functions, and disk populations of the star-forming regions in the solar neighborhood. However, the faintest members of these populations have remained elusive, particularly in highly-embedded regions of ongoing star formation. Mid-infrared color selection is not effective at distinguishing proto-brown dwarfs and disk-free young stars from dusty galaxies or reddened field stars, and optical/NIR spectroscopic confirmation remains too expensive. The most cost-effective method to identify this missing population is to confirm common proper motion with their host regions. The astrometric performance of IRAC has been considered insufficient for this task, but as we demonstrate, our new characterization of the IRAC optical distortion improves the astrometric noise floor from 0.1-0.2 arcsec to 0.01-0.02 arcsec at each epoch, corresponding to proper motion uncertainties as low as 2 mas/yr. We propose a Spitzer/IRAC Exploration Science program for 560 hours to conduct second-epoch imaging for a proper-motion search of six stellar populations: Ophiuchus, Lupus, Chamaeleon, Perseus, Taurus, and Corona Australis. We will observe dense mosaics that span the areas which were previously observed during the cryogenic mission. In combination with the existing first-epoch astrometry, we will measure proper motions with uncertainties of <=5 mas/yr for sources as faint as m_[3.6] = 17.5, reaching photospheric fluxes corresponding to 1-2 MJup at 1 Myr. Our census will reveal the shape and slope of the proto(sub)stellar luminosity function, identify free-floating counterparts of young giant planets, search for the dynamical signatures of star formation models, and study disk evolution/dispersal and planet formation around the youngest and lowest-mass primaries. In summary, our program will unveil the last unidentified members in the benchmark star-forming regions which have been studied so intensively by the Spitzer Space Telescope.

Spitzer Space Telescope - General Observer Proposal #11099

Exploring the Frontier of Exoplanet Atmosphere Dynamics with NASA's Great Observatories

Principal Investigator: Laura Kreidberg
Institution: University of Chicago

Technical Contact: Laura Kreidberg, University of Chicago

Co-Investigators:
Jacob Bean, University of Chicago
Kevin Stevenson, University of Chicago
Adam Showman, University of Arizona
Jonathan Fortney, University of California Santa Cruz
Michael Line, University of California Santa Cruz
Jean-Michel Desert, University of Colorado Boulder

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 134.3
Priority: 1

Abstract:
We propose a joint Spitzer+HST program to explore the frontier of exoplanet atmosphere dynamics. We will pursue a multi-wavelength approach to create detailed maps of the thermal structure of two of the best target hot Jupiters. First, we will perform secondary eclipse mapping for WASP-18b with Spitzer at 4.5 microns to complement existing Spitzer+HST phase curve observations. The combination of these data will yield the first ever map of an exoplanet's thermal structure as a function of latitude, longitude, and altitude, and provide a benchmark for 3D atmospheric circulation models of highly irradiated planets. Second, we will use a new technique pioneered by our team to observe full-orbit phase curves for WASP-103b with Spitzer and HST/WFC3. These observations will reveal the planet's phase-resolved emission spectrum and determine the global temperature-pressure profile and atmospheric composition, as well as its heat redistribution and Bond albedo. This program will significantly expand the sample of thoroughly characterized exoplanets and enable comparative planetology beyond the Solar System. Spitzer and HST are the facilities that have made the strongest contributions to our understanding of exoplanet atmospheres thus far, and we are now in a position to combine their powers in a strategic way to yield unprecedentedly detailed characterization of hot Jupiter atmospheric dynamics. This program will set the stage for even more precise investigations that will be possible with JWST.

Spitzer Space Telescope - General Observer Proposal #13140

Clouds in the Forecast? A Joint Spitzer and HST Investigation of Clouds and Hazes for Two Exo-Neptunes

Principal Investigator: Laura Kreidberg
Institution: University of Chicago

Technical Contact: Laura Kreidberg, University of Chicago

Co-Investigators:
Caroline Morley, UCSC
Michael Line, UCSC
Kevin Stevenson, University of Chicago
Diana Dragomir, University of Chicago

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 131.9
Priority: 1

Abstract:
Recent observations of transiting planets have revealed that clouds and hazes are common in exoplanet atmospheres. Little is known, however, about how the clouds/hazes form, what their composition is, and how their properties vary with planet parameters. We propose to characterize the atmospheres of two exo-Neptunes, GJ 436b and GJ 3470b, both of which show evidence for clouds or hazes in their near-infrared spectra. We will measure precise 3.6 and 4.5 micron transit depths for these planets, to compare with existing high-precision data at shorter wavelengths. We will also obtain a UV spectrum for GJ 3470 with HST/COS to enable accurate models of the planet's photochemistry. These observations will enable us to distinguish at high confidence between a range of physically realistic models for the atmospheric chemistry, including methanogenic photochemical hazes and equilibrium salt/sulfide clouds. The measurements will enable comparative planetology with the handful of other small, cool worlds currently accessible to observation, and serve as a first assessment of the prevalence, origin, and composition of clouds and haze in metal-enriched atmospheres below 1000 K. Our findings will guide the design of future observations of increasingly Earth-like worlds with JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13167

First Atmosphere Characterization of the Benchmark Exo-Neptune WASP-107b

Principal Investigator: Laura Kreidberg
Institution: Harvard University

Technical Contact: Laura Kreidberg, Harvard

Co-Investigators:
Kevin Stevenson, Space Telescope Science Institute
Michael Line, Arizona State University
Caroline Morley, Harvard University
Jonathan Irwin, Harvard University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 14.7

Abstract:
WASP-107b is a newly discovered transiting planet that is the highest signal-to-noise target for transmission spectroscopy discovered in the last decade, thanks to its low surface gravity and small, bright host star. It is also a strong candidate for emission spectroscopy. The planet is in the intriguing transition region between ice and gas giants, with a mass comparable to Neptune and a radius similar to Jupiter, and thus provides an excellent test case for planet formation theories. We propose reconnaissance transit and eclipse observations to preview the planet's atmospheric metallicity , climate, and aerosol properties. This program will guide the design of future JWST observing proposals, as well as cement Spitzer's legacy as a pioneer in the observation of extrasolar planets.

Spitzer Space Telescope - General Observer Proposal #14135

Taking the Temperature of a Lava Planet

Principal Investigator: Laura Kreidberg
Institution: Harvard

Technical Contact: Laura Kreidberg, Harvard

Co-Investigators:
Eric Lopez, NASA
Nick Cowan, McGill
Roxana Lupu, NASA Ames
Kevin Stevenson, STScI
Tom Louden, Warwick

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 65.7
Priority: 1

Abstract:
Ultra-short period rocky planets (USPs) are an exotic class of planet found around less than 1% of stars. With orbital periods shorter than 24 hours, these worlds are blasted with stellar radiation that is expected to obliterate any traces of a primordial atmosphere and melt the dayside surface into a magma ocean. Observations of USPs have yielded several surprising results, including the measurement of an offset hotspot in the thermal phase curve of 55 Cancri e (which may indicate a thick atmosphere has survived), and a high Bond albedo for Kepler-10b, which suggests the presence of unusually reflective lava on its surface. To further explore the properties of USPs and put these results in context, we propose to observe a thermal phase curve of the newly discovered USP K2- 141b. This planet is a rocky world in a 6.7 hour orbit around a bright, nearby star. When combined with optical phase curve measured by K2, our observations will uniquely determine the planet's Bond albedo, precisely measure the offset of the thermal curve, and determine the temperature of the dayside surface. These results will cement Spitzer's role as a pioneer in the study of terrestrial planets beyond the Solar System, and provide a critical foundation for pursuing the optimal follow-up strategy for K2-141b with JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14204

A Test for the Existence of an Atmosphere on a Terrestrial Exoplanet Orbiting a Small Star

Principal Investigator: Laura Kreidberg
Institution: Harvard University

Technical Contact: Laura Kreidberg, Harvard University

Co-Investigators:
Laura Schaefer, ASU
Renyu Hu, JPL,
Daniel Koll, MIT
Caroline Morley, UT Austin
Kevin Stevenson, STScI
Jonathan Irwin, Harvard-Smithsonian Center for Astrophysics
Ian Crossfield, MIT
Jason Dittmann, MIT
Chelsea Huang, MIT
Andrew Vanderburg, UT Austin
Roland Vanderspek, MIT
David Charbonneau, Harvard-Smithsonian Center for Astrophysics,
Sara Seager, MIT
David Latham, Harvard-Smithsonian Center for Astrophysics
George Ricker, MIT
Drake Deming, University of Maryland

Science Category: Exoplanets
Observingi Modes: IRAC Post-Cryo Mapping
Hours Approved: 100.9

Abstract:

Terrestrial planets orbiting M-dwarfs are among the most abundant worlds in the Galaxy, and they are promising targets for atmosphere characterization thanks to their diminutive host stars. However, their atmospheres are vulnerable to photoevaporation and nightside collapse, and it remains to be seen whether they can survive these dangers. Recently, the Transiting Exoplanet Survey Satellite revealed a 1.36 Earth radius planet transiting a nearby, small star every 11 hours. The equilibrium temperature is 1040 K, making this planet uniquely accessible for thermal emission measurements with current facilities. Here we propose to observe the thermal phase variation at 4.5 micron to search for signatures of atmospheric circulation. We will measure the phase curve amplitude with sufficient precision to distinguish at 3 sigma confidence between the large signal expected for a bare rock versus the smaller amplitude expected if an atmosphere redistributes 20% or more of the incident stellar energy to the nightside. We will also measure the phase of peak brightness to a precision of 10 degrees, to search for phase offsets that could arise from atmospheric circulation. These reconnaissance observations will provide crucial guidance for future study of this system with JWST, give us a first clue as to whether atmospheres can survive on terrestrial planets orbiting M-dwarfs, and cement Spitzer's role as a pioneer in the exploration of planets beyond the Solar System.

Spitzer Space Telescope - General Observer Proposal #80016

Comparative Atmospheric Study of Exoplanets

Principal Investigator: Jessica Krick
Institution: Spitzer Science Center

Technical Contact: Jessica Krick, Spitzer Science Center

Co-Investigators:
Kaspar von Braun, NExScI
Jim Ingalls, Spitzer Science Center
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Stephen Kane, NExScI
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Carl Grillmair, IPAC
Peter Plavchan, NExScI
Hilke Schlichting, UCLA
Dawn Gelino, NExScI
Chris Gelino, IPAC
Gerard van Belle, ESO
Adam Burrows, Princeton

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 619.0

Abstract:
Spitzer's extended warm mission gives us the opportunity to contribute to its legacy by performing comparative science on atmospheres of extrasolar planets. The goal of this proposal is to obtain high quality 4.5 micron phase curves for 22 transiting hot Jupiter systems, which represent a complete sample of systems that can be studied with Spitzer in a reasonable amount of time. The resulting dataset will not only quadruple the number of phase curve observations to date, but also populate gaps in parameter space explored by current phase curve studies. The combination of our phase curves with well-known literature ephemerides and observations of secondary eclipses will produce maps of the longitudinal brightness/temperature distributions in the planetary atmospheres. These maps can be used to calculate energy redistribution efficiencies between the hot dayside and cooler nightside -- exoplanetary weather. Our observations focus on the following three questions: (1) What is the contrast between exoplanetary day- and nightside temperatures, i.e., how efficiently is the incident energy redistributed? (2) Are the weather phenomena in the exoplanetary atmospheres stable over long periods of time? (3) How do the temperature distributions on the planetary surfaces correlate with astrophysical properties of the star-planet systems? To answer these questions with our proposed Spitzer observations, we will employ a novel observing technique using snapshot observing to reduce telescope time requirements, and PCRS peak-up to IRAC to increase the pointing accuracy and thus minimize the photometric error due to intrapixel sensitivity variation. The analysis of this comprehensive data set will elevate the study of phase curves to the level of comparative atmospheric studies outside the solar system.

Spitzer Space Telescope - General Observer Proposal #70165

Peek-a-boo: Mapping Dust in Galaxies with Spitzer IRAC Imaging of Back-lit Galaxy Pairs

Principal Investigator: Varsha Kulkarni
Institution: Univ. of South Carolina

Technical Contact: Varsha Kulkarni, Univ. of South Carolina

Co-Investigators:
Sarah Higdon, Georgia Southern University
James Higdon, Georgia Southern University

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 11.5

Abstract:
Interstellar dust affects the chemistry and energy budget of galaxies, and can profoundly affect studies of the distant universe. However, very little is known about the nature of interstellar dust in normal galaxies beyond the Milky Way and the Magellanic Clouds. A direct way to probe dust in galaxies is by using partially overlapping (backlit) pairs of galaxies. While this technique has been applied to a few galaxy pairs, it has been used primarily with optical data in B and I bands (and occasionally K band), which are all subject to substantial amounts of dust extinction. Here we propose to observe 15 backlit pairs/polar ring galaxies in IRAC 3.6 and 4.5 micron bands which are much less affected by dust. Our goals are: (1) to obtain essentially un-extinguished reference images for comparison with the existing optical images and thus to determine dust extinction more accurately across different parts of the foreground galaxies; (2) to determine the opacity of some nearby spiral disks and examine whether dust grain sizes decrease in outer parts of disks; (3) to probe large-scale dust structure in some elliptical galaxies; (4) to examine whether dust exhibits fractal structure; and (5) to map star formation rate across the galaxies using the 3.6/4.5 micron flux ratio. The very local nature of our sample allows a detailed look at dust properties at different positions within the galaxies, and examine what galaxy properties drive the variation in dust properties. Our study will provide new implications for observations of the distant universe that are necessarily affected by the presence of dust in foreground galaxies.

Spitzer Space Telescope - General Observer Proposal #80194

Rings of Fire: A Spitzer IRAC Study of Polar Ring Galaxies

Principal Investigator: Varsha Kulkarni
Institution: Univ. of South Carolina

Technical Contact: Varsha Kulkarni, Univ. of South Carolina

Co-Investigators:
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Sarah J. U. Higdon, Georgia Southern University
James L. Higdon, Georgia Southern University

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 25.2

Abstract:
Polar ring galaxies (PRGs) are visually spectacular objects, consisting of a robustly star forming ring of gas, dust and stars orbiting a plane perpendicular to the major axis of a central S0. Since the ring material experiences the gravitational potential in the polar plane, PRGs offer unique probes of the shapes of the dark matter halo. Furthermore, polar rings represent star forming environments distinct from the disks of spiral galaxies and collisional ring galaxies, where density waves act to collect the ISM and trigger star formation. Many questions remain regarding the formation and evolution of PRGs: How old are the polar rings? Are they formed through polar mergers or by mass accretion? Is star formation the result of gravitational instabilities or stochastic propagation? To answer these questions, it is important to determine properties of the polar ring's stellar component. This requires observations in the infrared where extinction is minimal and where evolved stellar populations are most prominent. IRAC 3.6 and 4.5 micron imaging remains the best means of probing the stellar structure of PRGs due to its high angular resolution and sensitivity. We propose to obtain IRAC 3.6 and 4.5 micron images for a comprehensive sample of PRGs, with the following goals (1) We will determine the ring's stellar mass surface density, both directly and in concert with existing UV and optical images. (2) We will estimate the ages of the rings. (3) Together with available HI data, we will estimate the ring's gravitational stability, and thus the dominant star formation trigger. (4) We will characterize extinction in the polar ring sections ``back-lit'' by the central S0, and (5) We will better constrain the Tully-Fisher relation for PRGs, and thus halo shapes. The proposed data will give fresh insights into the dynamics and star formation histories of PRGs, and the formation/evolution mechanisms of S0 galaxies. The Spitzer warm mission offers the best chance to realize these goals.

Spitzer Space Telescope - General Observer Proposal #11134

GREATS: GOODS Re-ionization Era wide-Area Treasury from Spitzer

Principal Investigator: Ivo Labbe
Institution: University of Leiden

Technical Contact: Ivo Labbe, University of Leiden

Co-Investigators:
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Garth Illingworth, UCSC/Lick
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Marijn Franx, Universiteit Leiden
Valentino Gonzalez, UC Riverside
Rychard Bouwens, Universiteit Leiden
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Mauro Stefanon, Leiden University
Massimo Stiavelli, STScI

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 733.3
Priority: 1

Abstract:
Joint HST/WFC3 and Spitzer/IRAC observations are a powerful tool to probe the buildup of early galaxies, as demonstrated by the recent IRAC detections and stellar mass estimates of several bright z~9-10 galaxies (only 500 Myr after the Big Bang). However, the vast majority of galaxies in the reionization epoch have not been individually detected with IRAC, as extragalactic surveys have mostly focused on medium-deep and wide surveys. IRAC detections are crucial for understanding the evolution of the first galaxies, providing constraints on stellar masses, star formation histories, emission line strengths, and ages. We therefore propose to complete Spitzer's legacy with an ultradeep survey in the CANDELS/GOODS South and North fields at 3.6 and 4.5 micron to 27.1, 26.7 mag (AB,5sigma). Ultradeep data over substantial areas are needed to detect normal galaxies at z>7, provide good statistics, and mitigate field-to-field variance. We demonstrate using pilot ultradeep data from cycle 10 on a small area in GOODS-S, that we can successfully recover IRAC photometry to these limits. GREATS will result in the IRAC detection of 200 galaxies at 7<z<10. This would quadruple the number of current IRAC-detected galaxies and probe >50% of the total stellar mass density to z~8. The full UV-IR spectral energy distributions would for the first time enable detailed studies of trends and scatter with luminosity, redshift, color, and size. GREATS will also detect quiescent galaxies at 3<z<6 to 1e9.5 M_sun, and constrain the SFR-mass relation to extremely low masses ~1e8 M_sun for star forming galaxies at z~4. The characterization of galaxy properties at all redshifts back to z~9-10 is the logical final step in the legacy of Spitzer. The combined HST+Spitzer ultradeep imaging will be a vital benchmark for planning efficient JWST follow-up surveys 4+ years from now, and will provide targets for the first cycles of JWST NIRSPEC observations. With such remarkable datasets, Spitzer's heritage will extend well into the JWST era.

Spitzer Space Telescope - Frontier Legacy Proposal #13094

Completing the Legacy of Spitzer/IRAC over COSMOS

Principal Investigator: Ivo Labbe
Institution: University of Leiden

Technical Contact: Matthew Ashby, Harvard-Smithsonian Astrophysical Observatory

Co-Investigators:
Karina Caputi, University of Groningen
Derek McLeod, The Royal Observatory, Edinburgh
Will Cowley, University of Durham
Pratika Dayal, University of Groningen
Peter Behroozi, UC Berkeley
Matt Ashby, Harvard?Smithsonian Center for Astrophysics
Marijn Franx, Leiden University
James Dunlop, The Royal Observatory, Edinburgh
Olivier Le Fevre, Laboratoire d?Astrophysique de Marseille
Johan Fynbo, DARK, University of Copenhagen
Henry McCracken, IAP
Bo Milvang-Jensen, DARK, University of Copenhagen
Olivier Ilbert, Laboratoire d'Astrophysique de Marseille
Lidia Tasca, Laboratoire d'Astrophysique de Marseille
Stephane de Barros, INAF
Pascal Oesch, University of Geneva
Rychard Bouwens, Leiden University
Adam Muzzin, University of Cambridge
Garth Illingworth, UCO Lick
Mauro Stefanon, Leiden University
Corentin Schreiber, Leiden University
Anne Hutter, Swinburne University of Technology
Pieter van Dokkum, Yale University

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1500.0
Priority: 1 (1000hr); 2 (500hr)

Abstract:
We propose to complete the legacy of Spitzer/IRAC over COSMOS by extending the deep coverage to the full 1.8 sq degree field, producing a nearly homogenous and contiguous map unparalleled in terms of area and depth. Ongoing and scheduled improvements in the supporting optical-to-NIR data down to ultradeep limits have reconfirmed COSMOS as a unique field for probing the bright end of the z=6-11 universe and the formation of large-scale structures. However, currently only one-third of the field has received sufficiently deep IRAC coverage to match the new optical/near-IR limits. Here we request deep matching IRAC data over the full 1.8 sq degree field to detect almost one million galaxies. The proposed observations will allow us to 1) constrain the galaxy stellar mass function during the epoch of reionization at z=6-8 with ~10,000 galaxies at these redshifts, 2) securely identify the brightest galaxies at 9 < z < 11, 3) trace the growth of stellar mass at 1 < z < 8 and the co-evolution of galaxies and their dark matter halos, 4) identify (proto)clusters and large scale structures, and 5) reveal dust enshrouded starbursts and the first quiescent galaxies at 3 < z < 6. The Spitzer Legacy over COSMOS will enable a wide range of discoveries beyond these science goals owing to the unique array of multiwavelength data from the X-ray to the radio. COSMOS is a key target for ongoing and future studies with ALMA and for spectroscopy from the ground, and with the timely addition of the Spitzer Legacy it will prove to be a crucial treasury for efficient planning and early follow-up with JWST.

Spitzer Space Telescope - General Observer Proposal #70145

The IRAC Ultra Deep Fields 2010: Using IRAC to Characterize Ultrafaint z~7-10 Galaxies

Principal Investigator: Ivo Labbe
Institution: Carnegie Instition of Washington

Technical Contact: Ivo Labbe, Carnegie Instition of Washington

Co-Investigators:
Rychard Bouwens, UCSC/Lick
Garth Illingworth, UCSC/Lick
Valentino Gonzalez, UCSC/Lick
Pieter van Dokkum, Yale University
Marijn Franx, Universiteit Leiden
Marcella Carollo, Eidgenossiche Technische Hochschule (ETH)
Dan Magee, UCSC/Lick
Pascal Oesch, Eidgenossiche Technische Hochschule (ETH)
Massimo Stiavelli, STScI
Michele Trenti, University of Colorado

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 261.6

Abstract:
Recent extremely-deep, near-IR imaging (to 29.3 mag 5sigma) with HST WFC3/IR in the HUDF from our 192 orbit HUDF09 program have enabled a huge leap in our knowledge of the galaxies populating the early universe at z>7. These early galaxies are compelling targets for many reasons: as beacons of the first sites of star formation, as testbeds to constrain galaxy formation models, and as probes of reionization. Existing deep IRAC observations of the newly-found z~7 and z~8 galaxies in the HUDF demonstrate that Spitzer/IRAC plays a vital role in probing their rest-frame optical light and constraining their stellar masses and star formation histories at just 600-800 million years from the Big Bang. Now the only constraint to immediate and enormous progress in this area lies in the limited depth and incomplete IRAC coverage of the three ultra-deep WFC3 HUDF fields. These three fields are by far the best places of the sky for z>7 searches: the ACS and WFC3 supporting data are unique, and large samples of z~7-8.5 galaxies have already been identified (but are awaiting deep IRAC imaging). Here we propose immediate progress by pushing deeper on the HUDF and completing the very deep IRAC coverage of the HUDF09-1 and HUDF09-02 fields. This will result in (a) 2X reduction in field-to-field variance, (b) up to 2-4X reduced uncertainties in the stellar mass density at z~7 and z~8, and (c) up to 5X increases in IRAC detection rates of existing z~7 and z~8 galaxies. An ultra-deep IRAC data set will yield a peerless Legacy dataset for a dazzling array of science questions for galaxy formation during reionization out to z~10. These public IRAC data will be a crucial Legacy complement to the thousands of hours of existing or approved IRAC wide-field (shallow) surveys and the lensed clusters studies. They will also position us to exploit the upcoming unique capabilities of ALMA and JWST, as well as providing an observational framework for increasingly sophisticated galaxy formation and evolution modeling.

Spitzer Space Telescope - General Observer Proposal #11086

A warm Spitzer survey of the LSST/DES "Deep drilling" fields

Principal Investigator: Mark Lacy
Institution: NRAO

Technical Contact: Mark Lacy, NRAO

Co-Investigators:
Duncan Farrah, Virginia Tech
Niel Brandt, Penn State
Masao Sako, U Penn
Gordon Richards, Drexel
Ray Norris, CSIRO/Macquarie University
Susan Ridgway, NOAO
Jose Afonso, Lisbon
Robert Brunner, Illinois
Dave Clements, Imperial College
Asantha Cooray, UC Irvine
Giovanni Covone, Naples
Chris D'Andrea, Portsmouth
Mark Dickinson, NOAO
Harry Ferguson, STScI
Joshua Frieman, Fermilab
Ravi Gupta, U Penn
Evanthia Hatziminaoglou, ESO
Matt Jarvis, Oxford/Western Cape
Amy Kimball, CSIRO
Lori Lubin, UC Davis
Minnie Mao, NRAO
Lucia Marchetti, Open University
Jean-Christophe Mauduit, IPAC
Simona Mei, Obs Paris-Meudon
Jeffrey Newman, Pittsburgh
Robert Nichol, Portsmouth
Seb Oliver, Sussex
Ismael Perez-Fournon, IAC
Marguerite Pierre, CEA Saclay
Huub Rottgering, Leiden
Nick Seymour, CSIRO
Ian Smail, Durham
Jason Surace, IPAC
Paul Thorman, UC Davis
Mattia Vaccari, Western Cape
Aprajita Verma, Oxford
Gillian Wilson, UC Riverside
Michael Wood-Vasey, Pittsburgh
Rachel Cane, U Penn
Risa Wechsler, Stanford
Paul Martini, Ohio State
August Evrard, Michigan
Richard McMahon, Cambridge
Kirk Borne, George Mason University
Diego Capozzi, Portsmouth
Jiashang Huang, CfA, Harvard
Claudia Lagos, ESO
Chris Lidman, AAO
Claudia Maraston, Portsmouth
Janine Pforr, NOAO
Anna Sajina, Tufts
Rachel Somerville, Rutgers
Michael Strauss, Princeton University
Kristen Jones, University of Virginia
Wayne Barkhouse, North Dakota
Michael Cooper, UC Irvine
David Ballantyne, Georgia Tech
Preshanth Jagannathan, Calgary

Chris Lidman, Australian Astronomical Observatory
Eric Murphy, IPAC, Caltech
Isabella Pradoni, INAF
Nicholas Suntzeff, Texas A&M
Ricardo Covarrubias, Illinois
Lee Spitler, Macquarie University

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1400.0
Priority: 1

Abstract:
We propose a warm Spitzer survey to microJy depth of the four predefined Deep Drilling Fields (DDFs) for the Large Synoptic Survey Telescope (LSST) (three of which are also deep drilling fields for the Dark Energy Survey (DES)). Imaging these fields with warm Spitzer is a key component of the overall success of these projects, that address the "Physics of the Universe" theme of the Astro2010 decadal survey. With deep, accurate, near-infrared photometry from Spitzer in the DDFs, we will generate photometric redshift distributions to apply to the surveys as a whole. The DDFs are also the areas where the supernova searches of DES and LSST are concentrated, and deep Spitzer data is essential to obtain photometric redshifts, stellar masses and constraints on ages and metallicities for the >10000 supernova host galaxies these surveys will find. This "DEEPDRILL" survey will also address the "Cosmic Dawn" goal of Astro2010 through being deep enough to find all the >10^11 solar mass galaxies within the survey area out to z~6. DEEPDRILL will complete the final 24.4 square degrees of imaging in the DDFs, which, when added to the 14 square degrees already imaged to this depth, will map a volume of 1-Gpc^3 at z>2. It will find ~100 > 10^11 solar mass galaxies at z~5 and ~40 protoclusters at z>2, providing targets for JWST that can be found in no other way. The Spitzer data, in conjunction with the multiwavelength surveys in these fields, ranging from X-ray through far-infrared and cm-radio, will comprise a unique legacy dataset for studies of galaxy evolution.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13221

Spitzer observations of the field of the hyperluminous quasar HE0515-4414

Principal Investigator: Mark Lacy
Institution: NRAO

Technical Contact: Mark Lacy, NRAO

Co-Investigators:
Jason Surace, Caltech/Eureka Scientific
Kristina Nyland, NRAO
Brian Mason, NRAO
Barnaby Rowe, UCL
Sutechana Chatterjee, President's University
Graca Rocha, JPL
Amy Kimball, NRAO

Science Category: cosmology
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0

Abstract:
We have used unique, ultradeep ALMA 140GHz data to obtain a tentative first direct detection of a thermal quasar wind via the SZ effect. We are requesting Spitzer time to image the environment of the quasar. In particular, we will map the galaxy distribution in the vicinity of our tentative detection of the quasar wind to rule out any contribution to the SZ decrement due to an intracluster or intragroup medium associated with a compact cluster or group of galaxies around the quasar or along the line of sight. In addition, the data will be used to quantify the environment of one of the most luminous quasars known, as well as study the serendipitous ALMA sources in the field, the deepest ever at this frequency.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14246

Spizter observations of the MeerKAT-D2 deep radio field

Principal Investigator: Mark Lacy
Institution: NRAO

Technical Contact: Mark Lacy, NRAO

Co-Investigators:
Allison Matthews, Virginia
Jim Condon, NRAO
Bill Cotton, NRAO
Tom Jarrett, Cape Town
Tom Mauch, SKA SA,
Jason Surace, Caltech
Eric Murphy, NRAO
Fernando Carmilo, SKA SA

Science Category: High-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 75.6
Priority:2

Abstract:
Radio continuum surveys provide a unique insight into the evolution of star formation in the Universe since 'Cosmic Noon' at z~2, unbiased by dust absorption. Using the new MeerKAT telescope, a new radio deep field has been defined and observed deeper than any prior radio observation. We are requesting to use Spitzer to survey this 1 square degree field deeply enough to identify 98% of the radio sources. These identifications will be used to improve the deblending of the radio sources in the confusion-limited radio survey to obtain accurate radio source counts, and thus constrain models for the evolution of the cosmic star formation rate. Once we have obtained complementary ground-based optical photometry for use in conjunction with the Spitzer data, we will also be able to directly study the evolution of the global star formation rate density, the star-forming main sequence, and the fraction of star formation obscured by dust as a function of redshift and host galaxy mass.

Spitzer Space Telescope - General Observer Proposal #60024

SERVS: the Spitzer Extragalactic Representative Volume Survey

Principal Investigator: Mark Lacy
Institution: Spitzer Science Center

Technical Contact: Mark Lacy, Spitzer Science Center

Co-Investigators:
Duncan Farrah, University of Sussex
Matt Jarvis, University of Hertfordshire
Seb Oliver, University of Sussex
Alastair Edge, University of Durham
Alberto Franceschini, University of Padua
Andreea Petric, SSC
Angela Mortier, Royal Observatory Edinburgh
Antonio Cava, IAC
Aprajita Verma, University of Oxford
Anna Sajina, Haverford College
Carol Lonsdale, NRAO
Claudia Maraston, University of Portsmouth
Dave Alexander, University of Durham
David Bonfield, GSFC
Eduardo Gonzales, University of Cambridge
Eelco van Kampen, ESO
Eleanor Dyke, University of Hertfordshire
Evanthia Hatziminaoglou, ESO
Glen Parish, University of Hertfordshire
Harry Ferguson, STScI
Huub Rottgering, Leiden
Ian Smail, Durham
Ismael Perez-Fournon, IAC
James Dunlop, UBC
Jason Surace, SSC
Jim Geach, Durham
Jose Afonso, Lisbon
Katherine Romer, University of Sussex
Kevin Xu, IPAC
Mauguerite Pierre, CEA
Markos Trichas, Imperial
Masami Ouchi, OCIW
Mattia Vaccari, Padova
Michael Rowan-Robinson, Imperial
Nick Seymour, MSSL
Nieves Castro, IAC
Olivier LeFevre, Marseille
Peter Thomas, Sussex
Philip Best, Edinburgh
Rob Ivison, ROE
Ross McLure, ROE
Samantha Hickey, Hertfordshire
Scott Chapman, Cambridge
Sebastian Foucaud, Nottingham
Susan Ridgway, CTIO
Tony Readhead, Caltech

Science Category: high-z galaxies (z>0.5)
Observing Modes: IracPostCryoMap
Hours Approved: 1400.0

Abstract:
We will use warm Spitzer to image 18deg^2 of sky to microJy depth. This is deep enough to undertake a complete census of massive galaxies from z~6 to ~1 in a volume ~0.8Gpc^3, large enough to overcome the effects of cosmic variance, which place severe limitations on the conclusions that can be drawn from smaller fields. We will greatly enhance the diagnostic power of the Spitzer data by performing most of this survey in the region covered by the near-IR VISTA-VIDEO

survey, and in other areas covered by near-IR, Herschel and SCUBA2 surveys. We will build complete near-infrared spectral energy distributions using the superb datasets from VIDEO, in conjunction with our Spitzer data, to derive accurate photometric redshifts and the key properties of stellar mass and star formation rates for a large sample of high-z galaxies. Obscured star formation rates and dust-shrouded BH growth phases will be uncovered by combining the Spitzer data with the Herschel and SCUBA2 surveys. We will thus build a complete picture of the formation of massive galaxies from z~6, where only about 1% of the stars in massive galaxies have formed, to z~1 where ~50% of them have. Our large volume will allow us to also find examples of rare objects such as high-z quasars (~10-100 at z>6.5), high-z galaxy clusters (~20 at z>1.5 with dark halo masses >10^14 solar masses), and evaluate how quasar activity and galaxy environment affect star formation. This survey makes nearly optimal use of warm Spitzer; (a) all of the complementary data is either taken or will be taken in the very near future, and will be immediately publicly accessible, (b) the slew overheads are relatively small, (c) the observations are deep enough to detect high redshift galaxies but not so deep that source confusion reduces the effective survey area.

Data from this program was split into multiple PIDs.
You can find the data in program IDs 60024, 61050, 61051, 61052, 61053

Spitzer Space Telescope - General Observer Proposal #14016

Spitzer/IRAC Study of the Origin of the Stellar Streams in SPRC047

Principal Investigator: Seppo Laine
Institution: Caltech

Technical Contact: Seppo Laine, Caltech

Co-Investigators:
David Martinez-Delgado, Astronomisches Rechen-Institut, Zentrum fur Astron
Sanjaya Paude, KASI
Denis Erkal, University of Surrey

Science Category: interacting/merging galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0
Priority: 2

Abstract:
We propose to observe the spectacular great circle stellar stream around SPRC047, an edge-on galaxy at redshift 0.03. Our aim is to study the origin of the multiple stellar streams with stellar clumps (possibly multiple progenitors) using stellar population synthesis fits to combined Spitzer/IRAC 3.6 micron and existing visual images, together with numerical simulations. Specifically, we will study any differences in stellar populations in various segments of the stream that could tell us about the formation of the stellar stream through the disruption of the progenitor companion(s). We will also model the observations with numerical simulations to understand the formation mechanism of the loops better.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14206

Predicted Eddington Flare from Blazar OJ 287 and the First Observational Test of the Black Hole No-Hair Theorem

Principal Investigator: Seppo Laine
Institution: Caltech/IPAC

Technical Contact: Seppo Laine, Caltech/IPAC

Co-Investigators:
Mauri Valtonen, University of Turku
Staszek Zola, Jagiellonian University
Achamveedu Gopakumar, Tata Institute of Fundamental Research
Stefano Ciprini, Agenzia Spaziale Italiana
Harry Lehto, University of Turku
Lankeswar Dey, Tata Institute of Fundamental Research
Pauli Pihajoki, University of Helsinki
Rene Hudec, Academy of Sciences of Czech Republic Astronomical Inst
Mark Kidger, ESAC, ESA
Stefanie Komossa, MPIfR

Science Category: Compact Objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.4

Abstract:
We propose to validate the celebrated no-hair theorem of black hole (BH) physics at 10% level with Spitzer observations of OJ 287. The binary BH central engine model for OJ 287, authenticated by detailed observational campaigns and theoretical investigations, predicts an impact flare on July 31, 2019, in the optical and within a day in the near-IR. Frequent monitoring of the expected flare should allow us to test for the first time a celebrated relation that uniquely connects the dimensionless quadrupole moment of a BH to its Kerr parameter. Spitzer is the only telescope that can monitor the expected impact flare because the blazar is very close to the Sun as seen from the Earth in July-August 2019. We also propose earlier multi-epoch Spitzer observations of OJ 287 to obtain the baseline behavior of the light curve under non-outburst conditions. These observations would establish Spitzer as a pioneering observatory for testing general relativity on the first centenary of Eddington's famous 1919 eclipse expedition for a similar purpose.

Spitzer Space Telescope - General Observer Proposal #60088

Spitzer/IRAC Study of Stellar Streams Around Nearby Galaxies

Principal Investigator: Seppo Laine
Institution: Caltech

Technical Contact: Seppo Laine, Caltech

Co-Investigators:
Steven Majewski, U. Virginia
Carl Grillmair, Spitzer Science Center
Matthew Ashby, CfA/Harvard
David Martinez-Delgado, IAC, Spain
Richard Arendt, CRESST/UMBC/GSFC
R. Jay GaBany, Blackbird Observatory

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 23.1

Abstract:
Minor mergers and satellite accretion events have the ability to dramatically change the appearance of the parent galaxy and even cause substantial evolution from bulgeless galaxies toward early-type disk galaxies and ellipticals. They also presumably take place at a much higher frequency than the more spectacular major mergers. We propose to characterize the stellar populations of extragalactic tidal stellar streams with ultra-deep IRAC channel 1 observations. These observations take advantage of IRAC's unique capability to detect extended, faint surface brightness emission, and will push IRAC to new frontiers. We seek to observe two edge-on disk galaxies which have known visible light stellar streams, and determine the visible light - infrared colors of the streams. This will help us to determine the structural types and stellar masses of the disrupted companion galaxies, which has immediate significance on the understanding of bulge formation, halo build-up and numerous other important topics that have been proposed to occur with the help of minor mergers. We ask for a total of 23.1 hours of observing time with IRAC.

Spitzer Space Telescope - General Observer Proposal #60102

Two for the Show: Observing the Periastron Passages of HD 80606 b

Principal Investigator: Jonathan Langton
Institution: UCO/Lick Observatory; University of California, Santa Cruz

Technical Contact: Jonathan Langton, UCO/Lick Observatory; University of California, Santa Cruz

Co-Investigators:
Gregory Laughlin, UCO/Lick Obs
Drake Deming, NASA Goddard Space Flight Center
Nicolas Iro, NASA Goddard Space Flight Center
Daniel Kasen, UCO/Lick Observatory

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 84.3

Abstract:
In Cycle 4, we observed a periastron passage of the eccentric giant HD 80606 b in Spitzer's 8-micron IRAC band, obtaining evidence of rapid heating during periastron, as well as discovering that the planet undergoes secondary eclipse several hours prior to periastron. Here, we are proposing to follow up on this success with observations of two near-term periastron passages in the 4.5 micron band. These observations will yield a number of concrete benefits: 1.) Measurement of the baseline flux of the planet at 4.5 microns will improve the characterization of the pre-periastron luminosity of the planet, and will thereby clarify the role of tidal dissipation in heating the planet, which will in turn yield insight into the planetary structure. 2.) Measurements of the secondary transit depth at 4.5 microns will give insight into the bolometric temperature of the planet, providing important constraints on all hydrodynamical models of exoplanet atmospheres. 3.) Measurement of the heating rate at 4.5 microns prior to periastron will improve knowledge of the infrared radiative timescale, which forms an essential constraint on competing exoplanetary general circulation models under development. If one has heating rates at both 4.5 microns and 8 microns, then the bulk energetics of the planet's infrared photosphere are clearer than if one relies on a brightness temperature derived from a single frequency. 4.) The 8-micron observations did not extend long enough after the periastron passage to determine the cooling rate as the planet recedes from its primary. Our proposed observations will run well past periastron, which will allow a more accurate determination of the post-periastron cooling rate, again providing vital constraints on both hydrodynamical and radiative models of strongly irradiated exoplanetary atmospheres. To achieve these goals, we are requesting 40 hours of observation time for each of the two periastron passages that will occur in Cycle 6 -- a total of 80 hours of observation time.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13163

A Continued Census of Mid-IR Variability from ULXs

Principal Investigator: Ryan Lau
Institution: Caltech/JPL

Technical Contact: Ryan Lau, Caltech/JPL

Co-Investigators:
Mansi Kasliwal, Caltech
Marianne Heida, Caltech
Dom Walton, Cambridge

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.8

Abstract:
The nature of ultraluminous X-ray sources (ULXs) that radiate at luminosities >10^39 erg/s is still a mystery. ULXs are believed to be binaries with an accreting compact object and stellar mass-donor companion, but such high luminosities require accretion rates that are factors of ~100 greater than the Eddington limit for accretion onto a neutron star or stellar mass black hole. The difficulties in interpreting ULXs are largely attributed to current observational challenges in determining their orbital properties as well as the properties of the mass-donor companion. Recently, near- and mid-infrared (IR) observations have been demonstrated as powerful diagnostics of the mass-donor companion and the circumstellar environment of ULXs. For example, serendipitous Spitzer/IRAC observations of the ULX Holmberg II X-1 in our Spitzer Infrared Intensive Transients Survey (SPIRITS) revealed the first detection of mid-IR variability from a ULX, where we claimed that the mid-IR emission arises from a dusty circumbinary torus in the winds of a supergiant B[e] mass-donor companion. We identified 5 additional mid-IR ULX counterparts detected by Spitzer/IRAC, one of which shows significant variability like Holmberg II X-1. Although we are finding a growing sample of ULXs exhibiting mid-IR variability, it is unclear what causes it. Notably, the week - year cadence baselines of the SPIRITS observations are inadequate for resolving variability timescales consistent with several observed ULX orbital periods. In this proposal, we request time-series observations of 6 ULXs with cadence baselines ranging from 0.5 days to 1 week in order to identify the timescales associated mid-IR variability.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14270

Monitoring the Enigmatic Behavior of the Supernova Impostor 2010da a.k.a. NGC 300 ULX1

Principal Investigator: Ryan Lau
Institution: ISAS/JAXA

Technical Contact: Ryan Lau, ISAS/JAXA

Co-Investigators:
Marianne Heida, Caltech
Dom Walton, University of Cambridge
Mansi Kasliwal, Caltech
Jamie Kennea, Penn State University

Science Category: Compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.9
Priority: 1

Abstract:
Since its discovery, the behavior of the impostor supernova (SN) 2010da has continued to defy our understanding. Its dusty nature and variable IR behavior highlight the importance of continued IR monitoring with Spitzer/IRAC, and Spitzer is the only observatory sensitive enough to detected its mid-IR emission. SN2010da was discovered as a low-luminosity optical transient in the nearby galaxy NGC 300. After its outburst, SN2010da did not fade away but instead re-brightened at optical, infrared, and X-ray wavelengths to levels higher than its red and dusty progenitor. In addition to its strange transient behavior, recent X-ray studies revealed ultraluminous emission (LX >10^39 erg s-1) and a ~30-second pulsation period. SN2010da, now dubbed NGC 300 ULX-1, has become the fourth example of the new class of Ultraluminous X-ray Sources (ULXs) that host pulsars emitting far above their Eddington limit. X-ray non-detections of its progenitor suggest the intriguing hypothesis that the 2010 outburst triggered the onset of super-Eddington accretion and ULX emission. The enigmatic behavior of SN2010da/NGC 300 ULX1 presents a unique opportunity for us to understand the accretion and mass exchange/loss in binary systems linked to the formation of a ULX. In this Spitzer DDT proposal, we request a total of 2.9 hrs to perform 6 observations of NGC 300 ULX1 at a weekly cadence during its upcoming visibility window in late 2019 to decipher the nature of its mid-IR/X-ray variability with coordinated observations with Swift/XRT. This would be our final chance to monitor the enigmatic mid-IR behavior of this mysterious SN impostor-turned ULX.

Spitzer Space Telescope - General Observer Proposal #80094

Third Time’s the Charm: The Tidal Q, Heating and Spin of HD 80606b

Principal Investigator: Gregory Laughlin
Institution: University of California, Santa Cruz

Technical Contact: Gregory Laughlin, University of California, Santa Cruz

Co-Investigators:
Drake Deming, NASA Goddard Space Flight Center
Jonathan Langton, Principia College

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 50.0

Abstract:
We propose to obtain a 50-hour, 3.6-micron photometric time series of the highly eccentric HD 80606 planetary system during the planetary periastron passage which will occur on June 17th-19th 2012. The observations will commence 15 hours prior to periastron (12 hours prior to secondary eclipse), and will end 35 hours after periastron. These observations, in conjunction with the 4.5-micron and 8-micron time series that we obtained in GO-4 and GO-6, will allow us to (1) confirm the tidal heating rate in the planet, (2) measure the radiative time scale at the pressure depth of the planet’s 3.5-micron photosphere, and (3) directly measure the rotation rate of the planet. The HD 80606 system is the best example of a planet that owes it’s orbit to the process of Kozai migration with tidal friction. This process is now believed to have produced a substantial fraction of the short-period hot-Jupiter type planets that have been discovered over the past 15 years.

Spitzer Space Telescope - General Observer Proposal #80162

All-Sky Catalog of Massive Clusters from Planck

Principal Investigator: Charles Lawrence
Institution: JPL

Technical Contact: Charles Lawrence, JPL

Co-Investigators:
Nabila Aghanim, IAS, Orsay
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Simona Mei, IPAC
Etienne Pointecouteau, CESR, Toulouse
Adam Stanford, UC Davis
Edward Wright, UCLA
Francine Marleau, University of Toronto

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 52.2

Abstract:
The most massive galaxy clusters are a scarce and highly prized resource for cosmological and astrophysical studies. Being rare, they are best found in all-sky surveys, the most recent of which, the ROSAT All-Sky Survey (RASS), dates back to the early 1990s. The all-sky cluster survey from the Planck mission, currently underway, will push significantly deeper than the RASS, and find the most massive clusters across the whole sky. We propose IRAC observations to: 1)~validate high redshift candidates; 2)~provide key data for photometric redshifts of the high redshift clusters; and 3)~measure the stellar mass of the high redshift clusters. Spitzer's capability in these areas is unmatched.

Spitzer Space Telescope - General Observer Proposal #90233

All-Sky Catalog of the Most Massive Clusters from Planck

Principal Investigator: Charles Lawrence
Institution: JPL

Technical Contact: Charles Lawrence, JPL

Co-Investigators:
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James Bartlett, JPL
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Tom Jarrett, IPAC
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Adam Stanford, UC Davis
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Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 57.9

Abstract:
The most massive galaxy clusters are a scarce and highly prized resource for cosmological and astrophysical studies. Being rare, they are best found in all-sky surveys, the most recent of which, the ROSAT All?Sky Survey (RASS) dates back to the early 1990s. The all-sky cluster survey from the Planck mission pushes significantly deeper than the RASS, and finds the most massive clusters in the Universe. We propose IRAC observations to determine the stellar masses of the high-redshift clusters in this important sample that cannot be seen by WISE.

Spitzer Space Telescope - Directors Discretionary Time Proposal #545

Search for rings and satellites around the temperate exoplanet CoRoT-9b

Principal Investigator: Alain Lecavelier
Institution: IAP

Technical Contact: Guillaume Hebrard, IAP

Co-Investigators:
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Jean-Michel Desert, CFA
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Hans Deeg, IAC
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Alfred Vidal-Madjar, IAP

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 29.0

Abstract:
The detection of the transiting extrasolar planet CoRoT-9b has just been reported (Deeg et al. 2010). With a semi-major axis of 0.41 astronomical unit on a quasi-circular orbit, this is the first transiting planet far enough from its parent star to have an extended Hill sphere (3.5 million kilometers in radius), as needed to form and sustain rings and satellites. Here we propose to observe a full transit of CoRoT-9b in front of its parent star to significantly improve the accuracy on the transit light curve as provided by the CoRoT satellite and to probe the nearby environment of the planet. Up to 2014, there will be only two opportunities to observe a transit of CoRoT-9b with Spitzer: the first one in June 2010, and the second will not happen before July 2011. Those rare events should not be missed. Here we propose Director Discretionary Time observations to observe the transit of June 2010, 17th. The primary aim of these observations will be the search for rings and satellites. The Spitzer/IRAC light curve will also allow the search for Transit Timing Variations (TTV) and Transit Duration Variations (TDV) potentially due to additional bodies in this planetary system, as well as a significant refinement of the system parameters, together with the photometric and spectroscopic ground-based campaign that we will simultaneously conduct in June 2010.

Spitzer Space Telescope - General Observer Proposal #12027

Dust evolution in L134

Principal Investigator: Charlene Lefevre
Institution: Observatoire de Paris

Technical Contact: Charlene Lefevre, Observatoire de Paris

Co-Investigators:
Laurent Pagani, Observatoire de Paris
Roberta Paladini, IPAC
Mika Juvela, University of Helsinki

Science Category: ISM
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5.2
Priority: 2

Abstract:
The recently discovered coreshine phenomenon corresponds to the high mid-infrared surface brightness that is observed exclusively in the densest parts of molecular clouds. It is caused by enhanced scattering and is a direct indicator of a significant growth of dust grains. Three-dimensional radiative transfer modelling aims at reproducing coreshine observations. Observations at 3.6 and 4.5 um give us access to the composition of the grains, to their shape (compact vs. porous) and to the spatial evolution of dust inside clouds. The modelling modeling of the L183 cloud has shown that dust scattering must remain efficient to even longer wavelengths, up to 8 µm. Compact spherical grains, even micrometer-size grains, are not able to explain observations beyond 5 µm. Spitzer observations are reproduced only by including large aggregates whose abundance increases towards the central core.For dust in emission, our results suggest a correlation between temperature and spectral emissivity index, with values that are only expected in later stages, i.e. in protoplanetary disks. L134 is another isolated high Galactic latitude cloud. It is located in the vicinity of L183 and the comparison of coreshine signal in Spitzer IRAC1 and IRAC2 bands will reveal the differences of grain properties between these two clouds possibly linked to a different evolution. Comparing clouds in similar environmental conditions is the best way to limit the influence of other parameters like the background sky brightness or the illumination of the clouds. It will give an opportunity to confirm aggregates as the sole source of scattering efficient enough to explain the extended mid-infrared emission. Because aggregates are one to two orders of magnitude more emissive than standard grains, the results can have a profound impact on dust modeling also at longer wavelengths.

Spitzer Space Telescope - General Observer Proposal #60093

3 - 5 micron Photometry of 500 - 800 K Brown Dwarfs

Principal Investigator: Sandy Leggett
Institution: Gemini Observatory

Technical Contact: Sandy Leggett, Gemini Observatory

Co-Investigators:
Loic Albert, Canada France Hawaii Telescope
Etienne Artigau, Gemini Observatory
Ben Burningham, Hertfordshire University
Xavier Delfosse, Grenoble Observatory
Philippe Delorme, St Andrews University
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Nicolas Lodieu, Inst. Astr. Canarias
Phil Lucas, Herftordshire University
Mark Marley, NASA-Ames
David Pinfield, Herfordshire University
Celine Reyle, Besancon Observatory
Didier Saumon, Los Alamos National Lab
Steve Warren, Imperial College London

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.1

Abstract:
We request 9.1hrs to obtain IRAC photometry of 11 cold brown dwarfs. The observations will complete the dataset of near-infrared spectroscopy and 1-5um photometry, for known brown dwarfs with spectral types >T7, and temperatures of 500K to 800K. These rare very late- type T dwarfs are the coolest objects known outside of the solar system. For these the [3.6] band samples a low-flux region of strong CH4 absorption, and the [4.5] band a bright region subject to absorption by dredged-up CO. The [4.5] flux becomes increasingly dominant at low temperatures, and is the best temperature indicator for the latest T dwarfs, for which the near- infrared features are saturated. Combining accurate IRAC photometry with our near-infrared data, and models, will allow us to constrain temperature, metallicity and gravity, as well as vertical mixing in the atmospheres of our targets. Now that objects as cool as ~500K are being found it is vital that we understand their behaviour in the mid-infrared, especially in the WISE era, when the red [3.6]-[4.5] color will be used to find even more extreme objects.

Spitzer Space Telescope - General Observer Proposal #70058

IRAC Photometry of 400-800K Brown Dwarfs

Principal Investigator: Sandy Leggett
Institution: Gemini Observatory

Technical Contact: Sandy Leggett, Gemini Observatory

Co-Investigators:
Steve Warren, Imperial College London
Phil Lucas, University of Hertfordshire UK
Ben Burningham, University of Hertfordshire UK
David Pinfield, University of Hertfordshire UK
Mark Marley, NASA Ames
Didier Saumon, Los Alamos National Lab

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.9

Abstract:
Spitzer data, including warm-IRAC [3.6] and [4.5] photometry, is critical for understanding the cold population of brown dwarfs now being found, objects which have more in common with planets than stars. As effective temperature drops from 800K to 400K, the fraction of flux emitted beyond 3um increases rapidly, from about 40% to >75%. This rapid increase makes a color like H-[4.5] a very sensitive temperature indicator, and it can be combined with a gravity- and metallicity-sensitive color like H-K to constrain all three of these fundamental properties, which in turn gives us mass and age for these, generally isolated, slowly cooling objects. Our goal is to accurately characterise the temperature/ gravity/ metallicity distribution of the coolest brown dwarfs being found in the UKIRT Infrared Deep Sky Survey, which is only possible if Spitzer photometry is available to complement our near- infrared data. At the same time we will define color trends which will allow better exploitation of the WISE mission by the community. We expect to find and spectroscopically confirm several new 400 - 800K brown dwarfs during Cycle 7, and possibly even cooler nearby objects (based on our recent discovery of a 400K object at a distance of only 3pc). Extrapolating from our current sample, we expect to trigger around eleven low-impact ToO observations during Cycle 7, totalling 9.9 hours of AORs.

Spitzer Space Telescope - General Observer Proposal #80077

IRAC Photometry of 400-800K Brown Dwarfs

Principal Investigator: Sandy Leggett
Institution: Gemini Observatory

Technical Contact: Sandy Leggett, Gemini Observatory

Co-Investigators:
Ben Burningham, University Hertfordshire UK
Nicolas Lodieu, IAC Tenerife Spain
Phil Lucas, University of Hertfordshire UK
Mark Marley, NASA Ames
David Pinfield, University of Hertfordshire UK
Didier Saumon, Los Alamos National Laboratory
Steve Warren, Imperial College London

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 9.9

Abstract:
Warm IRAC [3.6] and [4.5] photometry is critical for understanding the cold population of brown dwarfs now being found, objects which have more in common with planets than stars. As effective temperature drops from 800K to 400K, the fraction of flux emitted beyond 3um increases rapidly, from about 40% to >75%. This rapid increase makes a color like H-[4.5] a very sensitive temperature indicator, and it can be combined with a gravity and metallicity sensitive color like H-K to constrain all three of these fundamental properties - temperature, gravity and metallicity - which in turn gives us mass and age for these, generally isolated, slowly cooling objects. Our goal is to accurately characterise the temperature/ gravity/ metallicity distribution of the coolest brown dwarfs being found in the UKIRT Infrared Deep Sky Survey (UKIDSS) and the Visible and Infrared Survey Telescope for Astronomy (VISTA), which is only possible if IRAC photometry is available to complement our near-infrared data. While data at similar wavelengths will be provided by WISE for a sample of brown dwarfs, there are large differences between the photometric systems, which will be dependent on metallicity, gravity and the degree of turbulent mixing. Hence to fully exploit the sample of cold T dwarfs found by the near- and mid-infrared sky surveys, and to provide a homogeneous dataset for all ultracool dwarfs, a large number of sources must be observed in both the IRAC and WISE filter sets. Furthermore, different populations will be identified by the different surveys, and the number of cold brown dwarfs will be small, hence IRAC follow- up of UKIDSS, VISTA and WISE brown dwarfs is extremely valuable. The Cycle 8 time will increase the number of 400-600K near-infrared-selected brown dwarf (a sample with mass 5-20 M_Jupiter) that have IRAC data to ~25, a significant increase of ~50%. We expect to trigger eleven low impact ToO observations during Cycle 8, totalling 9.9 hours of AORs.

Spitzer Space Telescope - General Observer Proposal #10089

A last look at the relativistic tidal disruption Swift J1644+57

Principal Investigator: Andrew Levan
Institution: University of Warwick

Technical Contact: Andrew Levan, University of Warwick

Co-Investigators:
Nial Tanvir, University of Leicester

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4
Priority: 1

Abstract:
The discovery of a population of tidal disruption flares (stars torn apart by the tidal field of a supermassive black hole) offers new insight into accretion onto supermassive objects, high energy particle acceleration and the ubiquity of black holes in low mass galaxies. We have conducted a comprehensive observing campaign targetted at the best studied of these events (Swift J1644+57) utilzing many of the worlds premier observatories including HST, Spitzer, Swift, Chandra, XMM-Newton and others, and have mapped the outburst from start to finish. Here we request a final, short (0.4 hour) observation with Spitzer. This will allow us to subtract the host galaxy contribution from our earlier observations and ascertain the accurate late time shape of the optical/IR lightcurve. It will also provide the strongest possible constraints on the stellar and black hole mass in the host galaxy.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14317

Do collapsars create the heaviest elements?

Principal Investigator: Andrew Levan
Institution: Radboud University Nijmegen

Technical Contact: Andrew Levan

Co-Investigators:
Nial Tanvir, University of Leicester
Andrew Fruchter, Space Telescope Science Institute
Gavin Lamb, University of Leicester
Jens Hjorth, Dark Cosmology Centrer
Daniele Malesani, DTU Space
Kasper Heintz, University of Iceland
Daniel Perley, Liverpool John Moores University
Johan Fynbo, DAWN centre/NBI Copenhagen
Klaas Wiersema, University of Warwick
Jan Bolmer, ESO
Elena Pian, INAF Bologna
Steve Schulze, Weizmann
Luca Izzo, Dark Cosmology Centre

Science Category: GRBs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.5
Priority: 1

Abstract:
The origin of half of the elements heavier than iron- the so-called r-process elements including gold and uranium, is a central unsolved mystery in astrophysics. Recent observations utilising light and gravitational waves have demonstrated that at least some of these elements are formed through the merger of two neutron stars, but such a population struggles to reproduce the enrichment seen early in the lives of some of the oldest, lowest metallicity stars. Instead, recent work implies that the accretion discs formed in the stellar collapse that powers a long duration gamma-ray burst could in-fact be a dominant site. The signature of their creation is a late time infrared component visible on top of the associated supernova light. The extreme opacities of some elements mean this could peak in the mid-IR, and it is at these wavelengths that the contrast between a cool r-process dominated component and a hotter, "normal" supernova is at its largest. We propose to search for this component with Spitzer observations of the recently detected, local (z=0.08) long GRB 190829A (supported by approved optical/nIR observations with the VLT and HST). These observations provide the first and only opportunity for Spitzer to test if collapsars create very heavy elements.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80234

Search for a supernova in a GRB at 55 Mpc

Principal Investigator: Andrew Levan
Institution: University of Warwick

Technical Contact: Andrew Levan, Warwick

Co-Investigators:
Jens Hjorth, Dark Cosmology Centre, Copenhagen
Daniele Malesani, Dark Cosmology Centre, Copenhagen
Nial Tanvir, University of Leicester
Klaas Wiersema, University of Leicester
Johan Fynbo, Dark Cosmology Centre, Copenhagen

Science Category: GRBs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.3

Abstract:
We seek a rapid response target of opportunity observation of the recent GRB 111005A, which was detected by Swift last week. The burst is essentially invisible to most ground and space based optical/IR observations because it lies only 35 degrees from the Sun (as viewed from Earth). However, its gamma-ray error box contains the bright low redshift galaxy ESO 580-49, at only ~55 Mpc distance. Short integration (twilight) K-band observations do not show any sign of the burst in the optical/IR in the night after it occurred, perhaps because of extinction, or possibly because observations were too early to catch the associated supernova (SN). However, radio observations today (10 Oct) do locate a transient source within the galaxy, presumably the GRB afterglow. This makes GRB 1110005A the closest Swift-GRB by some margin, and the second closest of all time. Such bursts provide a Rosetta Stone for our understanding of the GRB phenomena, since their proximity allows exquisite data to be obtained, and for late time observations to fully characterise the nature of the stellar population. Unlike other observatories, Spitzer can observe GRB 111005A until the end of the 14th October, providing an opportunity to search for an associated SN at optical and IR wavelengths, and even probe through the dust that may be present in the host galaxy. This is a unique opportunity, and a role that only Spitzer can perform.

Spitzer Space Telescope - General Observer Proposal #10103

Exoplanet Atmospheres in High Definition: 3D Eclipse Mapping of HD 209458b and HD 189733b

Principal Investigator: Nikole Lewis
Institution: Massachusetts Institute of Technology

Technical Contact: Nikole Lewis, Massachusetts Institute of Technology

Co-Investigators:
Nicolas Cowan, Northwestern
Heather Knutson, California Institute of Technology
Julien de Wit, MIT
Sara Seager, MIT
Brice-Olivier Demory, MIT
Jonathan Fortney, University of California, Santa Cruz
Adam Showman, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 150.0
Priority: 1

Abstract:
Eclipse mapping is a newly developed technique in the arsenal of observational methods aimed at the characterization of exoplanet atmospheres. This technique was first applied to HD189733b using multiple 8 micron secondary eclipse observations to create a high-resolution snapshot of the dayside of the planet. The eclipse map of HD189733b at 8 microns was able to resolve the dayside brightness distribution of the planet both in latitude and longitude giving key insights into the atmospheric circulation of HD189733b. Here we propose to use this eclipse mapping technique to produce dayside brightness maps of the benchmark exoplanets HD189733b and HD209458b at both 3.6 and 4.5 microns. By combining brightness maps at multiple wavelengths, we will create the first three-dimensional maps of an exoplanet atmosphere (latitude, longitude, and pressure). HD209458 and HD189733 are among the brightest (Ks~6) planet harboring system and represent our best opportunity to achieve a high signal-to-noise eclipse maps. Comparisons between the brightness maps of these two planets will highlight key differences in the atmospheric circulation patterns of planets with (HD209458b) and without (HD189733b) thermal inversions in their dayside atmospheres. The atmospheres of HD189733b and HD209458b have been previously probed at wavelengths from the infrared to the ultraviolet through transit, eclipse, and phase-curve observations. With the addition of the three-dimensional eclipse maps proposed here, we will answer many of the outstanding questions about the basic radiative, chemical, and advective processes at work in these key planetary atmospheres. The observations proposed here will allow us to make the first direct comparisons of the observed thermal structure of an exoplanet with the plethora of three-dimensional atmospheric circulation models developed specifically for HD189733b and HD209458b, thus both informing the models and gaining new insights into the complex circulation patterns of exoplanet atmospheres.

Spitzer Space Telescope - Directors Discretionary Time Proposal #11185

Understanding Eccentric Behavior in the HAT-P-2 System: Orbital Evolution and Stellar Heartbeats

Principal Investigator: Nikole Lewis
Institution: STScI

Technical Contact: Nikole Lewis, STScI

Co-Investigators:
Julien de Wit, MIT
Heather Knutson, CalTech
Drake Deming, U of Maryland

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 36.0

Abstract:
The HAT-P-2 system has been the target of a number of observing campaigns aimed at understanding the short-period transiting exoplanet HAT-P-2b whose orbit is highly eccentric. Spitzer observations that aimed to map the dayside thermal distribution of this planet at 4.5 microns, instead revealed the presence of stellar oscillations and a rapid evolution of HAT-P-2b's orbit, which are not predicted by current theories. Here we request 36 hours of Spitzer time to observe two additional eclipses and transits of HAT-P-2b before the current observing window closes. These eclipse and transit observations will allow us to differentiate between different modes for HAT-P-2b's orbital evolution that are likely strongly linked to the amplitude and frequency of the observed stellar 'heartbeats'. Recent radial velocity observations have revealed new complex behaviors in the orbital evolution of the HAT-P-2 system. Only transit and eclipse measurements taken in the current observing window for HAT-P-2 will allow us to disentangle the effects of the HAT-P-2b's and HAT-P-2c's orbital evolution in the currently observed trends. The requested observations will also allow us to rapidly address referee concerns with our submitted manuscript which details our analysis of the currently available Spitzer data for the HAT-P-2 system. Once published, the stellar pulsations seen in HAT-P-2A will represent the smallest amplitude signal ever detected by Spitzer, which will serve as a shining example of the current capabilities of the Spitzer Space Telescope.

Spitzer Space Telescope - General Observer Proposal #60059

Are the brightest Lyman Alpha Emitters at z=5.7 primeval galaxies?

Principal Investigator: Christopher Lidman
Institution: European Southern Observatory

Technical Contact: Christopher Lidman, European Southern Observatory

Co-Investigators:
Heath Jones, Anglo-Australian Observatory
Eduard Westra, Harvard-CfA
Christian Tapken, Max Planck Institute for Astronomy
Matthew Hayes, Geneva Observatory
Klaus Meisenheimer, Max Planck Institute for Astronomy

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 11.2

Abstract:
Wide-field, narrow-band surveys have proven to be effective at finding very high redshift galaxies that emit brightly in the Lyman alpha line - the so-called Lyman alpha emitters (LAEs). It was through this technique that the most distant spectroscopically confirmed galaxy, a galaxy at z=6.96 (Iye et al. 2006), was discovered. Considerable effort is currently being spent on discovering these galaxies at ever higher redshifts by extending this technique into the near-IR. In contrast to this effort, there has been relatively little work on understanding these galaxies. In particular, how do LAEs relate to other high redshift galaxies, such as those discovered through drop out techniques, and, more importantly, what role LAEs play in re-ionising the universe, if any. We recently discovered two extremely luminous LAEs at z=5.7. These LAEs are among the brightest LAEs ever discovered at this redshift. In a recent paper by Mao et al. (2007), the brightest LAEs are associated to the most massive halos. One of these targets was successfully observed with the IRAC 3.6 micron imager on Spitzer during cycle 5. These data, when combined with constraints that we derive from our deep ground-based spectroscopic data, indicate that the bulk of the flux at 3.6 microns comes from a stellar population that is considserably older than the stars that dominate the flux in the UV. We propose to complete the project and image the second target. These data will enable us to estimate the age and mass of the stellar burst that produces the Lyman alpha line, to estimate the contribution from an older stellar population and to estimate the fraction of Lyman continuum photons that escape the galaxy and are thus available to re-ionise the universe.

Spitzer Space Telescope - General Observer Proposal #12068

Infrared Colors of Dwarf-Dwarf Galaxy Interactions

Principal Investigator: Sandra Liss
Institution: University of Virginia

Technical Contact: Sandra Liss, University of Virginia

Co-Investigators:
Sabrina Stierwalt, University of Virginia
Kelsey Johnson, University of Virginia
Dave Patton, Trent University
Nitya Kallivayalil, University of Virginia

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18
Priority: 2

Abstract:
We request Spitzer Warm Mission IRAC Channel 1 & 2 imaging for a sample of 60 isolated dwarf galaxy pairs as a key component of a larger, multi-wavelength effort to understand the role low-mass mergers play in galaxy evolution. A systematic study of dwarf-dwarf mergers has never been done, and we wish to characterize the impact such interactions have on fueling star formation in the nearby universe. The Spitzer imaging proposed here will allow us to determine the extent to which the 3.6 and 4.5 $\\mu$m bands are dominated by stellar light and investigate a) the extent to which interacting pairs show IR excess and b) whether the excess is related to the pair separation. Second, we will use this IR photometry to constrain the processes contributing to the observed color excess and scatter in each system. We will take advantage of the wealth of observations available in the Spitzer Heritage Archive for "normal" non-interacting dwarfs by comparing the stellar populations of those dwarfs with the likely interacting dwarfs in our sample. Ultimately, we can combine the Spitzer imaging proposed here with our current, ongoing efforts to obtain groundbased optical photometry to model the star formation histories of these dwarfs and to help constrain the timescales and impact dwarf-dwarf mergers have on fueling star formation. The sensitivity and resolution offered by Spitzer are necessary to determine the dust properties of these interacting systems, and how these properties vary as a function of pair separation, mass ratio, and gas fraction.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80256

IRAC View of a Late Heavy Comet Bombardment in the eta Corvi System

Principal Investigator: Carey Lisse
Institution: Johns Hopkins University

Technical Contact: Sean Carey, SSC

Co-Investigators:
Sean Carey, SSC
Massimo Marengo, Iowa State University
Karl Stapelfeldt, NASA/GSFC
Thayne Currie, NASA/GSFC

Science Category: debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.7

Abstract:
The nearby sun-like star eta Corvi (F2V, d=18 pc, age =1.2 Gyr) has long been known to possess a bright, dusty Kuiper Belt that has now been resolved with Herschel. A warm inner dust belt was indicated by an IRAS 12 micron excess and has recently been resolved as a 3-AU scale structure. In 2011 we further characterized this warm dust using Spitzer IRS, identifying the signatures of ice, organics and silicate dust in this system's Terrestrial Habitability Zone (THZ). The system appears to be undergoing a Late Heavy Bombardment (LHB), delivering primitive, water- and organic-rich material from the Kuiper Belt to the THZ, at roughly the same relative age as the solar system's LHB. Our data also showed an upturn in the excess flux shortwards of 6 um - evidence for a surprisingly large amount of icy dust scattering in the inner system (Lscat/Lstar ~ 1.0%). We have tentatively verified this IRS result using 2-5 um NASA/IRTF SPeX spectroscopy, but its absolute calibration is still in question. We propose a short series of Warm Spitzer IRAC 3.6 and 4.5 um observations of the system to (1) photometrically verify the presence of this icy scattered light excess in the unresolved stellar source, (2) image the region as close as 50 AU from the star to search for any scattered light from icy dust, and (3) search for a planetary object at 100 - 1000 AU whose perturbations to the system's Kuiper Belt could be the cause of its high level of inner warm dust.

Spitzer Space Telescope - Directors Discretionary Time Proposal #90261

Warm Spitzer Characterization of Comet C/2012 S1 (ISON)

Principal Investigator: Carey Lisse
Institution: Johns Hopkins University

Technical Contact: Carey Lisse, JHU

Co-Investigators:
James Bauer, JPL
Yan Fernandez, University of Central Florida
Michael Kelley, University of Maryland
Matthew Knight, Lowell Observatory
Jian-Yang Li, Planetary Science Institute
Karen Meech, University of Hawaii
William Reach, SOFIA
Michael Sitko, University of Cincinnati

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.0

Abstract:
We propose Warm Spitzer photometric imaging DDT observations of Comet ISON, as part of a worldwide observing campaign led by NASA of the comet. Warm Spitzer's 3 and 4 um near-IR passbands will provide unique scattering and emissivity information for the comet's nucleus and dust, and allow us to detect CO_2 gas emission from the comet. Spitzer holds a unique place in the solar system to observe the comet, right before it enters the region of rapid water ice sublimation after spending millions of years in the deep freeze of the Oort Cloud. It is likely the comet will undergo a rapid outburst soon after the time of the proposed observations in the week of June 7 - 14, 2013, and understanding its baseline behavior is critical to understanding the evolution of its activity, as is Spitzer's unique ability to detect CO_2 sublimation and outgassing activity from ISON. As for our previous Spitzer observations of comets Tempel 1 and Hartley 2, we will bootstrap from HST DDT imaging lightcurve and spectroscopic measurements taken over in April - May 2013. The combination of the two datasets will place strong constraints on the comet's coma morphology, and thus its pattern of outgassing jets and the rotation state of the nucleus, and the amount and kind of dust and gas emitted by the comet.

Spitzer Space Telescope - Snapshot Proposal #11013

Environments of radio-midinfrared selected ultraluminous AGN

Principal Investigator: Carol Lonsdale
Institution: National Radio Astronomy Observatory (NRAO)

Technical Contact: Carol Lonsdale, National Radio Astronomy Observatory (NRAO)

Co-Investigators:
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Carrie Bridge, Caltech
Jim Condon, NRAO
Peter Eisenhardt, JPL
Nina Hatch, University of Nottingham
Suzy Jones, University of Leicester
Minjin Kim, KISA
Amy Kimball, CSIRO Astrophysics & Space Science (CASS)
Mark Lacy, NRAO
Colin Lonsdale, MIT Haystack
Dan Stern, JPL
Mark Whittle, University of Virginia
Dominika Wylezalek, Johns Hopkins University

Science Category: high-z galaxies (z>0.5)
Hours Approved: 17.2
Priority: 2

Abstract:
Powerful AGN are known to be found in overdense environments at high-redshifts. A joint selection using WISE mid-IR and NVSS radio detections of galaxies over most of the sky has highlighted a new very luminous population of about 150 powerful, physically-compact AGN, which might involve the most powerful feedback processes taking place at any epoch. We propose to probe the environments the 33 examples which have spectroscopically confirmed redshifts z>1.3, to allow Spitzer-based color selection of companions over the 5.2-arcmin wide IRAC field. All have new JVLA radio imaging, all but three have ALMA photometry, 25 have VLBA resolution radio images. From SCUBA2 submillimeter imaging observations of about 50 of these galaxies, including 3 in this proposal, we know that the density of ultraluminous dusty companions in 3-arcmin fields around these AGN is unprecedentedly large: up to a factor of 6 in excess of field surveys, the largest overdensity seen for any population of high-redshift galaxies. We propose to exploit the same techniques pioneered by the CARLA program to probe the spatial distribution and stellar populations of high-redshift galaxies in the environments of our AGN. We will determine whether the dramatic overdensity of ultraluminous galaxies around these AGN is matched in more normal sub-L* objects probed by Spitzer, determine the relationship between the modelled stellar populations in our targets and companions, and the AGN/ environmental properties, and provide accurate positions for spectroscopic investigation using new multi-object spectrographs. The 2.5-Mpc regions probed by Spitzer at z>1.3 are ideal to encompass the protocluster in which the AGNs reside, and to understand their evolution and the relationship with their environments.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80259

An Extreme Variable in the Galactic Plane

Principal Investigator: Philip Lucas
Institution: University of Hertfordshire

Technical Contact: Philip Lucas, U. Hertfordshire

Co-Investigators:
Dante Â Minniti, Universidad Catolica, Chile
Valentin Ivanov, ESO
Nicolas Cross, University of Edinburgh
Istvan Dekany, Universidad Catolica, Chile
Radostin Kurtev, University of Valparaiso
Carlos Contreras, University of Hertfordshire
Nicola Masseti, IAS Bologna

Science Category: massive stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.2

Abstract:
Minniti et al.(2012, ATel 4041) reported the discovery of WIT-01, an extreme transient in the infrared VVV survey of the Milky Way. Ks images were acquired from March 2010 to March 2012. The mean magnitude in March 2010 was Ks=12.3 but in July 2010 it was Ks=16.7. The object faded from view (Ks>18.85) by early 2011. It was very red (H-Ks=5.0 mag) and invisible at shorter wavelengths (ZY>20.5, J>19.5). The source was not present in 2MASS, DENIS, GLIMPSE and MSX surveys, but the March 2010 WISE photometry shows a very bright source at its position. This object could be a very reddened (Av>80 mag) Supernova in the Galactic disk or an eruptive Pre-Main Sequence star, although other alternatives (a reddened LBV, a Nova, or even a new kind of variable star) cannot be discarded. Since the SED peaked at 4.6 microns in 2010, Spitzer/IRAC imaging at 4.5 microns offers the best chance to detect it, or else to show that it has faded by >12 mag, as would be expected for a Supernova. We therefore request a short Spitzer DDT pointing to observe this object, in order to try to determine its nature and enable us to plan long term multiwaveband follow up.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10168

Characterizing Our 4th Closest Neighbor and the Coldest Known Brown Dwarf

Principal Investigator: Kevin Luhman
Institution: Penn State University

Technical Contact: Kevin Luhman, Penn State University

Co-Investigators:
Taran Esplin, Penn State University

Science Category: brown dwarfs/low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.2

Abstract:
We have conducted a search for high proper motion brown dwarfs using multi-epoch all-sky mid-infrared images from the WISE satellite. Through this work, we have discovered an object with a parallactic distance of 2.2 pc and a temperature of 250 K, making it the 4th closest neighbor of the Sun, and the coldest known brown dwarf. Because of its extreme proximity and temperature, it represents an unparallaled laboratory for studying planet-like atmospheres in an unexplored temperature regime. We propose to use IRAC on Spitzer to 1) improve the accuracy of the parallax measurement, and thus better constrain its absolute magnitudes and temperature, 2) search for widely separated companions to this object, which would have even colder temperatures.

Spitzer Space Telescope - General Observer Proposal #11056

Characterizing Water Ice Clouds on the Coldest Known Brown Dwarf

Principal Investigator: Kevin Luhman
Institution: Pennsylvania State University

Technical Contact: Kevin Luhman, Pennsylvania State University

Co-Investigators:
Adam Burgasser, UCSD
Michael Cushing, University of Toledo
Taran Esplin, Penn State University
Jonathan Fortney, UCSC
Kevin Hardegree-Ullman, University of Toledo
Mark Marley, NASA Ames
Caroline Morley, UCSC
Adam Schneider, University of Toledo
Jesica Trucks, University of Toledo

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 47.0
Priority: 1

Abstract:
We have conducted a search for high proper motion brown dwarfs using multi-epoch all-sky mid-infrared images from the WISE satellite. Through this work, we have discovered an object with a parallactic distance of 2.3 pc and a temperature of 250 K, making it the 4th closest neighbor of the Sun, and the coldest known brown dwarf. Because of its extreme proximity and temperature, it represents an unparalleled laboratory for studying planet-like atmospheres in an unexplored temperature regime. We propose to photometrically monitor this object with IRAC to 1) detect and characterize water ice clouds in its atmosphere via the short-term variations induced during rotation and 2) constrain the long-term evolution of its clouds across a period of months.

Spitzer Space Telescope - General Observer Proposal #60046

A Survey for Wide Substellar Companions in the Solar Neighborhood

Principal Investigator: Kevin Luhman
Institution: Pennsylvania State University

Technical Contact: Kevin Luhman, Pennsylvania State University

Co-Investigators:
John Stauffer, Spitzer Science Center
Giovanni Fazio, Smithsonian Astrophysical Observatory
Joseph Hora, Smithsonian Astrophysical Observatory

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 37.8

Abstract:
We propose to obtain IRAC images of 328 stars, brown dwarfs, and white dwarfs in the solar neighborhood that have been observed previously with IRAC. By combining the data at these two epochs, we will search for wide (>100 AU) substellar companions through their common proper motions with the primaries. The detection limits will reach up to 100 times fainter than the faintest known T dwarfs. These observations will comprise the deepest survey for wide companions to nearby stars that is possible with any current or planned telescope, providing the best available opportunity for finding brown dwarfs cooler than known T dwarfs, such as the as-of-yet-undiscovered Y dwarfs.

Spitzer Space Telescope - Snapshot Proposal #70021

A Survey for Wide Substellar Companions in the Solar Neighborhood

Principal Investigator: Kevin Luhman
Institution: Pennsylvania State University

Technical Contact: Kevin Luhman, Pennsylvania State University

Co-Investigators:
John Stauffer, Spitzer Science Center
Giovanni Fazio, Smithsonian Astrophysical Observatory
Joseph Hora, Smithsonian Astrophysical Observatory

Science Category: brown dwarfs/very low mass stars
Hours Approved: 6.8

Abstract:
We propose to obtain IRAC images of 58 stars, brown dwarfs, and white dwarfs in the solar neighborhood that have been observed previously with IRAC. By combining the data at the two epochs, we will search for wide (>100 AU) substellar companions through their common proper motions with the primaries. The detection limits will reach up to 100 times fainter than the faintest known T dwarfs. These observations (combined with our previous GO programs) will comprise the deepest survey for wide companions to nearby stars that is possible with any current or planned telescope, providing the best available opportunity for finding brown dwarfs cooler than known T dwarfs, such as the as-of-yet-undiscovered Y dwarfs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #70203

Confirmation of a Candidate for the Coolest Known Brown Dwarf

Principal Investigator: Kevin Luhman
Institution: Penn State University

Technical Contact: Kevin Luhman, PSU

Co-Investigators:
Addam Burgasser, UC San Diego
John Bochanski, Penn State University

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
We have used multi-epoch Spitzer/IRAC images to search for substellar companions to several hundred nearby stars based on their common proper motions. Through this work, we have identified a very promising candidate that could be the coldest and faintest known brown dwarf by a fairly large margin, and thus may inhabit a new spectral class (tentatively dubbed the Y class). Given the low value of our mass estimate (10-15 M_Jup), this object could also be a giant planet that formed in a disk and was scattered to a larger orbit. To verify the cool nature of this candidate, we propose to obtain photometry at 3.6um and combine it with the existing data at 4.5um to measure the 3.6-4.5um color, which should be very red if methane absorption is present at 3.6um. If confirmed as the coolest known brown dwarf, this companion will represent a valuable laboratory for studying atmospheres in a new temperature regime, and its colors will help to guide searches for the coolest brown dwarfs with facilities like WISE.

Spitzer Space Telescope - General Observer Proposal #80187

The Lifetime of Circumstellar Disks Around Low-Mass Brown Dwarfs

Principal Investigator: Kevin Luhman
Institution: Pennsylvania State University

Technical Contact: Kevin Luhman, Pennsylvania State University

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.5

Abstract:
The lifetimes of optically thick accretion disks around young stars are important because they represent a limit on the amount of time available for the formation of giant planets. Estimating disk lifetimes as a function of stellar mass requires measurements of disk fractions for samples of stars that cover a wide range of ages and masses. Previous photometric surveys with Spitzer have explored much of this phase space. However, one area that has relatively few disk fraction measurements is the least massive brown dwarfs at >3 Myr (<0.03 Msun). Therefore, we propose to measure IRAC photometry for the least massive known brown dwarfs in the Upper Sco association (5 Myr). We will use the IRAC data to measure the disk fraction in this sample, which will then be combined with disk fractions previously measured with Spitzer in younger regions to estimate the typical lifetimes of disks around the smallest brown dwarfs.

Spitzer Space Telescope - General Observer Proposal #90095

A Survey for Wide Substellar Companions in the Solar Neighborhood

Principal Investigator: Kevin Luhman
Institution: Pennsylvania State University

Technical Contact: Kevin Luhman, Pennsylvania State University

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 16.0

Abstract:
During previous Spitzer cycles, we have used multi-epoch images from IRAC to search for wide substellar companions to stars in the solar neighborhood via common proper motions. Through this work, we discovered a companion to the white dwarf WD 0806-661 that is the coldest companion directly imaged outside of the solar system and is a contender for the coldest known brown dwarf (T=300-345 K). We propose to continue this survey by obtaining second-epoch IRAC images of a new sample of 150 stars that have been observed previously with IRAC. Because their ages and distances are known via their primaries, any new companions will serve as rare and valuable benchmarks for testing models of substellar objects.

Spitzer Space Telescope - General Observer Proposal #10056

The Beasts' Lair: A Spitzer Survey of the Host Galaxies of Superluminous Supernovae

Principal Investigator: Ragnhild Lunnan
Institution: Harvard University

Technical Contact: Ragnhild Lunnan, Harvard University

Co-Investigators:
Edo Berger, Harvard University
Ryan Chornock, Harvard University
Tanmoy Laskar, Harvard University

Science Category: GRBs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 37.6
Priority: 1

Abstract:
The new generation of wide-field optical time-domain surveys is providing an opportunity to discover and decipher new classes of astronomical transient phenomena. One of the most unexpected results from Pan-STARRS and other time-domain surveys is the discovery of superluminous supernovae (SLSNe), with bolometric luminosities up to 100 times higher than normal core-collapse and Type Ia supernovae (SNe), and with spectra that do not match the known SN classes. These SLSNe represent a new challenge to our understanding of the deaths of massive stars, the standard core-collapse picture, and the mechanism for powering optical emission in SNe. Progress in our understanding of these mysterious explosions requires detailed studies of their light curves and spectra (available from our Pan-STARRS data and follow-up), as well as an understanding of their galactic environments - the focus of this Spitzer proposal. We propose 3.6 micron imaging of a complete sample of 25 SLSN host galaxies at z~0.1-1.6, with the goal of measuring stellar masses and dust extinction. Combined with our existing and on-going ground-based and HST follow-up observations (multi-band optical photometry and optical spectroscopy), the Spitzer data will allow us to fully characterize the environments of SLSNe over a wide range of redshifts, thus beginning to address one of the key new mysteries in time-domain astrophysics. The Spitzer data will form a central component of the PI's PhD thesis.

Spitzer Space Telescope - General Observer Proposal #12104

The Stellar Population of Metal-Poor Galaxies at z~1

Principal Investigator: Chun Ly
Institution: NASA Goddard Space Flight Center

Technical Contact: Chun Ly, NASA Goddard Space Flight Center

Co-Investigators:
Jane Rigby, NASA Goddard Space Flight Center
Michael Cooper, University of California, Irvine
Jeffrey Newman, University of Pittsburgh
Renbin Yan, University of Kentucky

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 16.5
Priority: 1

Abstract:
We propose to observe 21 metal-poor strongly star-forming galaxies selected from the DEEP2 Galaxy Redshift Survey. This spectroscopic sample is unique for it has "gold standard" gas-phase metallicity measurements from detections of the weak [OIII]4363 emission line, dust attenuation estimates from Balmer emission lines, and dust-corrected instantaneous SFRs. However, the stellar masses for these galaxies are poorly measured as infrared data do not exist or are very shallow for the majority (80%) of the sample. The IRAC 3.6-micron observations will provide robust stellar mass estimates by observing redward of the 1.6 micron bump where the light is dominated by low-mass stars. Combined with Spitzer archival data for 5 other galaxies from our sample, we will determine the relationships between gas metallicity, stellar mass, and SFR for dwarf galaxies at z~0.8. We will examine if the same galaxy evolution processes in massive galaxies also hold for lower mass galaxies when the Universe was half its age. These observations will further benefit the DEEP2 Survey, as ~2,600 galaxies (~200 with Keck spectra; ~100 with redshift) will be in each IRAC [3.6] or [4.5] pointing.

Spitzer Space Telescope - General Observer Proposal #11145

Regolith Size Sorting on Q-type NEAs

Principal Investigator: Eric MacLennan
Institution: University of Tennessee

Technical Contact: Eric MacLennan, University of Tennessee

Co-Investigators:
Joshua Emery, The University of Tennessee
Benjamin Rozitis, The University of Tennessee

Science Category: asteroids
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.2
Priority: 1

Abstract:
Q-type near-Earth asteroids show a characteristically un-weathered surface due to regolith movement acting to effectively erase the effects of space weathering. It has been shown that Q-types are only found in orbits that periodically bring them in close proximity to at least one terrestrial planet. This observation is used to infer that these close planetary encounters (i.e. tidal interactions) are likely causing regolith mobilization on these bodies. This mechanism may lead to particle size segregation on the surface and interior of these bodies, particularly the sorting of large boulders to the surface. We target nine Q-types in a search for evidence that boulders have been brought to the surface via tidal-interactions. Since a large spatial fraction of boulders will raise the thermal inertia of a surface, we aim to constrain the thermal inertia of our targets using thermal emission observations with IRAC. Objects are strategically targeted at different observing geometries so that thermal inertia can be constrained without knowledge of the shape/spin state of these objects. These proposed observations will be used to test the occurrence of regolith sorting on asteroids that have undergone recent tidal interactions from close planetary encounters. Evidence of this will aid the understanding of the internal structure of these objects. Additionally, this study will provide information used to advance the understanding of the mechanical behavior of granular material at low gravitational regimes.

Spitzer Space Telescope - General Observer Proposal #13102

Regolith Size Sorting on Q-type NEAs

Principal Investigator: Eric MacLennan
Institution: University of Tennessee

Technical Contact: Eric MacLennan, University of Tennessee

Co-Investigators:
Joshua Emery, The University of Tennessee
Benjamin Rozitis, The Open University

Science Category: asteroids
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10.4
Priority: 1

Abstract:
Q- and Sq-type near-Earth asteroids show a characteristically un-weathered surface due to regolith movement acting to effectively erase the effects of space weathering. It has been shown that these "spectrally fresh" asteroids are always found in orbits that can bring them in close proximity to at least one terrestrial planet. This observation is used to infer that these close planetary encounters (i.e. tidal interactions) are likely causing regolith mobilization on these bodies. This mechanism may lead to particle size segregation on the surface and interior of these bodies, particularly the sorting of large boulders to the surface. We target seven Q-/Sq-types in a search for evidence that boulders have been brought to the surface via tidal-interactions. Since a large spatial fraction of boulders will raise the thermal inertia of a surface, we aim to constrain the thermal inertia of our targets using thermal emission observations with IRAC. Objects are strategically targeted at different observing geometries so that thermal inertia can be constrained without knowledge of the shape/spin state of these objects. These proposed observations will be used to test the occurrence of regolith sorting on asteroids that have undergone recent tidal interactions from close planetary encounters. Evidence of this will aid the understanding of the internal structure of these objects. Additionally, this study will provide information used to advance the understanding of the mechanical behavior of granular material at low gravitational regimes.

Spitzer Space Telescope - General Observer Proposal #60058

Dynamic atmosphere of the eccentric and massive planet XO-3b

Principal Investigator: Pavel Machalek
Institution: Johns Hopkins University

Technical Contact: Peter McCullough, STScI

Co-Investigators:
Peter McCullough, Space Telescope Science Institute
Drake Deming, NASA Goddard
Christopher Johns-Krull, Rice University
Joseph L. Hora, Harvard-CfA
Adam Burrows, Princeton University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 131.3

Abstract:
We propose to observe the extended duration (63.0 hours) phase light curves spanning the transit and secondary eclipse of the exoplanet XO-3b, which has a period of 3.19 days, in the 3.6 and 4.5 micron IRAC bands to study the presence of a thermal inversion in its stratosphere and determine the phase variability of the planetary emission temperature. Full phase 3.6 and 4.5 micron photometry will allow us to constrain the longitudinal variation of the XO-3b emission, determine the day-night side heat circulation as well as constrain the presence of any hot-spots on the surface. XO-3b is an unique planet with a high mass Mp = 12.5 MJup, which is close to the deuterium burning limit and so far has the highest observed surface gravity, g = 209 m.s^-2 amongst the known transiting planets. Its orbit has eccentricity e = 0.287, which causes stellar irradiance to vary three-fold over the entire orbit. Unique to XO-3b, the planet revolves around the star on an almost polar orbit with a 70 +/- 15 deg inclination angle relative to the stellar equatorial plane . Of the 11 transiting planets with measured Rossitter-McLaughlin effect, XO-3b is the only one with a nearly polar orbit, thus XO-3b represents a new orbital mode of transiting Hot Jupiters, which in principle would allow us to constrain the latitudinal distribution of the thermal emission from the planet, in addition to the longitudinal thermal distribution. This proposal is a follow-up to the approved Cycle-5 Cold Spitzer DDT program OX3B "Thermal Inversion in the atmosphere of XO-3b", which investigates the secondary eclipse of XO-3b in all 4 IRAC channels.

Spitzer Space Telescope - General Observer Proposal #70060

Balancing the Budget: Simultaneous Near- and Mid-IR Phase Curves of WASP-12b

Principal Investigator: Pavel Machalek
Institution: Johns Hopkins University

Technical Contact: Drake Deming, NASA's Godddard Space Flight Center

Co-Investigators:
Nick Cowan, University of Washington
Bryce Croll, University of Toronto
Adam Burrows, Princeton Univserity
Joseph Hora, Harvard Smithsonian Center for Astrophysics
Drake Deming, NASA Goddard Space Flight Center
Tom Greene, NASA Ames Research Center

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 72.5

Abstract:
We propose to observe a 3.6 micron and a 4.5 micron phase curve (65.0 hours total) of WASP-12b, one of the most the highly irradiated (~10 x 10^9 ergs cm^-2 s^-1) and shortest-period (P ~1.09 d) exoplanets discovered to date. Each 32.5 hour phase curve will start before the secondary eclipse of WASP-12b and will last for more than a full period, allowing us to observe the transit and subsequent secondary eclipse. Each of these phase curves - weather permitting - will be accompanied by simultaneous ground-based full-night (~8 hour) phase curve measurements in the Ks (~2 micron) and H-bands (~1.6 micron) using the Wide-Field Infrared Camera (WIRCam) on the Canada-France-Hawaii Telescope (CFHT). Obtaining four phase curve measurements from wavelengths spanning 1.5 - 5 micron will allow an unprecendented understanding of the energy budget, radiative transfer, and dynamics of the deep, high pressure atmosphere of this hot Jupiter. Specifically the 3.6 and 4.5 micron IRAC phase curve observations that we propose here will allow us to measure the longitudinal variation of WASP-12b's thermal emission as well as determine the dayside and nightside brightness temperature of this very highly irradiated hot Jupiter. With each of our four phase curves we will be able to observe the phase lag of the hottest point of the planet, and thus measure how far downwind the hottest layer of the atmosphere is blown at the four different atmospheric layers we probe here. An additional epoch of observations will also constrain the precession rate of WASP-12b.

Spitzer Space Telescope - General Observer Proposal #70010

Cepheids in the Small Magellanic Cloud: Mapping the 3D Structure, the Metallicity Sensitivity of the Leavitt Law, and the Temperature Structure of Cepheid Instability Strip

Principal Investigator: Barry Madore
Institution: Carnegie Institution of Washington

Technical Contact: Jane Rigby, OCIW

Co-Investigators:
Wendy Freedman, OCIW
Eric Persson, OCIW
Andy Monson, OCIW
Jane Rigby, OCIW
Vicky Scowcroft, OCIW
Mark Siebert, OCIW
Peter Stetson, DAO
Laura Sturch, Boston University

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 119.0

Abstract:
Uniformly sampled 3.6 and 4.5 micron lightcurves of 100 Classical Cepheids in the Small Magellanic Cloud (SMC) are requested. The 3.6 micron Period-Luminosity relation will be used to map the 3-dimensional structure of the SMC to unprecedented precision and accuracy. The [3.6] - [4.5] micron light curves will then be used to explore the systematics of the newly discovered carbon manoxide (CO) feature (exclusively in the 4.5micron band) recently found to be heavily influencing Cepheid color curves at this mid-IR wavelength. A comparison of the mean period-color relations will be made between the Milky Way, LMC and SMC to explore the metallicity sensitivity of this CO feature, with the SMC anchoring the low end of the metallicity scale. And finally, the cyclical variations of individual Cepheids (of individually fixed metallicity) will allow us to explore the positions of these stars inside and across the Cepheid instability strip, unencumbered by differential reddening effects that continue to plague optical studies.

Spitzer Space Telescope - General Observer Proposal #80021

Cepheid Astrophysics: Measuring the Fundamental Physical Properties of a 3.8-day Classical Cepheid Variable in the Eclipsing Binary System OGLE-LMC-CEP227

Principal Investigator: Barry Madore
Institution: Carnegie Institution of Washington

Technical Contact: Barry Madore, Carnegie Institution of Washington

Co-Investigators:
Victoria Scowcroft, Carnegie Observatories
Wendy Freedman, Carnegie Observatories
Ian Thompson, Carnegie Observatories
Grzegorz Pietrzynski, Universidad de Concepcion
Darek Graczyk, Universidad de Concepcion
Wolfgang Gieren, Universidad de Concepcion

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 19.4

Abstract:
Using Spitzer, we have a unique opportunity to measure the zero point of the Cepheid Period-Luminosity relation and determine a direct distance to the Large Magellanic Cloud. We will map the surface brightness structure of a short-period, fundamental-mode Classical Cepheid variable in the LMC, measure its mean radius in two independent ways, and thereby determine its intrinsic luminosity and distance taking two physically based and independent paths to the same end goal. Located in the Large Magellanic Cloud, OGLE-LMC-CEP227 is a detached, eclipsing binary system, having an orbital period of 309 days. It is composed of a yellow supergiant (the secondary) and an equal-mass, but more luminous, Cepheid variable (the primary) having a radial pulsation period of 3.8 days. The mass and radius of each star is independently well determined from the eclipse timings and orbital-parameter solutions. By photometrically monitoring the ingress and egress of the Cepheid while passing behind and then again while passing in front of the physically larger but slightly cooler secondary star we will be able to map the surface-brightness structure (most notably the limb darkening) of each star in the mid-infrared. Out of eclipse we will use the Baade-Wesselink Method to again, but independently, determine the radius and luminosity of the Cepheid, this time from its observed pulsation properties. Comparing the orbital and pulsational solutions will provide a fundamental test of the input physics currently being used to calibrate the zero point of Cepheid Period-Luminosity relation using the Baade-Wesselink Method. An extremely well understood distance to the LMC (with a highly constrained uncertainty) will be an important end-product.

Spitzer Space Telescope - Directors Discretionary Time Proposal #551

Follow-up Observations of Lyra1

Principal Investigator: Amy Mainzer
Institution: JPL

Technical Contact: Amy Mainzer, JPL

Co-Investigators:
Michael Cushing, JPL
Davy Kirkpatrick, IPAC
Michael Skrutskie, University of Virginia
Chris Gelino, IPAC
Peter Eisenhardt, JPL

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.3

Abstract:
We have recently discovered an object with the Wide-field Infrared Survey Explorer with colors that suggest that it could be the coldest brown dwarf discovered to date. This object, dubbed Lyra1, could be the first representative of an entirely new spectral class (the so-called Y dwarfs). If the object is as cold as its WISE colors indicate, we may have at last found the final link between low mass stars and the giant planets in our own solar system. To date, we have discovered and spectroscopically confirmed over a dozen new ultra-cool brown dwarfs drawn from the WISE dataset, proving that WISE is an excellent tool for identifying these objects and lending confidence to our detection of Lyra1. This object is detected to 25 sigma at 4.6 um, but it is undetected in the other three WISE bandpasses (3.6, 12 and 22 um). The 2.5 sigma lower limit of its [3.4]-[4.6] color is 4.3 magnitudes, making it over a magnitude redder than the reddest spectroscopically confirmed brown dwarfs presently known. We propose to use the 20 times better sensitivity of Spitzer to detect the object at 3.6 um, even if it is as cold as 250 K, allowing us to better determine the object’s effective temperature. We also propose to observe it at 4.5 um to begin to determine if it has measurable parallax and proper motion.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14227

Characterizing a newborn warm Jupiter-sized exoplanet

Principal Investigator: Eric Mamajek
Institution: Jet Propulsion Laboratory

Technical Contact: Trevor David, Jet Propulsion Laboratory

Co-Investigators:
Trevor David, Jet Propulsion Laboratory
David Ciardi, NASA Exoplanet Science Institute / IPAC
Varoujan Gorjian, Jet Propulsion Laboratory
Lynne Hillenbrand, California Institute of Technology
Erik Petigura, California Institute of Technology
Luisa Rebull, IRSA/SSC/IPAC
John Stauffer, SSC/IPAC

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.4
Priority: 1

Abstract:
Planets are expected to evolve over time. At the youngest ages (tens of Myr), some planets may be contracting and radiating away heat from their formation. Orbits that begin as eccentric may gradually be circularized through tidal dissipation. Atmospheres which are only weakly bound to their planet may be quickly eroded by high energy stellar radiation. There are many theories about how exoplanets evolve, but very few opportunities to directly constrain fundamental planet parameters at young ages. This is primarily due to two reasons: (1) there are relatively few young (<100 Myr) stars near the Sun, and (2) stellar activity in young stars inhibits the detection of close-in planets. Thus, each young exoplanet is an indispensable benchmark for testing the various evolutionary theories. Our group has recently discovered the first Jupiter-sized exoplanet transiting a pre-main sequence star (20 Myr in age). V1298 Tau b is the second youngest transiting exoplanet and a factor of 100 younger than typical systems. With an age only slightly older than the typical lifetime of protoplanetary disks, the planet is young enough to place compelling constraints on planet evolution models. Our group is planning several follow-up observations to characterize this newborn planet in detail. The aim is to understand whether the planet's properties are in agreement with theoretical expectations for its radius, temperature, and atmospheric mass-loss rate, as well as to differentiate between viable formation and migration scenarios. As a first step, we are proposing to observe a single transit with Spitzer. These observations will help (1) accurately measure the planet's radius, (2) secure its ephemeris, and (3) be used in a future atmospheric characterization study.

Spitzer Space Telescope - General Observer Proposal #13037

Zodical Exoplanets in Time: Are These Worlds Flat?

Principal Investigator: Andrew Mann
Institution: University of Texas, Austin

Technical Contact: Andrew Mann, University of Texas, Austin

Co-Investigators:
Aaron Rizzuto, University of Texas at Austin
Elisabeth Newton, Harvard-Smithsonian Center for Astrophysics
Eric Gaidos, University of Hawaii at Manoa
Adam Kraus, University of Texas at Austin
Paul Dalba, Boston University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 106.3
Priority: 1

Abstract:
Over the past decade, Spitzer has helped to revolutionize our understanding of exoplanet atmospheres. By extending the reach of transmission spectroscopy (change in transit depth with wavelength) past 3 microns, Spitzer has provided unique constraints on the composition of the atmospheres of transiting planets. Such studies of super-Earth and Neptune size planets with both the Hubble Space Telescope and Spitzer have generally found featureless atmospheres, consistent with high clouds or a haze layer. This finding motivates more questions; how and when do these atmospheres form, how do they sustain themselves, and how long do they persist? Some answers could be found by comparing the atmospheres of similar planets with a range of ages from infancy (0-20 Myr) to adolescence (100-1000 Myr) to maturity (more than 1 Gyr). The mature part of this comparison is starting to become complete with many older super-Earth to Neptune size systems undergoing detailed study. However, even among the known young and adolescent systems, few were known to transit and none were amenable to transmission spectroscopy. Observations of young stars by the K2 mission has changed the landscape. From this data our team has identified and confirmed two transiting planets that will promote studies of exoplanet evolution. The first, K2-25b, orbits an M4.5 in the Hyades cluster (650 Myr), and the second, K2-33b, orbits an M3.5 pre-main sequence star in the Upper Scorpius OB association (11 Myr). We propose to observe 6 transits of the former and 5 of the latter with Spitzer/IRAC 3.6 and 4.5 micron bands. In combination with our K2 and ground-based data we can construct low-resolution transmission spectra of each planet in the key regions of atmospheric differentiation. This will provide the first insight into the atmospheres of young, small planets, determine when featureless atmospheres first appear, and provide constraints on the evolution of planetary atmospheres.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13212

A Young Three-Planet System in the Hyades

Principal Investigator: Andrew Mann
Institution: Columbia University

Technical Contact: Andrew Mann, Columbia University

Co-Investigators:
Elisabeth Newton, MIT
Aaron Rizzuto, UT Austin
Andrew Vanderburg, UT Austin

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.5

Abstract:
Planets are nor born in their final state; instead, before reaching a more mature and stable phase, young planets have their structures, orbits, and atmospheres disrupted by their environment. Early changes in planetary systems can have profound implications for the final configuration of the planets, which makes it critical to study planets during their most formative years (0-1 Gyr). However, most of the known planets have poorly constrained ages or are older than the timescales of interest. In the latest K2 data release we identified a 3-planet system in the Hyades cluster (700 Myr). The smallest of these planets is Earth-sized, creating a unique opportunity to study small, rocky planets while they are still evolving. However, the parameters of this planet are poorly constrained from the K2 light curve, and the ephemeris needs updating. The largest planet should have a large atmospheric scale-height based on similar planets, but could be flat if material in the upper atmosphere has not yet settled. Here we propose Spitzer observations of both planets to significantly improve their parameters, lock the ephemerides well into the era of JWST, take early steps to characterize their atmospheres, and search for expected transit timing variations.

Spitzer Space Telescope - General Observer Proposal #70030

Metallicity evolution at high redshift: the stellar mass of a sample of LBGs at z>3

Principal Investigator: Filippo Mannucci
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Co-Investigators:
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Giovanni Cresci, INAF
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Alessandro Marconi, Univ. di Firenze
Alessio Gnerucci, Univ. di Firenze

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.7

Abstract:
We are using the new multi-object spectrograph of the LBT telescope to obtain deep, near-IR spectra of a large, representative sample of Lyman-Break Galaxies at z>3. These data are used to study the metallicity and dynamical properties of these galaxies and constrain the models of galaxy formation. In particular, we want to study the presence of metallicity evolution at z>3 with respect to the recently discovered Fundamental Metallicity Relation (FMR), which is found to show no evolution up to z=2.5. To optimize the use of the multi-object spectrograph, target galaxies are selected in projected overdensities containing 10-20 objects. We propose to use a limited amount of Spitzer time to observe one of these field, containing 14 LBG, whose spectra have been already obtained. IRAC photometry will be used to measure stellar mass and, as a consequence, compare these galaxies to the FMR

Spitzer Space Telescope - General Observer Proposal #10084

Unveiling the Most Massive Galaxies in the Universe: IRAC Mapping of the NMBSII/CFHTLS Fields

Principal Investigator: Danilo Marchesini
Institution: Tufts University

Technical Contact: Danilo Marchesini, Tufts University

Co-Investigators:
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Tomer Tal, UC - Santa Cruz
Ivo Labbe, Leiden Observatory
Rachel Bezanson, Yale University
Catherine Weigel, Tufts University

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 21.4
Priority: 1

Abstract:
Observations of massive galaxies and their redshift evolution place strong constraints on the physical processes of galaxy formation. Although substantial data have been collected on galaxies with masses LogM~11.2 out to z~4-5 from the recent myriad of ground-based wide-field NIR surveys, very little is known about the evolution of the most massive (LogM>11.4) galaxies in the universe. At the tip of the Schechter function, their space density is estimated to be 30x lower than LogM=11 galaxies and hence only a few have been found, even in the widest-field surveys. We recently undertook the NMBS-II survey, a medium-deep wide-field (4.7 deg^2) NIR medium-band survey designed to accurately characterize the stellar mass function, number density, stellar populations, and clustering properties of the most massive galaxies out to z=3. The primary survey fields of the NMBS-II are the CFHTLS-deep fields; however, presently only 60% of these fields have IRAC coverage. We propose to complete the IRAC coverage of the NMBS-II. The IRAC data are essential for accurately measuring photometric redshifts and stellar masses of the high-redshift population. IRAC data are critical for constructing the UVJ diagram, which has become the de-facto method for differentiating red dusty star-forming from red quiescent galaxies. The proposed observations will allow us to construct a sample of ~300 ultra-massive (LogM>11.4) galaxies at 1.5<z<3, and, for the first time, to accurately characterize the evolution and clustering properties of these monster galaxies. Because these massive galaxies are expected to be one of the most clustered populations, and thus greatly affected by cosmic variance, maximal area and number of independent sight-lines are needed for robust clustering measurements. The proposed IRAC survey will more than double the sight-lines allowing us to exploit the full NMBS-II area. We waive our proprietary data-rights period, committing to publicly release the fully reduced IRAC mosaics.

Spitzer Space Telescope - General Observer Proposal #11139

IRAC Monitoring of the Late Heavy Comet Bombardment in the eta Corvi System

Principal Investigator: Massimo Marengo
Institution: Iowa State University

Technical Contact: Massimo Marengo, Iowa State University

Co-Investigators:
Carey Lisse, John Hopkins University / Applied Physics Laborato
Karl Stapelfeldt, NASA/GSFC
Alan Hulsebus, Iowa State University

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.7
Priority: 1

Abstract:
The nearby sun-like star eta Corvi (F2V, d=18 pc, age =1.2 Gyr) has long been known to possess a bright, dusty Kuiper Belt that has now been resolved with Herschel PACS. A warm inner dust belt indicated by an IRAS 12 micron excess and has recently been resolved as a 3-AU scale structure by VLT observations. In 2012 Lisse et al. further characterized this warm dust using Spitzer IRS, identifying the signatures of ice, organics and silicate dust in this system's Terrestrial Habitability Zone (THZ). The system appears to be undergoing a Late Heavy Bombardment (LHB), delivering primitive, water- and organic-rich material from the Kuiper Belt to the THZ, at roughly the same relative age as the solar system's LHB. Our data also showed an upturn in the excess flux shortwards of 6 micron ? evidence for a surprisingly large amount of icy dust scattering in the inner system (fscat/fstar ~ 1.0%). This results is corroborated by our recent 2-5 micron NASA/IRTF SpeX spectroscopy. In 2012 we have obtained Spitzer/IRAC photometric data for the system, detecting the disk at 3.6 and 4.5 micron in two separate epochs, followed by a third epoch in 2013. We now propose to continue our photometric monitoring with 15 additional visits to be scheduled within cycle 11, in order to extend our temporal coverage to 4 years on a variety of timescales ranging from days, to weeks, to months. The proposed campaign will allow us to test the two competing hypothesis for the origin of the warm disk: (1) single collison event leading to the breakup of a large Kuiper Belt object in the system or (2) continual raining of small comets scattered towards the inner system.

Spitzer Space Telescope - General Observer Proposal #13079

Search for Planetary-mass Companions of the LHB Star eta Corvi

Principal Investigator: Massimo Marengo
Institution: Iowa State University

Technical Contact: Massimo Marengo, Iowa State University

Co-Investigators:
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Karl Stapelfeldt, Jet Propulsion Laboratory
Alan Hulsebus, Iowa State University
Michael Sitko, University of Cincinnati

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.3
Priority: 1

Abstract:
The nearby sun-like star eta Corvi (F2V, d = 18 pc, age = 1.2 Gyr) has long been known to possess a bright, dusty Kuiper belt that has been recently resolved with Herschel/PACS. In addition to this structure, eta Corvi is one of the rare mature planetary systems to possess also an inner warm belt (~ 3 AU radius), located within the Terrestrial Habitable Zone (TLZ) of this star. Our characterization of this structure, based on Spitzer/IRS and NASA/IRTF SpeX spectral observations, reveals the signature of ice, organics and silicate dust in this warm belt. This supports the hypothesis that eta Corvi is undergoing a Late Heavy Bombardment (LHB), delivering life-bearing water- and organic-rich material from the Kuiper belt to the TLZ, at roughly the same age as the Solar System?s LHB. For the past four years we have monitored the brightness of eta Corvi?s warm belt with Spitzer/IRAC, finding that its infrared emission has been stable over a multi-year timescale. In 2012 we have also conducted a search for widely separated substellar-mass companions of this star, whose presence as been suggested as a possible trigger for the LHB currently undergoing in the system. This search has led to the identification of three sources with colors and magnitudes consistent with being late-T and Y dwarf companions of this star. We here propose to acquire a new deep roll-subtracted image of the system, 5 years after our first visit, to test for common proper motion of these candidate companions, and determine if any of this sources is physically associated with eta Corvi. A positive identification of a substellar-mass companions (one of which could be a 3-5 MJ planet at ~360 AU from the star) would be a significant step in understanding the processes leading to LHB-like events in a system analogous to the Solar System.

Spitzer Space Telescope - General Observer Proposal #80071

Search for Planetary Mass Companions of Nearby Young Stars

Principal Investigator: Massimo Marengo
Institution: Iowa State University

Technical Contact: Massimo Marengo, Iowa State University

Co-Investigators:
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Joseph Hora, Smithsonian Astrophysical Observatory
Giovanni Fazio, Smithsonian Astrophysical Observatory
Volker Tolls, Smithsonian Astrophysical Observatory
Joseph Carson, College of Charleston
Alan Hulsebus, Iowa State University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 58.1

Abstract:
Our view of extrasolar planetary systems was revolutionized in late 2008, when the first images of planets orbiting 50-100 AU from HR 8799 and Fomalhaut were announced. These results revealed the existence of giant extrasolar planets orbiting their host stars at distances comparable to the size of protoplanetary disks (100-500 AU). Despite their importance to understand the dynamics of the Kuiper belts of extrasolar systems, their possible role in the creation of transient debris disks, and the effects that these bodies can have on the stability of inner planets, little is known about the characteristics of planets at distances of 100 AU or more. To fill this gap, we propose to search for planetary mass companions around 23 young nearby stars. Thanks to the young age (<1 Gyr) and limited distance (<15 pc) of our targets, we will be sensitive to planets with masses as low as 5 MJ at 150 AU from the host star, and <1 MJ at 300 AU or more orbital separation. These observations will increase by 2-3 magnitudes the sensitivity of previous IRAC searches for low mass companions, and probe smaller separations from the primary star. This project will provide a census of planetary mass objects, or strong limits on their existence, in a currently unexplored region of extrasolar planetary systems. The proposed observations represent one of the best remaining opportunities to directly image extrasolar planets in the Spitzer mission.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14279

Characterization of one of the coldest known brown dwarfs

Principal Investigator: Federico Marocco
Institution: Jet Propulsion Laboratory

Technical Contact: Federico Marocco, Jet Propulsion Laboratory

Co-Investigators:
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Aaron M. Meisner, NOAO
Dan Caselden, Gigamon ATR
Michael C. Cushing, U. Toledo
Jacqueline K. Faherty, AMNH
Christopher R. Gelino, IPAC
Edward L. Wright, UCLA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.2
Priority: 1

Abstract:
We want to obtain a definitive measurement at [3.6] for one of the coldest brown dwarfs known: CWISEP J1935-1546. This object was identified in the CatWISE catalog, and a preliminary, low signal-to-noise-ratio detection at [3.6] leads to a [3.6]-[4.5] color of 3.24+/-0.31 mag, making CWISEP J1935-1546 one of the reddest, therefore coldest, brown dwarfs known. Its estimated effective temperature is in the 270-360 K range. A higher SNR [3.6] measurement is however vital to place a more robust constraint on the temperature. With 1h of integration time we will achieve a precision of 10 K on the temperature, which is fundamental to characterize this source. Expanding the current census of extremely cold brown dwarfs like CWISEP J1935-1546 is crucial to answer one of the central questions in all of astrophysics - how can star formation create objects of extremely low mass?

Spitzer Space Telescope - Directors Discretionary Time Proposal #14307

Confirming that CWISEP J1446-2317 is the coldest brown dwarf known

Principal Investigator: Federico Marocco
Institution: Jet Propulsion Laboratory

Technical Contact: Federico Marocco, Jet Propulsion Laboratory

Co-Investigators:
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Aaron M. Meisner, NOAO
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Peter R. Eisenhardt, JPL
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Jacqueline K. Faherty, AMNH
Michael C. Cushing, U. Toledo

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.2
Priority: 1

Abstract:
We want to test whether CWISEP J1446-2317 is the coldest brown dwarf ever observed, by obtaining a definitive flux measurement at [3.6]. This object was identified in the CatWISE catalog, and a preliminary, low signal-to-noise-ratio detection at [3.6] leads to a [3.6]-[4.5] color of 3.77+/-0.42 mag, making CWISEP J1446-2317 potentially the reddest, and therefore the coldest, brown dwarf known. Its effective temperature is estimated to be 250+40/-10 K. A higher SNR [3.6] measurement is vital to place a more robust constraint on the temperature. With 1h of integration time, we will achieve a precision of ~10 K on the temperature, which is fundamental to characterize this source. Expanding the current census of extremely cold brown dwarfs like CWISEP J1446-2317 is crucial to answer one of the central questions in all of astrophysics - how does star formation create objects of extremely low mass?

Spitzer Space Telescope - Directors Discretionary Time Proposal #14329

Identifying the coldest brown dwarfs in the Solar neighborhood

Principal Investigator: Federico Marocco
Institution: Caltech/IPAC

Technical Contact: Federico Marocco

Co-Investigators:
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Aaron M. Meister, OIR
Dan Caselden, Gigamon ATR
Michael Cushing, U Toledo
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Christopher Gelino, Caltech/IPAC
Edward Wright, UCLA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.5
Priority: 1

Abstract:
We will obtain high-significance [3.6] and [4.5] photometry for 10 cold brown dwarf candidates in the Solar neighborhood, thereby placing strong constraints on their temperature and distance. These objects hold the key to answering some of the most important open questions in all of astrophysics - is there a low-mass cutoff to star formation? And if so, where is it? These candidates have been selected from the CatWISE 2020 catalog, which is an improved version of the CatWISE Preliminary catalog (Eisenhardt et al. 2019). We have begun generating the CatWISE 2020 catalog in November, prioritizing processing sky regions which are still visible to Spitzer. The 10 new sources we propose here are excellent candidates for extremely cool brown dwarfs - perhaps supplanting WISE J0855-0714 as the coldest known brown dwarf. Spitzer is the only facility capable of following up these sources. Access to few hours from its final weeks of operation is vital for the advancement of understanding the local census and the star formation cutoff, and represents our last chance to easily prioritize cold brown dwarfs for JWST follow-up.

Spitzer Space Telescope - General Observer Proposal #13149

Exploring a Massive Starburst in the Epoch of Reionization

Principal Investigator: Daniel Marrone
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Technical Contact: Daneil Marrone, Arizona

Co-Investigators:
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A. Weiss, Max-Planck-Institut fur Radioastronomie
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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.0
Priority: 1

Abstract:
We request deep multi-band imaging of a unique dusty galaxy in the Epoch of Reionization (EoR), selected via its millimeter-wavelength dust emission in the 2500-square-degree South Pole Telescope survey. Spectroscopically confirmed to lie at z=6.900, this galaxy has a large dust mass and is likely one of the most rapidly star-forming objects in the EoR. Using Gemini-S, we have identified z-band emission from this object that could be UV continuum emission at z=6.9 or from a foreground lens. Interpretation of this object, and a complete understanding of its meaning for the census of star formation in the EoR, requires that we establish the presence or absence of gravitational lensing. The dust mass observed in this source is also unexpectedly large for its era, and measurements of the assembled stellar population, through the UV-continuum slope and restframe optical color, will help characterize the stellar mass and dust properties in this very early galaxy, the most spectacular galaxy yet discovered by the SPT.

Spitzer Space Telescope - General Observer Proposal #60132

Enigmatic features in Centaurus A

Principal Investigator: Francesco Massaro
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Mark Birkinshaw, University of Bristol

Co-Investigators:
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Larry Rudnick, University of Minnesota
Howard Smith, Harvard-CfA
Zhong Wang, Harvard-CfA
Steve Willner, Harvard-CfA
Diana Worrall, University of Bristol

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10.9

Abstract:
Centaurus A is the closest radio-bright active galaxy, and provides a detailed view of the physics of radio sources and their interaction with the surrounding interstellar and intergalactic gas. In our recent X-ray based work on Centaurus A we have found two surprising new results: that the shock feature around the inner SW radio lobe is a synchrotron rather than thermal gas structure; and that the northern jet generates X-ray bright knots of thermal emission as it enters the northern middle lobe. In these knots we see some evidence for associated star clusters. These unexpected discoveries have important implications for source physics. The broad-band energy output of the X-ray shock traces the population of relativistic particles and hence acceleration physics at the shock. The knots are evidence of interaction of radio jets with interstellar gas, and the subsequent injection of thermal matter into radio lobes. Here we propose a single AOR that will make 1-hour exposures of the shock feature and the X-ray bright knots in each band. This will constrain the spectral energy distribution of the shock, and measure the IR properties of the dissipating gas clouds and embedded stars in the X-ray knots, comparing the properties of these clouds with HI clouds which appear not yet to have interacted with the jet.

Spitzer Space Telescope - General Observer Proposal #10086

Infrared outburst in Arp 299

Principal Investigator: Seppo Mattila
Institution: University of Turku

Technical Contact: Seppo Mattila, University of Turku

Co-Investigators:
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Rubina Kotak, Queen's University Belfast
Almudena Alonso-Herrero, Instituto de Fisica de Cantabria
Erkki Kankare, University of Turku
Miguel Perez-Torres, Instituto de Astrofisica de Andalucia
Petri Vaisanen, South African Astronomical Observatory

Science Category: interacting/merging galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.3
Priority: 1

Abstract:
Arp 299 is one of the nearest examples of a luminous infrared galaxy. We discovered a strong outburst in Arp 299 which is apparent at infrared (IR) wavelengths but not in the optical indicating emission from warm dust and a high extinction. This source could originate from an IR 'dust echo' resulting either from a highly obscured outburst in an active galactic nucleus or an energetic supernova. To complete our study of the origin of this outburst we propose short IRAC observations.

Spitzer Space Telescope - General Observer Proposal #11076

Infrared outburst in Arp 299

Principal Investigator: Seppo Mattila
Institution: University of Turku

Technical Contact: Seppo Mattila, University of Turku

Co-Investigators:
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Rubina Kotak, Queen's University of Belfast
Erkki Kankare, Queen's University of Belfast
Miguel Perez-Torres, Instituto de Astrofisica de Andalucia
Almudena Alonso-Herrero, CSIC
Petri Vaisanen, SAAO
Peter Lundqvist, Stockholm University

Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.5
Priority: 1

Abstract:
Arp 299 is one of the nearest examples of a luminous infrared galaxy. We discovered a strong outburst in Arp 299 which is apparent at infrared (IR) wavelengths but not in the optical indicating emission from warm dust and a high extinction. This source could originate from an IR 'dust echo' resulting either from a highly obscured outburst in an active galactic nucleus or an energetic supernova. To complete our study of the origin of this outburst we propose short IRAC observations.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13226

Spitzer study of an extreme tidal disruption event in a luminous infrared galaxy

Principal Investigator: Seppo Mattila
Institution: University of Turku

Technical Contact: Seppo Mattila, University of Turku

Co-Investigators:
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Stuart Ryder, Australian Astronomical Observatory
Miguel Perez-Torres, Instituto de Astrofisica de Andalusia
Erkki Kankare, Queen's University Belfast
Thomas Reynolds, University of Turku
Morgan Fraser, University College Dublin
Rubina Kotak, Queen's University Belfast

Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0

Abstract:
Observations of thermal emission from warm dust surrounding tidal disruption events (TDEs) are still very sparse. We propose short IRAC observations to follow the 3.6 and 4.5 um light curve evolution of an extreme TDE candidate in a nearby luminous infrared galaxy (LIRG) IRAS 23436+5257. Although LIRGs are locally a rare class of galaxies, they already appear to be over-abundant among TDE hosts. This event was discovered using adaptive optics (AO) assisted near-IR observations with the Keck telescope and is consistent with an extremely energetic TDE with much of its emission reprocessed by dense gas, and re-radiated at IR wavelengths by local dust. Combined with our already ongoing ground-based near-IR and multifrequency radio interferometric monitoring, we will be able to determine the nature of the event, its bolometric luminosity and the total radiated energy. Finally, events similar to the one in IRAS 23436+5257 would not be detectable by optical surveys nor ultraviolet or soft X-ray observations and could be just the tip of the iceberg of a hitherto missed TDE population which remains to be unveiled by the JWST.

Spitzer Space Telescope - General Observer Proposal #14054

Spitzer study of extreme tidal disruption events in luminous infrared galaxies

Principal Investigator: Seppo Mattila
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Technical Contact: Seppo Mattila, University of Turku

Co-Investigators:
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Morgan Fraser, University College Dublin
Erkki Kankare, Queen's University Belfast
Erik Kool, Australian Astronomical Observatory
Rubina Kotak, University of Turku
Miguel Perez-Torres, Instituto de Astrofisica de Andalusia
Thomas Reynolds, University of Turku
Stuart Ryder, Australian Astronomical Observatory

Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.0
Priority: 2

Abstract:
Observations of thermal emission from warm dust surrounding tidal disruption events (TDEs) are still very sparse. We propose short IRAC observations to follow the 3.6 and 4.5um light curve evolution of two extreme TDE candidates in nearby luminous infrared galaxies (LIRGs) Arp 299 and IRAS 23436+5257. Although LIRGs are locally a rare class of galaxies, they already appear to be over-abundant among TDE hosts. These events were discovered using near-IR observations and are consistent with extremely energetic TDEs with much of their emission reprocessed by dense gas, and re-radiated at IR wavelengths by local dust. Combined with our already ongoing ground-based near-IR monitoring we will be able to determine their bolometric luminosities and the total radiated energies whereas our multifrequency radio interferometric monitoring will be used to investigate the jet formation and evolution around supermassive black holes. Events similar to the ones in Arp 299 and IRAS 23436+5257 are not be detectable by optical surveys nor ultraviolet or soft X-ray observations and could be just the tip of the iceberg of a hitherto missed TDE population which could be far more numerous at higher redshifts where LIRGs are more common and remains to be unveiled by the James Webb Space Telescope (JWST).

Spitzer Space Telescope - Directors Discretionary Time Proposal #14239

Spitzer study of extreme TDEs

Principal Investigator: Seppo Mattila
Institution: University of Turku

Technical Contact: Seppo Mattila, University of Turku

Co-Investigators:
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Thomas Reynolds, University of Turku
Rubina Kotak, University of Turku
Andreas Efstathiou, European University Cyprus
Erik Kool, Macquarie University

Science Category: ULIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.3
Priority: 2

Abstract:
Observations of thermal emission from warm dust surrounding tidal disruption events (TDEs) are still very sparse. We propose short IRAC (3.6 and 4.5 micron) observations of the energetic TDE candidate PS16dtm in a Seyfert host. Combined with our ongoing ground-based optical and near-IR monitoring the proposed Spitzer observations would allow extending the early-time mid-IR light curves (from WISE) to the current epoch. This would provide a more complete picture of this unique object where we are currently witnessing a slow evolution (or even re-brightening) in the near-IR as the emission is being strongly shifting to longer wavelengths. Therefore, the proposed observations will be crucial for estimating the total radiated energy of the event and light travel times in the system that will be essential for understanding its origin. This study will thus add to the observations of thermal emission from warm dust surrounding TDEs. In the future, the James Webb Space Telescope (JWST) will be well suited for systematic studies of the warm dust surrounding TDEs.

Spitzer Space Telescope - General Observer Proposal #60142

Infrared outburst in Arp 299

Principal Investigator: Seppo Mattila
Institution: University of Turku

Technical Contact: Seppo Mattila, University of Turku

Co-Investigators:
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Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
Arp 299 is one of the nearest examples of a luminous infrared galaxy. We discovered a strong infrared outburst in Arp 299 at near-infrared wavelengths which we have been monitoring now for four years. The outburst is apparent at infrared wavelengths but not in the optical indicating emission from warm dust and a high extinction. This source could originate from an IR 'dust echo' resulting either from a very energetic and highly obscured SN or an outburst of a highly obscured active galactic nucleus. To study the origin of this outburst we propose short IRAC observations.

Spitzer Space Telescope - General Observer Proposal #80105

Infrared outburst in Arp 299

Principal Investigator: Seppo Mattila
Institution: University of Turku

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Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
Arp 299 is one of the nearest examples of a luminous infrared galaxy. We discovered a strong outburst in Arp 299 which is apparent at infrared (IR) wavelengths but not in the optical indicating emission from warm dust and a high extinction. This source could originate from an IR 'dust echo' resulting either from a highly obscured outburst in an active galactic nucleus or an energetic supernova. To continue our study of the origin of this outburst we propose short IRAC observations.

Spitzer Space Telescope - General Observer Proposal #90157

Infrared outburst in Arp 299

Principal Investigator: Seppo Mattila
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Miguel Perez-Torres, IAA CSIC

Science Category: ULIRGS/LIRGS/HLIRGS
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.3

Abstract:
Arp 299 is one of the nearest examples of a luminous infrared galaxy. We discovered a strong outburst in Arp 299 which is apparent at infrared (IR) wavelengths but not in the optical indicating emission from warm dust and a high extinction. This source could originate from an IR 'dust echo' resulting either from a highly obscured outburst in an active galactic nucleus or an energetic supernova. To complete our study of the origin of this outburst we propose short IRAC observations.

Spitzer Space Telescope - General Observer Proposal #60056

The mass and radius of a low mass white dwarf

Principal Investigator: Pierre Maxted
Institution: Keele University

Technical Contact: Pierre Maxted, Keele University

Co-Investigators:
Peter Wheatley, Warwick University
Tom Marsh, Warwick University

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 23.2

Abstract:
The mass-radius relation and cooling timescale for low-mass white dwarfs depends on their composition, particularly the amount of hydrogen remaining on their surface. There are currently no strong observational constraints on this parameter. This severely limits our ability to interpret observations of white dwarfs in close binary stars. RR Cae is a binary star in which an M-dwarf eclipses a low-mass white dwarf every 0.3037 days. This makes it possible, in principle, to measure a precise, model independent mass and radius for the white dwarf. In practice, this can only be done with lightcurves obtained at infrared wavelengths because i. flaring and star-spots from the M-dwarf distort the lightcurve at optical wavelengths and ii. the depth of the eclipse due to the transit of the white dwarf becomes undetectable at optical wavelengths. We will use Spitzer to obtain lightcurves at 3.6um of RR Cae. These lightcurves together with spectroscopic data already obained will be used to measure the mass and radius of the white dwarf to an accuracy of better than 1-percent. This will be the most precise reliable mass and radius measurement made for any white dwarf to-date. This level of precision is essential to make a useful estimate of the thickness of hydrogen layer on this white dwarf. RR Cae will also be a benchmark object for testing model atmospheres of cool white dwarfs because the surface gravity and effective temperature will then be known independently of the analysis of the spectrum. These observations are essential for the accurate interpretation of data for many types of white dwarf, including white dwarfs accreting metals from from the dust discs detected by Spitzer; cool white dwarfs used for measuring the age of globular clusters and the hundreds of white dwarf binaries identified in SDSS data. RR Cae is the only white dwarf known where data of this quality can be obtained.

Spitzer Space Telescope - General Observer Proposal #60134

WASP-17 - testing the paradigm of pM/pL class planets

Principal Investigator: Pierre Maxted
Institution: Keele University

Technical Contact: Pierre Maxted, Keele University

Co-Investigators:
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Coel Hellier, Keele University
David Anderson, Keele University
Leslie Hebb, University of St Andrews
Didier Queloz, Geneva
Michael Gillon, Geneva
Don Pollacco, Queens University Belfast
Andrew Collier-Cameron, University of St Andrews
Peter Wheatley, Warwick University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 17.4

Abstract:
The structure, formation and fate of hot Jupiter exoplanets is governed by the properties of their atmospheres. There is an urgent need for for strong observational constraints to guide the development of model atmospheres for hot Jupiters. WASP-17b is a newly discovered transiting hot Jupiter exoplanet. It has the lowest density of any transiting hot Jupiter discovered to-date. The host star, WASP-17, is a bright (V=11.6) F6V star. This combination of factors make WASP-17 a key object for testing the current paradigm in which hot pM class planets have stratospheres and cooler pL class planets do not. We will use Spitzer to observe the secondary eclipse of the planet by its host star at 3.6um and 4.5um, and use these data to measure the brightness temperature at these wavelenghs. In the current paradigm, this pM class planet should show evidence of a stratosphere from the ratio of the brightness temperatures at these wavelengths. We will also use transmission spectroscopy to determine independently whether WASP-17b has a stratoshere. VLT time to obtain the required spectroscopy has already been approved. WASP-17 is currently the only pM class planet apart from HD209458 for which the results from the two methods can be compared. The Spitzer data that we will obtain for WASP-17 are essential for us to fully understand exploit the Spitzer observations of exoplanets that will be obtained in the warm mission.

Spitzer Space Telescope - General Observer Proposal #60185

Lightcurves of two newly discovered ultra-short period planets

Principal Investigator: Pierre Maxted
Institution: Keele University

Technical Contact: Pierre Maxted, Keele University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 60.0

Abstract:
The structure, formation and fate of hot Jupiter exoplanets is governed by the properties of their atmospheres. There is an urgent need for for strong observational constraints to guide the development of model atmospheres for hot Jupiters. One of the most powerful techniques for probing hot Jupiter atmospheres is to observe the small variation in infrared flux through the orbital cycle for transiting hot Jupiters. These observations can be converted into a map of the temperature distribution around the planet. This gives us a direct measurement of the way heat is redistributed through the planet’s atmosphere. The processes that redistribute heat from the day-side to the night-side in these tidally locked planets are very poorly understood. This limits our ability to interpret observations of hot Jupiters obtained with Spitzer and other instruments. Phase variations are small so they have only been succesfully observed in a handful of hot Jupiter systems. There are, as yet, no detections of the phase variation in any transiting hot-Jupiters with atmospheres hot enough to have a stratosphere, and only one (HD189733) for a cooler transiting hot Jupiter. We will observe the lightcurves of WASP-18 and WASP-19, to newly discovered ultra-short period planets (P<1day). These are key objects for understanding heat redistribution in hot Jupiters because the irradiation of their day-side is so extreme.

Spitzer Space Telescope - General Observer Proposal #13066

Characterizing Gas Rich Companion Galaxies of z~6 QSOs

Principal Investigator: Chiara Mazzucchelli
Institution: Max-Planck-Institut fuer Astronomie

Technical Contact: Chiara Mazzucchelli, Max-Planck-Institut fuer Astronomie

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Dominik Riechers, Cornell University
Michael Strauss, Princeton University
Bram Venemans, MPIA
Fabian Walter, MPIA
Ran Wang, Peking University

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 26.9
Priority: 1

Abstract:
Luminous QSOs at z>6 are formidable probes of the early Universe, and are believed to reside in overdense regions. However, previous UV-based observational searches did not provide concurring evidence for such galaxy overdensities. Our on-going ALMA Cycle 3 survey to detect [CII] and FIR dust emission in a large sample of high-z QSOs has revealed the presence of bright, close companion galaxies at the same redshift of six QSOs. These newly discovered gas-rich companion galaxies promise to shed new light on early structure formation at the very dawn of time. Now we want to unveil the properties of these companion sources. The ALMA measurement only inform us on the cool gas/dust content; observations of their rest-frame optical emission are needed to characterize the bulk of the stellar population. Spitzer/IRAC is the only instrument available to date which can provide these sensitive information at z>6. Here, we propose to collect deep photometry with Spitzer/IRAC of six companion sources to z>6 QSOs. Together with ALMA data in hand, they will allow us to assess, or place strong limits on, the shape of their spectral energy distributions and to obtain their stellar masses. The observations requested here will provide a unique observational benchmark for theoretical studies of early galaxy formation.

Spitzer Space Telescope - General Observer Proposal #11062

Monitoring Young Evolving Mergers

Principal Investigator: Bruce McCollum
Institution: The Catholic University of America

Technical Contact: Bruce McCollum, The Catholic University of America

Co-Investigators:
Frederick Bruhweiler, The Catholic University of America
Seppo Laine, Spitzer Science Center
Lee Rottler, Pisgah Astronomical Research Institute

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.8
Priority: 1

Abstract:
Recently there has arisen the first opportunity to study a stellar merger in progress and to follow the evolution of the merger remnant. The 2008 outburst of V1309 Sco was recognized in 2011 to have resulted from a merger. We have been monitoring the evolution of its unusual IR SED in J, H, and K and in the IRAC channels, as well as at other wavelengths. We request additional IRAC data because the merger remnant has not yet "settled down" into a final state. We shall also obtain IRAC photometry of what are currently the two other objects most widely suspected of being recent mergers, in order to compare their post-merger evolution with that of V1309 Sco. It is important to monitor these objects so that their SEDs and physical evolution can be understood and accurately modeled.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80258

Infrared Evolution of a Stellar Merger

Principal Investigator: Bruce McCollum
Institution: IPAC/Caltech

Technical Contact: Bruce McCollum, IPAC/Caltech

Co-Investigators:
Seppo Laine, IPAC/Caltech
Lee Rottler, PARI
Frederick Bruhweiler, CUA

Science Category: evolved stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.3

Abstract:
Mergers between nondegenerate stars are thought to eventually be the fate of a significant fraction of all binaries, and to affect the evolution of stellar clusters and some types of galactic centers. We request a set of IRAC observations to perform photometry of the first stellar merger ever "caught in the act". The WISE data show that, in the bandpasses which are comparable to IRAC's, two years after the merger the remnant object was still several orders of magnitude brighter that the pre-merger system. New IRAC observations obtained this year will help to clarify the time scale and physical nature of the IR emission variations. The new Spitzer data will be combined with pre-merger Spitzer observations, WISE data, and contemporaneous ground-based J, H, and K photometric monitoring in order to characterize the evolution of the infrared SED of this type of object for the first time.

Spitzer Space Telescope - General Observer Proposal #90182

Constructing and Monitoring the Infrared SED of the First Known Recent Stellar Merger

Principal Investigator: Bruce McCollum
Institution: The Catholic University of America

Technical Contact: Bruce McCollum, The Catholic University of America

Co-Investigators:
Seppo Laine, Spitzer Science Center
Frederick Bruhweiler, Catholic University of America
Lee Rottler, PARI

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.2

Abstract:
Stellar mergers have long been thought to be astrophysically important to the evolution and global properties of dense stellar aggregates and even open clusters. However, the study of this phenomenon has until now been severely impeded by the lack of any definite, recent merger with which to compare models. It was recently realized that a 2008 nova was in fact a contact binary which erupted when the two stars finally merged. We have obtained post-merger infrared observations which show a large IR excess and a nonstellar SED which have changed subsantially over time, and near-IR emission lines from shocked material. This object is an important opportunity to learn about the nature and time evolution of recent merger products, and to assemble a unique data set which will be used for many years as a basis for modeling stellar mergers.

Spitzer Space Telescope - Snapshot Proposal #70091

Low Surface Brightness Galaxies

Principal Investigator: Stacy McGaugh
Institution: University of Maryland, College Park

Technical Contact: Stacy McGaugh, University of Maryland, College Park

Co-Investigators:
Jim Schombert, University of Oregon
Erwin de Blok, University of Cape Town
Rachel Kuzio de Naray, University of California, Irvine

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Hours Approved: 95.0

Abstract:
We propose a snapshot program to observe a large sample of Low Surface Brightness (LSB) galaxies. Galaxies are selected for their extreme LSB nature (with central surface brightness fainter than 23 B mag/[]) and the availability of ancillary data. The Spitzer archive is largely devoid of such galaxies. Many programs have targeted LSB galaxies, but these have usually been objects of intermediate surface brightness (between 22 and 23 B mag/[]). The samples of the large galaxy surveys conducted with Spitzer suffer from the unavoidable selection bias against LSB systems. Our sample goes a considerable way towards remedying this hole in the Spitzer legacy archive. To maximize the utility of these data, LSB galaxies have been further selected to possess at least some ancillary data. These ancillary data may include optical broad band colors (UBVRI), narrow band Halpha photometry, nebular oxygen abundances, and/or detailed velocity fields. Even warm, Spitzer is the ideal instrument to image these low contrast targets in the near infrared. IRAC images of the sample will be used to measure the sum and distribution of stellar mass. This is important to confirming and interpreting the apparent correlation between stellar birthrate and gas mass fraction. They will also be used to construct detailed mass models. The contribution of the stellar component to the radial mass distribution is the largest outstanding uncertainty in the cusp-core problem, a critical test of the LCDM structure formation paradigm. In sum, this project will provide fundamental data with considerable archival value for an important class of objects.

Spitzer Space Telescope - General Observer Proposal #13046

IRAC imaging of GOGREEN clusters

Principal Investigator: Sean McGee
Institution: University of Birmingham

Technical Contact: Sean McGee, University of Birmingham

Co-Investigators:
Michael Balogh, University of Waterloo
Michael Cooper, UC Irvine
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Adam Muzzin, Cambridge
Lyndsay Old, Toronto
Greg Rudnick, Kansas
Gillian Wilson, UC Riverside
Howard Yee, Toronto

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.7
Priority: 1

Abstract:
We propose deep IRAC imaging of three galaxy clusters drawn from the GOGREEN survey of 21 galaxy clusters in the redshift range $1 < z < 1.5$. This imaging will enable the accurate measurement of unprecedentedly low stellar masses at this redshift, leveraging our deep spectroscopy. This will give a first look at environmental effects on galaxy evolution at a time when galaxies are growing in a fundamentally different way from today. With this data, we will perform accurate SED modeling in order to classify galaxies as passive or star-forming and measure stellar masses, as well as compute cluster membership using accurate photometric redshifts. These data will be augmented by approved VLT, Subaru, Magellan and CFHT imaging and by an ongoing Gemini Large Programme, with which we are obtaining deep spectroscopy of > 1000 member and > 600 field galaxies. With these data and our own lower-redshift descendant data, we will measure 1) the evolution of the quenched fraction and its dependence on distance from the cluster center and 2) the relation between stellar and halo mass and its evolution. This will provide unique constraints to our in-house theoretical models at an epoch where there are currently almost none available. The imaging that we propose will ensure all 21 GOGREEN clusters have deep IRAC data, ensuring the lasting legacy of this benchmark sample.

Spitzer Space Telescope - General Observer Proposal #90195

Constraining the stellar population of an unusually bright galaxy at z>5

Principal Investigator: Ian McGreer
Institution: Steward Observatory, U. Arizona

Technical Contact: Ian McGreer, Steward Observatory, U. Arizona

Co-Investigators:
Xiaohui Fan, Steward Observatory
Linhua Jiang, ASU
Dan Stark, Steward Observatory
Brenda Frye, Steward Observatory
Fuyan Bian, Steward Observatory

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.2

Abstract:
We serendipitously discovered the brightest galaxy known at z>5 as part of a faint quasar survey. This galaxy has i(AB)=23.2, extremely strong Lyman alpha emission, and is at a redshift of z=5.419. We detected stellar continuum in a relatively shallow optical spectrum, showing that this object is uniquely suited for detailed studies of a star-forming galaxy near the epoch of reionization. We propose brief (1800s x 2) IRAC imaging in the [3.6] and [4.5] bands in order to fill out the spectral energy distribution (SED) at rest-frame optical wavelengths redward of the Balmer break. Using Spitzer data we will constrain the stellar population of this unusual galaxy through SED fitting, determining key parameters such as the stellar mass and age, and the amount of dust extinction. Constraints on the star formation history of a potentially massive galaxy at z>5 will impact models of galaxy formation during the reionization epoch and provide clues to the star formation activity at higher redshift that is thought to drive reionization.

Spitzer Space Telescope - General Observer Proposal #10072

Observations of CO2 in Comets C/2012 S1 ISON and C/2012 K1 PANSTARRS

Principal Investigator: Adam McKay
Institution: New Mexico State University

Technical Contact: Adam McKay, New Mexico State University

Co-Investigators:
Michael Kelley, University of Maryland
Michael DiSanti, NASA Goddard Space Flight Center
Anita Cochran, University of Texas Austin
Neil Dello Russo, Johns Hopkins Applied Physics Laboratory
Carey Lisse, Johns Hopkins Applied Physics Laboratory
Nancy Chanover, New Mexico State University

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.9
Priority: 1

Abstract:
Comets have undergone very little thermal evolution in their lifetimes, resulting in a primitive composition. This primitive composition makes observations of comets very important tools for understanding the origin of the Solar System. The ices H2O, CO2, and CO are the primary ices present in cometary nuclei, and constraining their abundances has tremendous implications for the formation and evolutionary history of comets. Of these ices, H2O and CO can be observed from the ground, while CO2 cannot. A potentially effective tracer for CO2 in comets that is accessible from the ground is atomic oxygen. However, the relationship between these ices and atomic oxygen is only understood at a qualitative level. We propose to use Spitzer observations in IRAC's 4.5 micron band pass to observe the CO2 v3 band at 4.26 microns in comets C/2012 S1 ISON and C/2012 K1 PANSTARRS. These observations will be coordinated with observations of atomic oxygen obtained at Apache Point Observatory and McDonald Observatory and observations of H2O and CO at Keck and IRTF. These observations of H2O, CO2, and atomic oxygen in a cometary coma will increase our understanding of the link between these primary ices and atomic oxygen. With a complete understanding of the relationship between atomic oxygen and the primary ices on the nucleus, observations of atomic oxygen can serve as a powerful proxy for the production of CO2. In addition, ISON is the target of an extensive observing campaign led by NASA, and the proposed Spitzer observations fill a vital niche as the only observatory that can observe CO2 during both the near-perihelion time frame and significantly (months) after perihelion. Understanding the evolution of the CO2 abundance over the apparition is a key piece to understanding how the volatile compostion of the comet changes over the apparition.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13252

Measuring the Hypervolatile Abundance in Comet C/2016 R2 (PanSTARRS)

Principal Investigator: Adam McKay
Institution: NASA GSFS/USRA

Technical Contact: Adam McKay, NASA GSFS/USRA

Co-Investigators:
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Michael DiSanti, NASA GSFC
Neil Dello Russo, Johns Hopkins APL
Olga Harrington Pinto, University of South Florida

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.3

Abstract:
Comets serve as invaluable tools for understanding the formation of the Solar System. By measuring their compositions, we can infer the processes that prevailed over the early Solar System. Despite being recently perturbed into the inner-Solar System, the comets we observe today have undergone very little thermal evolution since their formation, resulting in a near pristine composition. A particularly important quantity to measure in comets is the CO/CO2 ratio, which has implications for the formation and evolution of cometary nuclei. We propose to use Spitzer IRAC observations of CO2 in the likely atypically CO-rich comet C/2016 R2 (PanSTARRS) to better understand CO2 and CO in comets.

Spitzer Space Telescope - General Observer Proposal #14092

Constraining the Compositional Heterogeneity in CO-Dominated Comet C/2016 R2 (PanSTARRS)

Principal Investigator: Adam McKay
Institution: NASA GSFC/USRA

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Anita Cochran, University of Texas at Austin/McDonald Observatory
Olga Harrington Pinto, University of South Florida

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.9
Priority: 2

Abstract:
Comets exhibit a primitive volatile composition, making them invaluable tools for understanding the formation of the Solar System. Constraining the compositional heterogeneity of cometary nuclei is vital for interpreting cometary composition in terms of the physical conditions operating in the protosolar disk at the time of planet formation. Some comets exhibit variability in observed coma composition over the course of their orbit. This could be indicative of a heterogeneous nucleus consisting of cometesimals formed in different parts of the protosolar nebula under differing conditions. Alternatively, the observed heterogeneity could be post-formation evolution. We propose to use Spitzer IRAC observations of CO2 in the atypically CO-rich comet C/2016 R2 (PanSTARRS) to better understand the compositional heterogeneity of cometary nuclei.

Spitzer Space Telescope - General Observer Proposal #80082

Observations of Carbon Dioxide in the Coma of Comet C/2009 P1 Garradd

Principal Investigator: Adam McKay
Institution: New Mexico State University

Technical Contact: Adam McKay, New Mexico State University

Co-Investigators:
William Reach, NASA Ames
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Michael DiSanti, Goddard Space Flight Center
Nancy Chanover, New Mexico State University

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.6

Abstract:
The study of cometary composition is important to understanding the formation and evolution of our solar system. Comets have undergone very little thermal evolution in their lifetimes, which results in their near pristine composition. The nucleus of a comet is very rarely detected directly. Instead, we observe the coma that surrounds the nucleus. Physical and chemical processes in the coma affect its composition, and therefore coma composition is not a direct representation of nuclear composition. An important trend is the observed variation of coma composition with heliocentric distance, most likely influenced by the volatility of the main surface ices, H2O, CO2, and CO. Infrared studies of these molecules are complicated by telluric features, so often daughter molecules of these species such as OH are observed instead. A potentially effective tracer for these primary ices is atomic oxygen in the coma. However, the relationship between these ices and atomic oxygen is only understood at a qualitative level. We propose to use Spitzer observations in IRAC's 4.5 micron band pass to observe the CO2 v3 band at 4.26 microns in comet C/2009 P1 Garradd. These observations will be coordinated with observations of atomic oxygen obtained at Apache Point Observatory and observations of H2O at NASA's Infrared Telescope Facility (IRTF). These near simultaneous observations of H2O, CO2, and atomic oxygen in a cometary coma will increase our understanding of the link between these primary ices and atomic oxygen. With a complete understanding of the relationship between atomic oxygen and the primary ices on the nucleus, observations of atomic oxygen can serve as a powerful proxy for the production of these primary volatiles and aid our understanding of the variation in coma composition as a function of heliocentric distance, and therefore the composition of the nucleus and how our solar system was formed.

Spitzer Space Telescope - General Observer Proposal #90130

Observation of CO2 in Comet C/2012 K5 LINEAR

Principal Investigator: Adam McKay
Institution: New Mexico State University

Technical Contact: Adam McKay, New Mexico State University

Co-Investigators:
Michael Kelley, University of Maryland
Michael DiSanti, NASA Goddard Space Flight Center
Nancy Chanover, New Mexico State University

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18

Abstract:
The study of cometary composition is important to understanding the formation and evolution of our solar system. Comets have undergone very little thermal evolution in their lifetimes, which results in their near pristine composition. The nucleus of a comet is very rarely detected directly. Instead, we observe the coma that surrounds the nucleus. Physical and chemical processes in the coma affect its composition, and therefore coma composition is not a direct representation of nuclear composition. An important trend is the observed variation of coma composition with heliocentric distance, most likely influenced by the volatility of the main surface ices, H2O, CO2, and CO. Infrared studies of these molecules are complicated by telluric features, so often daughter molecules of these species such as OH are observed instead. A potentially effective tracer for these primary ices is atomic oxygen in the coma. However, the relationship between these ices and atomic oxygen is only understood at a qualitative level. We propose to use Spitzer observations in IRAC's 4.5 micron band pass to observe the CO2 v3 band at 4.26 microns in comet C/2012 K5 LINEAR. These observations will be coordinated with observations of atomic oxygen obtained at Apache Point Observatory and observations of H2O at Keck. These near simultaneous observations of H2O, CO2, and atomic oxygen in a cometary coma will increase our understanding of the link between these primary ices and atomic oxygen. With a complete understanding of the relationship between atomic oxygen and the primary ices on the nucleus, observations of atomic oxygen can serve as a powerful proxy for the production of these primary volatiles and aid our understanding of the variation in coma composition as a function of heliocentric distance, and therefore the composition of the nucleus and how our solar system was formed.

Spitzer Space Telescope - General Observer Proposal #13010

Orion: The Final Epoch (OrionTFE)

Principal Investigator: Tom Megeath
Institution: Ritter Observatory, University of Toledo

Technical Contact: Tom Allen, Lowell Observatory

Co-Investigators:
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Thomas Stanke, ESO
Amelia Stutz, MPIA
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Scott Wolk, Harvard Smithsonian Center for Astrophysics

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 59.2
Priority: 1

Abstract:
The Orion molecular clouds are an essential laboratory for studying low mass star formation over the broad range of environments in which they form. Starting with the Spitzer survey of Orion in 2004, more than a decade of observations with Spitzer, WISE, HST and Herschel, have accumulated an unparalleled characterization of the young stellar object population in Orion. We propose a final epoch of observations divided into two separate, complementary observations: A repeat of the entire Orion molecular cloud survey to 1.) identify ejected stars from clusters, 2.) measure the bulk proper motions of groups and clusters of stars, 3.) constrain the rate of luminous, accretion driven outbursts from both protostars and pre-main sequence stars with disks and 4.) use proper motions of IR Herbig-Haro knots as a fossil record of previous accretion events. A high cadence variability survey of the L1641 cloud extending the YSOVAR variability survey of the Orion Nebula Cluster across the Orion A cloud with the goals of 1.) constraining the star formation history of Orion A, 2.) studying the evolution of mid-IR variability from the protostellar to pre-main sequence phase, 3.) searching for periodicities in (nearly) edge-on protostars and disks due to orbiting clumps and structures from orbiting planets, and 4.) assessing whether inner disk processes - as traced by variability - are affected by their birth environment. This program completes an unparalleled, > 12 year multi-epoch, mid-IR study of the nearest large molecular cloud complex with both a wide spatial coverage and a uniformity that will not be exceeded in the forseeable future. It will place unique constraints on the highly dynamic processes that control low mass star formation, serve as a

pathfinder to molecular cloud surveys of WFIRST, and provide well characterized targets needed to study mass accretion and planet formation around young low mass stars with SOFIA and JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14301

A final epoch of YSO variability in Orion

Principal Investigator: Tom Megeath
Institution: University of Toledo

Technical Contact:Tom Megeath, University of Toledo

Co-Investigators:
Wafa Zakri, University of Toledo

Science Category: YSOs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.5
Priority: 1

Abstract:
In the past few years, the importance of episodic accretion in young stellar objects has become clear, with up to 40% of the stellar mass accreted during outbursts. We propose final observations of 36 protostars and pre-ms stars in Orion that have shown > 1 magnitude variability. This will provide the final observations at these wavelengths for the foreseeable future, and will extend the data for these YSOs from 2004 to 2020.

Spitzer Space Telescope - General Observer Proposal #60060

A Wide-Field Survey for Low Mass Star Formation around the Galactic Massive Young Cluster NGC 3603

Principal Investigator: Tom Megeath
Institution: Ritter Observatory, University of Toledo

Technical Contact: Tom Megeath, Ritter Observatory, University of Toledo

Co-Investigators:
Dieter Nuernberger, European Southern Observatory
Hans Zinnecker, Astrophysical Institute Potsdam
Rupali Chandar, University of Toledo

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.8

Abstract:
NGC 3603 is one of the most massive (~10,000 solar masses) and compact (5~pc) young star clusters known in the Milky Way. It is therefore a candidate young globular cluster, with properties similar to massive young clusters found in other galaxies such as the LMC, M51 and the Antenna. Due to its proxmity and low extinction, NGC 3603 is one of the few massive clusters where it is possible to detect the low mass stars that dominate the total mass of the cluster. NGC 3603 lies in the center of a 40 pc diameter, 100,000 solar mass molecular cloud complex; little is known about the stars forming in this complex. We propose the first systematic survey of this complex using deep 3.6 and 4.5 micron Spitzer imaging of a 59 by 57 pc region centered on NGC 3603. By combining this data with scheduled VLT JHK imaging of the same field, we can detect and identify low to intermediate mass stars with disks and protostars in the cloud complex. Our goal is to probe the relationship between spatially extended OB associations and compact clusters of OB stars. Our method is to compare the spatial distribution of intermediate to low mass stars in the extended NGC 3603 complex to that found in OB associations like Orion. Specifically, is NGC 3603 part of a large, extended complex containing both clustered and distributed star formation, and consequently similar to nearby associations? Or did NGC 3603 result from a distinct, compact mode of star formation? These observations will give us unique insight into the process of massive star cluster formation in other galaxies and how this process may differ from star formation near the Sun.

Spitzer Space Telescope - General Observer Proposal #70044

Probing Star and Planet Formation in a Young OB Assocation: Warm Mission Mapping of the Orion OB1 Association

Principal Investigator: Tom Megeath
Institution: Ritter Observatory, University of Toledo

Technical Contact: Tom Megeath, Ritter Observatory, University of Toledo

Co-Investigators:
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Rob Gutermuth, Smith College
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Judy Pipher, University of Rochester
John Stauffer, Spitzer Science Center
David Ciardi, NexSci
Joe Hora, SAO
Fred Adams, University of Michigan

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 78.0

Abstract:
We propose to extend the Spitzer Survey of Orion from the molecular clouds into the neighboring OB association. Together the clouds and association comprise a 75 pc diameter star forming complex where star formation has been sustained for 10 million years. To date, Spitzer surveys of Orion have concentrated on the molecular cloud to probe ongoing star formation. However, the clouds contain only a fraction of the total population of young stars in the complex. A growing number of observations show that the Orion OB1 association, which neighbors the molecular cloud, contains a large a population of young (2-10 Myr) pre-main sequence stars and sub-stellar objects, many of which still retain their dusty disks. Using Spitzer's unique capability to survey wide fields and detect mid-IR emision from dusty disks, we will map the distribution of young stars in two of the youngest sub-groups of the association, the OB1b and c subgroups with ages of 2-5 Myr. The association is likely to contain a few thousand stars, many hundreds of which will exhibit IR-excesses from disk. Based on small, existing fields within the OB1b association, and from examples in other regions such as W5, we expect to see fossil structures in the spatial distribution of young stars which trace the distribution of star formation sites. The distribution of stars both inside and outside the clouds is thus a powerful probe of the star forming history of the Orion complex, and when combined with ground based spectroscopy, can be used to study how star formation is initiated, regulated and terminated in massive complexes like Orion (where most stars of all masses are formed!). In addition, the data will be used to study disk evolution in one of the richest collections of 1-5 Myr old intermediate to solar mass stars and sub-stellar objects within 500 pc of the Sun.

Spitzer Space Telescope - General Observer Proposal #10096

Uncovering Dark Matter in Galaxies Across the Hubble Sequence

Principal Investigator: Sharon Meidt
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Co-Investigators:
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Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 80.7

Abstract:
The CALIFA survey is currently obtaining high-quality Integral Field Spectroscopic (IFS) data for a diameter-selected sample of nearby galaxies, providing stellar kinematics that are essential to accurately infer through dynamical modelling the total mass in galaxies ranging from ellipticals to spirals. The survey extends out to larger galactocentric radii, overlapping with regions where the dark matter begins to dominate, and covers a longer wavelength range than existing IFS surveys. Here we propose to obtain IRAC imaging at 3.6 and 4.5 microns to map the stellar mass distributions in a sample of 365 CALIFA galaxies. With our new techniques to robustly isolate the old stellar population in the IRAC images, we are able to estimate stellar masses significantly more accurately than at other wavelengths. The difference between the total mass from CALIFA and stellar mass from Spitzer will place unparalleled constraints on the dark matter content of galaxies across the Hubble sequence. The combination of CALIFA stellar kinematics and IRAC imaging will further allow us to perform a novel homogeneous study of the shape and variation of the stellar intitial mass function (IMF) in galaxies of all types, thereby testing the framework of a 'Universal' IMF. The pairing of the CALIFA data set with the proposed observations--ideally matched in field of view and resolution--will put us firmly on the path to understanding the interplay between baryons and dark matter in galaxies.

Spitzer Space Telescope - General Observer Proposal #14034

IRAC Photometry of the Coldest CatWISE-selected Brown Dwarfs

Principal Investigator: Aaron Meisner
Institution: University of California, Berkeley

Technical Contact: J.Davy Kirkpatrick, IPAC

Co-Investigators:
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Peter Eisenhardt, JPL
Federico Marocco, JPL
Jacqueline Faherty, AMNH
Michael Cushing, University of Toledo
Edward Wright, UCLA

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 40.5
Priority: 1

Abstract:
We will obtain IRAC [3.6] and [4.5] photometry of ~250 extremely cool brown dwarfs newly revealed by the powerful combination of WISE and NEOWISE imaging at 4.6 microns. Our CatWISE effort, which is an archival data analysis program using WISE and NEOWISE data, will improve upon the motion selection of AllWISE by enabling a >10x time baseline enhancement, from 0.5 years (AllWISE) to 6.5 years (CatWISE). As a result, CatWISE motion selection is expected to yield a dramatic 8-fold increase in the sample of known brown dwarfs at spectral types T5 and later (T < 1,200 K). Many of the coolest such CatWISE discoveries will be detected exclusively in the WISE 4.6 micron (W2) channel. WISE W1 (3.4 micron) nondetections, which we expect for the majority of our most interesting sources, will provide only limits on mid-infrared color. Spitzer can supply this critical datum by measuring accurate [3.6]-[4.5] colors of our discoveries. These Spitzer color measurements will permit photometric spectral type estimates, which in turn yield estimates for critical parameters including luminosity, distance, and near-infrared flux. Using large [3.6]-[4.5] color to pinpoint the coldest late T and Y dwarfs among our CatWISE sample will enable us to prioritize these objects for spectroscopic follow-up, better understand the bottom of the substellar mass function, and identify nearby giant planet analogs suitable for future atmospheric studies with JWST.

Spitzer Space Telescope - General Observer Proposal #70020

Period Luminosity Relationships and Mass-Loss Rates of Asymptotic Giant Branch Stars

Principal Investigator: Margaret Meixner
Institution: Space Telescope Science Institute

Technical Contact: David Riebel, Johns Hopkins University

Co-Investigators:
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Marilyn Meade, University of Wisconsin
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Uma Vijh, University of Toledo
Peter Wood, Mt. Stromlo Obs. & Aust. Nat. Univ.
Paul Woods, University of Manchester

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 43.6

Abstract:
Using data from the Spitzer Surveys of the Large Magellanic Cloud (LMC) and Small Magellanic cloud (SMC): Surveying the Agents of Galaxy Evolution (SAGE), we have been able to classify candidate asymptotic giant branch (AGB) star populations, estimate their mass-loss rates based on infrared excesses and derive infrared period-luminosity (P-L) relationships from a sample of ~30,000 stars. However, the intrinsic variability of these sources, especially at 3.6 and 4.5 microns, which sample the peak of the SEDs, causes our estimates of the mass-loss rate to be uncertain by a factor of ~2, and produces a scatter of +/- 1 mag in the period-luminosity relationship at these wavelengths. We propose to obtain 4 additional epochs of data at both 3.6 and 4.5 microns for ~6100 and ~1500 AGB variable stars in the bar regions of the LMC and Small Magellanic Cloud (SMC), respectively. These data will provide, for the first time, precise (+/- 0.05 mag) mean magnitudes at the crucial peak of the SED for these sources. This accuracy will allow us to use radiative transfer modeling to reduce the uncertainty in our estimates of the mass-loss rate by a factor of ~2, and the scatter in the P-L relationship by a factor of ~20. The reduced scatter will make the P-L relationship of AGB stars a viable distance indicator for future IR missions, such as JWST. The proposed survey area overlaps deliberately with the OGLE-III, SuperMacho, and IRSF variability surveys of the LMC and SMC, adding to the legacy value of our proposed variability study.

Spitzer Space Telescope - General Observer Proposal #80121

The First Light Curves of the Dustiest, Most Extreme Asymptotic Giant Branch Stars in the LMC and SMC

Principal Investigator: Margaret Meixner
Institution: Space Telescope Science Institute

Technical Contact: Margaret Meixner, Space Telescope Science Institute

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Massimo Marengo, Iowa State University
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Masaaki Otsuka, STScI
Ben Sargent, STScI
Sundar Srinivasan, Institute Astrophysique de Paris

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 19.1

Abstract:
Asymptotic giant branch (AGB) variable stars are, together with supernovae, the main sources of enrichment of the interstellar medium (ISM) in processed material, particularly carbon, nitrogen and heavy s-process elements. The dustiest, extreme AGB stars contribute the largest enrichment per star. We propose to measure the first light curves for 20 and 5 of the dustiest, most extreme AGB variable stars in the bar regions of Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC), respectively, using the warm Spitzer mission?s IRAC 3.6 and 4.5 micron imaging for monthly imaging measurements. Though we know they are variable based on dual-epoch observations from the Spitzer Surveying the Agents of Galaxy Evolution (SAGE) surveys of the LMC and SMC, the periods of these extreme AGB stars have NOT been measured before because they are too faint in the optical and near-infrared to have been captured in the ground based synoptic surveys such as MACHO, OGLE and IRSF. Only Spitzer will be able to measure the light curve of this key phase of the AGB: the dustiest and indeed final stage of the AGB. Without this information, our developing picture of AGB evolution is decidedly incomplete. The observations we propose will test the validity of AGB evolution models, and, thus, their predictions of the return of mass and nucleosynthetic products to the ISM.

Spitzer Space Telescope - General Observer Proposal #70149

IRAC Imaging of Massive ACT SZ Clusters

Principal Investigator: Felipe Menanteau
Institution: Rutgers University

Technical Contact: Matt Hilton, University of KwaZulu-Natal

Co-Investigators:
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David Spergel, Princeton University
Tobias Marriage, Princeton University
Kavilan Moodley, University of KwaZulu-Natal
Leopoldo Infante, P. Universidad Catolica de Chile
Felipe Barrientos, P. Universidad Catolica de Chile
Yen-Ting Lin, IPMU

Science Category: cosmology
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 53.4

Abstract:
We propose to obtain deep Spitzer observations for a mass-selected and redshift-independent sample of galaxy clusters detected by the Atacama Cosmology Telescope (ACT) using the Sunyaev-Zeldovich effect (SZE). The proposed deep IRAC observations of 19 massive, newly-discovered SZE clusters will provide an unprecedented window to study the properties of high redshift lensed background galaxies and an unbiased census of the stellar mass content in massive clusters out to redshifts of 1. Additionally, we propose shallower IRAC imaging of 6 high-significance (S/N > 5) SZE cluster candidates that were not detected in our deep optical program in order to probe the existence of z > 1.5 massive systems and provide a simple yet powerful test of Lambda-CDM. The proposed Spitzer observations are part of an intensive multi-wavelength campaign to produce an unbiased, well-observed sample of massive galaxy clusters out to high redshifts for cosmological investigations.

Spitzer Space Telescope - General Observer Proposal #80138

IRAC Imaging of Massive ACT SZ Clusters in SDSS Stripe 82

Principal Investigator: Felipe Menanteau
Institution: Rutgers University

Technical Contact: Matt Hilton, University of Nottingham

Co-Investigators:
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Felipe Barrientos, P. Universidade Catolica de Chile
Yen-Ting Lin, IPMU

Science Category: cosmology
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 57.5

Abstract:
We propose to complete a program of deep Spitzer observations of a mass-selected and redshift-independent sample of galaxy clusters detected by the Atacama Cosmology Telescope (ACT) using the Sunyaev-Zeldovich effect (SZE). The proposed deep IRAC observations of 22 massive, newly-discovered, optically confirmed SZE clusters will provide an unprecedented window to study the properties of high redshift lensed background galaxies and an unbiased census of the stellar mass content in massive clusters out to redshifts of 1. The clusters are located within the footprint of SDSS Stripe 82, providing deep optical (ugriz) data. The proposed Spitzer observations are part of an intensive multi-wavelength campaign to produce an unbiased, well-observed sample of massive galaxy clusters out to high redshifts for cosmological investigations.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12124

"Where’s the flux" star: Exocomets, or Giant Impact?

Principal Investigator: Huan Meng
Institution: University of Arizona

Technical Contact: Huan Meng, Arizona

Co-Investigators:
Tabetha Boyajian, Yale University
Grant Kennedy, University of Cambridge
Carey Lisse, Johns Hopkins University
Massimo Marengo, Iowa State University
Jason Wright, Pennsylvania State University
Mark Wyatt, University of Cambridge

Science Category: debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
The discovery of an unusual stellar light curve in the Kepler data of KIC 8462852 has sparked a media frenzy about "alien megastructures" orbiting that star. Behind the public’s excitement about "aliens," there is however a true science story: KIC 8462852 offers us a unique window to observe, in real time, the rare cataclysmic events happening in a mature extrasolar planetary system. After analysis of the existing constraints of the system, two possible models stand out as the plausible explanations for the light curve anomaly: immediate aftermath of a large planetary or planetesimal impact, or apparitions of a family of comets or comet fragments. The two plausible models predict very different IR evolution over the years following the transit events, providing a good diagnostic to distinguish them. With shallow mapping of the Kepler field in January 2015, Spitzer/IRAC has found KIC 8462852 with a marginal excess at 4.5 micron. Here, we propose to monitor KIC 8462852 on a regular basis to identify and track its IR excess evolution with deeper images and more accurate photometry.

Spitzer Space Telescope - General Observer Proposal #13138

"Where's the flux" star: Return of the Dust?

Principal Investigator: Huan Meng
Institution: Arizona

Technical Contact: Huan Meng, Arizona

Co-Investigators:
Tabetha Boyajian, Yale University
Grant Kennedy, University of Cambridge
Carey Lisse, Johns Hopkins University
Massimo Marengo, Iowa State University
Jason Wright, Pennsylvania State University
Mark Wyatt, University of Cambridge

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.4
Priority: 1

Abstract:
The Kepler lightcurve of star KIC 8462852 (F2/3V, d=450 pc with M = 1.43 M_{\\sun}, R = 1.58 R_{\\sun}, L = 4.7 L_{\\sun} is unique in its magnitude and complex structure, and provides, in real time, the rare chance to observe cataclysmic events happening in a mature extrasolar planetary system. After analysis of the existing constraints of the system, two possible models stand out as the plausible explanations for the light curve anomaly: immediate aftermath of a large planetary or planetesimal impact (associated to a 750 days orbit corresponding to the separation of the main dimming events observed by Kepler), or apparitions of a family of comets or comet fragments. To discriminate between these two possible scenarios we have monitored the brightness of the source with Spitzer/IRAC during Cycle 12. Our photometry shows that the IR brightness of the source has not changed since Spitzer?s first visit in January 2015, suggesting either that the cloud formed following a giant impact has still not spread to interplanetary space, or that the cometary fragments have yet to return to the proximity of the star. Cycle 13 offers a unique opportunity to solve this riddle: if the ~750 days period associated to the large impact scenario is real, we may be able to finally detect an increase in the infrared flux in May 2017. We thus propose to extend our monitoring of the source during Cycle 13.

Spitzer Space Telescope - General Observer Proposal #14110

"Where's the flux" star: Where's the excess?

Principal Investigator: Huan Meng
Institution: Arizona

Technical Contact: Huan Meng, Arizona

Co-Investigators:
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Grant Kennedy, University of Cambridge
Carey Lisse, Johns Hopkins University
Massimo Marengo, Iowa State University
Jason Wright, Pennsylvania State University
Mark Wyatt, University of Cambridge

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.8
Priority: 2

Abstract:
KIC 8462852 provides, in real time, the rare chance to observe cataclysmic events happening in a mature extrasolar planetary system. The Kepler light curve of the star sees two major dips ~750 days apart with depths of ~20%, as well as a number of smaller dips (~1%) at apparently random time. A series of new, shallow (2-4% in flux) dips has been observed since May 2017 and as late as March 2018. In addition to the days-long dips, the star has also been found to have long-term variations over years, and possibly centuries. Conclusions from existing observations suggest that the dips and long-term variations are likely caused by transits of dust clumps in front of the star. We have observed KIC 8462852 with Spitzer/IRAC since cycle 12. We propose to continue the monitoring in cycle 14 to track the long-term variations of the stellar flux, measure the optical properties of the transit dust, and look for possible transient excess if new dips happen close in time to our observations.

Spitzer Space Telescope - General Observer Proposal #11174

A Paradigm Shift in Substellar Classification: Understanding the Apparent Diversity of Substellar Atmospheres through Viewing Geometry

Principal Investigator: Stanimir Metchev
Institution: The University of Western Ontario

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Co-Investigators:
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Mark Marley, NASA Ames
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Adam Burgasser, UCSD

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 512.5
Priority: 1

Abstract:
Results from our Cycle 8 Spitzer Exploration Science program Weather on Other Worlds (WOW) have suggested a potential transformative result for understanding the atmospheric and evolutionary properties of substellar objects. We have found tentative evidence for a correlation between atmospheric appearance and viewing geometry - much as in the now established AGN unification models. In particular, we have found that among L6-T8 dwarfs only those with J-K colors redder than the median are variable. Since apparent variability is enhanced for equator-on viewing geometries, we interpret this as a latitudinal dependence in appearance: redder L6-T8 dwarfs are seen closer to equator-on, and bluer ones are closer to pole-on. This result has the potential to solve the long-standing problem of cloud dissipation in L and T dwarfs: by explaining the broad range in spectroscopic appearance and near-infrared colors of L and T dwarfs as a geometric effect, rather than related to atmospheric dynamics. The implications are substantially broader, and touch on a range of issues in substellar astrophysics, such as the calibration of substellar effective temperatures and bolometric luminosities, and the modeling of ultracool atmospheres and substellar evolution - both of which will require at least a 2-D treatment. We propose an Exploration Science program to map the correspondence between spin-axis orientation, substellar colors, and spectral type. All of the L and T dwarfs in our proposed sample will have measured projected (vsini) rotational velocities within a year. By obtaining photometric periods through sensitive staring observations with Spitzer, and by using the fact that the radii of >1 Gyr-old brown dwarfs are approximately age-independent, we will be able to solve for the spin axis orientations. We will correlate these with variability amplitude, near-infrared colors, and spectral types, to solve for the meridional dependence in the spectroscopic appearance of L and T dwarfs.

Spitzer Space Telescope - General Observer Proposal #80179

Weather on Other Worlds: A Survey of Cloud-Induced Variability in Brown Dwarfs

Principal Investigator: Stanimir Metchev
Institution: State University of New York, Stony Brook

Technical Contact: Daniel Apai, University of Arizona, USA

Co-Investigators:
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Etienne Artigau, University of Montreal, Canada
Mark Marley, NASA Ames Research Center, USA
Peter Plavchan, Caltech/IPAC, USA
Bertrand Goldman, Max-Planck Institut fur Astronomie, Germany
Kerstin Geissler, SUNY Stony Brook, USA
Ray Jayawardhana, University of Toronto, Canada

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 873.0

Abstract:
We propose a comprehensive program to detect periodic brightness variations in L and T dwarfs caused by the spatially inhomogeneous distribution of dusty clouds--weather patterns--in their atmospheres. We will seek trends over a broad set of substellar characteristics, encompassing objects with a range of temperatures, colors, and ages. While numerous variability searches have been conducted on L and T dwarfs to date, the vast majority have been ground-based and limited in precision. Only recently did members of the presently assembled team produce clear and repeatable detections of periodic flux variations in a half dozen substellar objects, thus providing the first strong evidence for heterogeneous cloud cover in their atmospheres. Spitzer's factor of 3-5 superior photometric precision enables a much more sensitive and comprehensive study of the atmospheric dynamics underlying the phenomenon. Our program will increase the scope of mid-infrared variability studies of brown dwarfs by more than an order of magnitude. We will target 44 ultra-cool dwarfs with spectral types between L3-T8, spanning the full color range at each spectral subtype, and including both low-gravity and field objects. We anticipate significant detections of periodicities as small as 10 milli-magnitudes in amplitude, which will enable the routine detection of weather patterns smaller than Jupiter's Great Red Spot on extrasolar substellar objects. The presence and brightness temperature distribution of these weather patterns will be analyzed in the context of state-of-the-art cloudy atmospheric models, and will reveal the longitudinal and vertical thermodynamics of substellar atmospheres. The proposed program will be relevant to the broader understanding of rotating, low-temperature, brown dwarf and exoplanetary atmospheres: a regime entirely different from that of the irradiated hot-Jupiter type extrasolar planets studied with Spitzer to date.

Spitzer Space Telescope - General Observer Proposal #14131

Ultra-cool dwarfs viewed equator-on: surveying the best host stars for biosignature detection in transiting exoplanets

Principal Investigator: Paulo Miles-Paez
Institution: The University of Western Ontario

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Megan Tannock, The University of Western Ontario
Amaury Triaud, Cambridge Exoplanet Research Centre

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1074.7
Priority: 1

Abstract:
There are about 150 known planets around M dwarfs, but only one system around an ultra-cool (>M7) dwarf: Trappist-1. Ultra-cool dwarfs are arguably the most promising hosts for atmospheric and biosignature detection in transiting planets because of the enhanced feature contrast in transit and eclipse spectroscopy. We propose a Spitzer survey to continuously monitor 15 of the brightest ultra-cool dwarfs over 3 days. To maximize the probability of detecting transiting planets, we have selected only targets seen close to equator-on. Spin-orbit alignment expectations dictate that the planetary systems around these ultra-cool dwarfs should also be oriented nearly edge-on. Any planet detections from this survey will immediately become top priority targets for JWST transit spectroscopy. No other telescope, present or within the foreseeable future, will be able to conduct a similarly sensitive and dedicated survey for characterizeable Earth analogs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14257

Confirming the First Exoplanet around an L Dwarf

Principal Investigator: Paulo Miles-Paez
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Etienne Artigau, Universite de Montreal
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Amaury Triaud, University of Birmingham
Megan Tannock, The University of Western Ontario

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 316.8
Priority: 1

Abstract:
There are nearly 200 known planets around M dwarfs, but only one system around an ultra-cool (>M7) dwarf: Trappist-1. Ultra-cool dwarfs are arguably the most promising hosts for atmospheric and biosignature detection in transiting planets because of the enhanced feature contrast in transit and eclipse spectroscopy. We are conducting a Spitzer Cycle 14 survey to continuously monitor 15 of the brightest ultra-cool dwarfs over 3 days. To maximize the probability of detecting transiting planets, we have selected only targets seen close to equator-on. Spin-orbit alignment expectations dictate that the planetary systems around these ultra-cool dwarfs should also be oriented nearly edge-on. We have detected our first rocky transiting exoplanet: a potentially habitable sub-Earth around a 0.076 solar-mass L1.5 dwarf. Our three-day sequence shows only a single transit. We seek follow-up monitoring to determine the period of the planet and detect any additional planets in the system. If the planet is confirmed to be in the habitable zone, it will become a top JWST target for atmospheric characterization and biogenic gas detection.

Spitzer Space Telescope - General Observer Proposal #70059

Linking Cold Gas and Dust with Intracluster-Medium Cooling, Star Formation and AGN Heating in Brightest Cluster Galaxies

Principal Investigator: Rupal Mittal
Institution: Rochester Institute of Technology

Technical Contact: Rupal Mittal, Rochester Institute of Technology

Co-Investigators:
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Stefi Baum, Rochester Institute of Technology
Francoise Combes, Observatoire de Paris
Megan Donahue, Michigan State University
Brian McNamara, University of Waterloo
Alastair Edge, University of Durham
Grant Tremblay, Rochester Institute of Technology
Alice Quillen, University of Rochester
Eiichi Egami, University of Arizona

Science Category: galaxy clusters and groups(low-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
Numerous studies of the cores of galaxy clusters have revealed that the gas in central regions is not cooling at the rates predicted by the traditional cooling flow model. This discrepancy has inspired a search for heating models that can explain current observations. AGN feedback is considered an attractive solution to several connected problems, such as the high-mass end truncation of galaxy distribution and the absence of cooling-flows in centers of galaxy clusters. Amidst the emerging hypothesis of self-regulated AGN feedback, infrared, optical and FUV observations of clusters also indicate the presence of large amounts of cold gas in their brightest cluster galaxies (BCGs). In this proposal we aim to investigate a sample of 11 BCGs covering a representative range of BCG and cluster properties and having an extensive wavelength coverage. This sample is the basis of a Herschel Key Project and has been awarded 130 hrs with Herschel to study the detailed properties of the cold gas and dust in these systems. We propose to obtain Spitzer IRAC 3.6 micron and 4.5 micron observations of the only two BCGs in our sample that have MIPS but no IRAC data. All of the remaining 9 BCGs have been observed with both IRAC as well as MIPS. These observations will help us to accurately constrain the spectral energy distribution of the dust in these BCGs, to estimate the star formation rates for comparison with the X-ray derived gas mass-deposition rates, and to examine the AGN contribution to the IR emission. We can then better understand the complex inter-relationship between the cooling of the intracluster-medium, cold gas and dust, star formation and AGN activity.

Spitzer Space Telescope - General Observer Proposal #10109

(Not yet) Dead Comets in the Near-Earth Object Population

Principal Investigator: Michael Mommert
Institution: Northern Arizona University

Technical Contact: Michael Mommert, Northern Arizona University

Co-Investigators:
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Michael Mueller, SRON
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Robert McMillan, LPL
William Reach, USRA
Josh Emery, University of Tennessee
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Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.4
Priority: 2

Abstract:
Near-Earth objects (NEOs) are replenished from a number of source regions in the asteroid main belt, but also from the comets. Most of the objects of cometary origin in the NEOs have ceased their activity, making these "dead comets" nearly indistinguishable from low-albedo asteroids. Knowledge of the fraction of cometary NEOs is important to constrain the amount of cometary, carbonaceous material that has been brought to the Earth. We propose to observe 9 NEOs that are likely to be dead comets, for which we will derive diameters and albedos using thermal modeling. The measurement of the albedo provides evidence for a possibly cometary nature. The results of this project will contribute to constraining the fraction of NEOs that are of cometary origin. Furthermore, it will help investigating a possible relationship between dynamical properties and the albedo. In addition, high dynamic range (HDR) observations of 3 of our sample targets will be used to search for cometary activity in these objects. This method has been successful in NEO (3552) Don Quixote, where it revealed activity driven by CO2 gas. Our observations will be supported by ground-based optical observations that will improve the accuracy of the albedo measurements and perform an independent search for activity.

Spitzer Space Telescope - General Observer Proposal #12043

Search for CO2/CO Band Emission in Active Asteroid 324P

Principal Investigator: Michael Mommert
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Technical Contact: Michael Mommert, Northern Arizona University

Co-Investigators:
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Science Category: asteroids
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5.1
Priority: 1

Abstract:
Until a few decades ago, the distinction between asteroids and comets seemed to be simple: comets exhibit activity in the form of a coma and/or a tail as a result of the sublimation of surface ices, whereas asteroids are inactive, rocky bodies. The separation between the two groups became less clear with the discovery of asteroidal bodies that exhibit comet-like dust activity - the active asteroids. For some of those objects, disruption or mass loss due to rotational destabilization or recent collisions are the most likely processes causing the activity. Other objects display recurrent dust activity near perihelion that seems to be caused by the sublimation of ices, but gases have never been directly measured in them. We propose the first Spitzer observations of recurrently active asteroid 324P to search for emission from CO2 or CO. Our observations will detect emission from either gas with unprecedented sensitivity and provide the first ever confirmed detection of volatiles in an active asteroid. We will measure the CO2/CO gas production rates - or put upper-limits on them in the case of a lack of emission. The detection of sublimation-driven activity in active asteroids provide important constraints on the volatile inventory of the inner Solar System and Solar System formation models, gives insight into volatile preservation/retention in asteroidal bodies, and may be relevant to primordial terrestrial water delivery scenarios, as well as future asteroid resource utilization. This proposal conforms with the Spitzer Cycle 12 focus on planetary science programs observing targets in our Solar System.

Spitzer Space Telescope - General Observer Proposal #13008

Constraining the Bulk Density of 10m-Class Near-Earth Asteroid 2012 LA

Principal Investigator: Michael Mommert
Institution: Northern Arizona University

Technical Contact: Michael Mommert, Northern Arizona University

Co-Investigators:
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Davide Farnocchia, JPL
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Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30
Priority: 1

Abstract:
The physical properties of near-Earth asteroids (NEAs) provide important hints on their origin, as well as their past physical and orbital evolution. Recent observations seem to indicate that small asteroids are different than expected: instead of being monolithic bodies, some of them instead resemble loose conglomerates of smaller rocks, so called ’rubble piles’. This is surprising, since self-gravitation is practically absent in these bodies. Hence, bulk density measurements of small asteroids, from which their internal structure can be estimated, provide unique constraints on asteroid physical models, as well as models for asteroid evolution. We propose Spitzer Space Telescope observations of 10 m-sized NEA 2012 LA, which will allow us to constrain the diameter, albedo, bulk density, macroporosity, and mass of this object. We require 30 hrs of Spitzer time to detect our target with a minimum SNR of 3 in CH2. In order to interpret our observational results, we will use the same analysis technique that we used in our successful observations and analyses of tiny asteroids 2011 MD and 2009 BD. Our science goal, which is the derivation of the target’s bulk density and its internal structure, can only be met with Spitzer. Our observations will produce only the third comprehensive physical characterization of an asteroid in the 10m size range (all of which have been carried out by our team, using Spitzer). Knowledge of the physical properties of small NEAs, some of which pose an impact threat to the Earth, is of importance for understanding their evolution and estimating the potential of destruction in case of an impact, as well as for potential manned missions to NEAs for either research or potential commercial uses.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13164

Spitzer identification of potentially active Near-Earth Asteroids

Principal Investigator: Michael Mommert
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Science Category: NEOs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.4

Abstract:
The separation between asteroids and comets has become less clear with the discovery of a small group of asteroids that display comet-like activity. While the activity is attributed to different mechanisms, some objects seem to activate close to the Sun. Near-Earth Asteroids (NEAs) come close to the Earth and the Sun, constituting a natural laboratory for the study of thermally induced activity. Two NEA sub- populations are especially suspected of being potentially active: dormant comets and near-Sun asteroids. We propose 12.4 hrs of Spitzer IRAC observations of 3 near-Sun asteroids and one dormant comet (3552) Don Quixote, about which we have already published. Our goals are (1) to search for activity in Don Quixote, which showed CO/CO2 activity during its previous apparition and (2) to search for activity and measure the diameters and albedos of the near-Sun asteroids. In combination with a funded ground-based observing program, our results will provide significant legacy value to the investigation of activity in near-Earth asteroids.

Spitzer Space Telescope - General Observer Proposal #14025

A Spitzer Search for Activity in Dormant Comets

Principal Investigator: Michael Mommert
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Technical Contact: Michael Mommert, Northern Arizona University

Co-Investigators:
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Science Category: asteroids
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.9
Priority: 2

Abstract:
Dormant comets are inactive cometary nuclei hiding in the asteroid populations. Due to their cometary origin, it is possible that volatiles are still retained in their interiors. This hypothesis is supported by the case of near-Earth asteroid Don Quixote, which had been known as an asteroid for 30 yr before activity was discovered in this team's prior Spitzer observations. Interestingly, Don Quixote showed outgassing of CO or CO2, but no dust activity. This significant observation was repeated in 2017 with the same result, suggesting that Don Quixote is continuously outgassing - and still an active comet. Don Quixote's case suggests that other dormant comets might be outgassing with low dust production rates, concealing their activity to optical surveys. The implication of this scenario is that the volatile inventory of the asteroid populations might be significantly larger than currently assumed. We propose 48.8 hr of deep IRAC observations of eight dormant comets in search of faint activity in them. For each target, we will (1) measure (or provide upper limits on) gas and dust production rates from our IRAC CH1 and CH2 observations, (2) derive the diameters and albedos of five of our targets using asteroid thermal modeling, (3) measure the near-infrared spectral slope between CH1 and CH2 for three of our targets, and (4) obtain lightcurve observations of the nuclei of all of our targets. Our observations, which are combined with ground-based observations as part of a NASA-funded program, will provide important constraints on the volatile content of the asteroid population, as well as the origin, evolution, and physical properties of cometary nuclei.

Spitzer Space Telescope - General Observer Proposal #10122

LHS 6343C: Precise Constraints on the Atmospheric Parameters of an Effectively Isolated Brown Dwarf

Principal Investigator: Benjamin Montet
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Co-Investigators:
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Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.2
Priority: 1

Abstract:
While more than 1000 brown dwarfs have been detected, the only objects with measured masses, radii, and atmospheric properties are highly irradiated transiting companions with atmospheric temperatures significantly higher than comparable isolated brown dwarfs. Considerable effort has been made in the development of models to explain brown dwarf mass-radius relations; these models depend on the cooling and corresponding contraction of the object. Models of the radius evolution through time remain poorly constrained because there are no benchmark systems to which to compare the models. LHS 6343C, a brown dwarf transiting one member of a nearby M+M binary in the Kepler field, has a well-constrained mass and radius but not yet a luminosity. Since it is in a relatively wide orbit around a cool dwarf star, irradiation effects are negligible and LHS 6343C should behave like a field brown dwarf. We propose to obtain secondary eclipse observations of this brown dwarf, providing us the first opportunity to measure atmospheric properties of an effectively isolated brown dwarf with known mass and radius. By observing eclipses in each of Spitzer?s bandpasses, we can determine the temperature and mid-IR color of the brown dwarf and constrain its luminosity. This will be the first brown dwarf for which mass, radius, and luminosity have been independently measured and will enable a strong and unique test of brown dwarf evolution models. The availability of precise secondary eclipse measurements for this brown dwarf will allow for the first comparison to models in the mass-radius-luminosity surface and, if discrepancies are found, will motivate the development of entirely new brown dwarf atmosphere models.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13161

Variability in the terrestrial zone of an extreme debris disk: an uninterrupted Spitzer monitoring

Principal Investigator: Attila Moor
Institution: Konkoly Observatory

Technical Contact: Attila Moor, Konkoly Observatory

Co-Investigators:
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Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 7.6

Abstract:
The origin of the high fractional luminosity 'extreme debris disks', discovered by Spitzer as a new class, is thought to be related to recent giant collisions in the innermost 1-2 AU of the debris disk. Previous monitoring data revealed that the infrared emission is often variable, suggesting changes in the dust distribution on orbital timescales, but long continuous multi-epoch data sets are still missing. Our group recently discovered the most extreme debris disk so far around a young solar-analog star, and here we propose to scrutinize it with Spitzer. Sparse data from the NEOWISE mission shows that the disk is variable at 3.4 and 4.6 micrometer. The proposed long gap-free Spitzer monitoring at an ecliptic latitude of 87 deg will reveal brightening/fading timescales, which determine the minimum mass of the released dust, constrain the size of fragmented bodies, and point to probable dust formation mechanisms. The observations will provide the highest value dataset to detect and understand those huge collisions which probably occurred also in the early solar system, being responsible for the formation of the Moon.

Spitzer Space Telescope - General Observer Proposal #14071

Exploration of the aftermath of a large collision in an extreme debris disk

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Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5.8
Priority: 2

Abstract:
Warm debris disks with extremely high fractional luminosities are exceptional, rare systems. Not explainable by steady-state evolutionary models, these extreme debris disks are believed to stem from a recent large collision of planetary embryos in the terrestrial zone. Our team recently discovered a new extreme debris disk around TYC 4209-1322-1, whose WISE W1/W2 band photometry showed a significant brightening probably related to a giant collision in the inner disk. In Cycle 13 we monitor the system by Spitzer, revealing a fading trend with an e-folding time of ~1500 days with hints for a quasi-periodic modulation and a possible second smaller amplitude collision event. Here we propose to continue the monitoring campaign until the end of Cycle 14 to explore the evolution of the current long fading trend and of the second collision, and characterize the hinted modulation. Thanks to a better sampled Spitzer light curve and the unique opportunity that NASA's TESS satellite will obtain high-precision optical photometry in the same period, a new dimension will be opened in Cycle 14 in the study of one of the most spectacular extreme debris disk, scrutinizing for the first time the possible influence of stellar activity on a debris disk.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14233

Confirmation of the brightest galaxy candidates at z>8

Principal Investigator: Takahiro Morishita
Institution: Space Telescope Science Institute

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Co-Investigators:
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Science Category: High-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.3
Priority: 1

Abstract:
Studying galaxy luminosity functions (LFs) over the cosmic time is a key approach for progress before JWST.Recent studies at z>7 reported a possible evidence of deviation from the Schechter form LF, with an excess at the bright end. Indeed, previous spectroscopic confirmation of two very luminous galaxies at z=8.68 and z=11.09 supports the argument, and dramatically changed our understanding of the universe and galaxy evolution in the early universe. In this program, we aim at confirmation of 12 bright galaxy candidates at z>8, recently identified from the Brightest of Reionizing Galaxies (BoRG), a pure-parallel HST observing program, which is acquiring 1000 pure-parallel orbits with WFC3 in HST cycles 22 and 25. Among all photometric sources collected in 106 independent HST line-of-sights, those high-quality photometric sources are exceptionally bright (m125=25-26, or MUV~-23 to -21.5 if confirmed at z>8). Addition of an hour IRAC CH1 imaging for each field will significantly improve their photometric redshift estimate, efficiently differentiating if they are genuine high-z galaxies or low-z interlopers. With the redshift confirmation, we will gain insight into the early evolution of galaxy from the shape of refined LFs, while those luminous sources will be promising and ideal high-z samples for future spectroscopic observations by JWST.

Spitzer Space Telescope - General Observer Proposal #70054

First thermal observations of an eclipsing near-Earth asteroid

Principal Investigator: Michael Mueller
Institution: Observatoire de la Cote d'Azur

Technical Contact: Michael Mueller, Observatoire de la Cote d'Azur

Co-Investigators:
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Cristina Thomas, NAU
John Kistler, NAU
Alan Harris, DLR Berlin
Michael Mommert, DLR Berlin
Joshua Emery, University of Tennessee

Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 17.6

Abstract:
We propose to obtain the first thermal observations of an eclipsing binary near-Earth asteroid, 1996 FG3. Through previous Spitzer observations, we have demonstrated (Mueller et al., 2010) that such observations enable a uniquely direct determination of the thermal inertia. Thermal-inertia measurements are crucial for constraining the surface properties by differentiating between regolith-covered, mature surfaces and younger bare-rock surfaces. Additionally, thermal inertia governs the important (for all D<10 km objects) Yarkovsky effect, a non-gravitational orbital drift due to thermal photons. Thanks to its low-deltaV orbit, our target has been repeatedly considered as a spacecraft target. Our results may be uniquely important in planning sample-return missions such as those being prepared by all major space agencies.

Spitzer Space Telescope - General Observer Proposal #80084

Eclipsing binary asteroid 2000 DP107

Principal Investigator: Michael Mueller
Institution: Observatoire de la Cote d'Azur

Technical Contact: Michael Mueller, Observatoire de la Cote d'Azur

Co-Investigators:
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Shantanu Naidu, UCLA

Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 11.0

Abstract:
We propose thermal observations of the eclipsing binary near-Earth asteroid 2000 DP107 before, during, and after two total secondary eclipses, where the secondary component is completely eclipsed by the primary. Through previous Spitzer observations, we have demonstrated (Mueller et al., 2010) that such observations enable a uniquely direct determination of the thermal inertia. Thermal-inertia measurements are crucial for constraining the surface properties by differentiating between regolith-covered, mature surfaces and younger bare-rock surfaces. Additionally, thermal inertia governs the important (for all D<10 km objects) Yarkovsky effect, a non-gravitational orbital drift due to thermal photons. Thanks to its low-deltaV orbit and our excellent knowledge about its physical properties (to which the proposed observations will add), 2000 DP107 is a desirable, low-risk target for spacecraft exploration.

Spitzer Space Telescope - General Observer Proposal #90145

Last call for Spitzer support of sample-return mission Hayabusa 2: measuring the thermal inertia of 1999 JU3

Principal Investigator: Michael Mueller
Institution: SRON, Netherlands Institute for Space Research

Technical Contact: Michael Mueller, SRON, Netherlands Institute for Space Research

Co-Investigators:
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Andrew Rivkin, JHU / APL
David Trilling, NAU
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Seiji Sugita, University of Tokyo
Sunao Hasegawa, JAXA
Masateru Ishiguro, Korean National University
Young-Jun Choi, KASI
Michael Mommert, DLR Berlin

Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 19.8

Abstract:
The JAXA mission Hayabusa 2, scheduled to launch in 2014/2015, will visit the low-albedo near-Earth asteroid 1999 JU3, and will return a regolith sample to Earth in 2020. An international observation campaign has amassed a large body of data toward the physical characterization of the target asteroid, informing the mission planning and maximizing the mission's scientific return. While the physical characterization of JU3 has advanced significantly in the past years, open questions remain that only Spitzer can answer: * Just what is the object's thermal inertia? Thermal inertia governs the surface temperature distribution, crucial knowledge for near-surface operations and sampling, and is an indicator for the presence or absence of regolith. Previous thermal observations led to inconclusive results. * Is there any surface variability in thermal inertia or albedo? There is tantalizing evidence for a variable 0.7-micron spectral feature, which may indicate further reaching surface heterogeneity. The only way to answer these questions before Hayabusa-2's arrival at its target is through Spitzer observations in 2013. Only Spitzer affords the required sensitivity and repeatability at thermal-infrared wavelengths. Additionally, due to JU3's peculiar orbit, 2013 is the last chance to obtain Spitzer observations through the end of 2016 (Horizons does not provide Spitzer-centric ephemerides beyond this date). JU3 is already too poorly placed for Earth-based observations to be obtained of sufficient quality to address these critical science questions. The 2013 apparition is uniquely favorable for thermal-inertia measurements from Spitzer due to the wide range spanned in solar phase angle and sub-Spitzer latitude. We propose observations at 2 times 7 phase angles, with Spitzer-centric latitudes on both the Northern and Southern hemisphere. Additional thermal lightcurves will provide evidence for the presence of absence of thermal-inertia variegation over the surface.

Spitzer Space Telescope - General Observer Proposal #14033

A complete catalog of stellar mass maps for PHANGS

Principal Investigator: Juan-Carlos Munoz-Mateos
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Diederik Kruijssen, Heidelberg University
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Frank Bigiel, Heidelberg University

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.2
Priority: 1

Abstract:
We request IRAC 3.6 and 4.5 um imaging of four galaxies that have been mapped in molecular gas by ALMA as part of its first large program targeting nearby galaxies (PHANGS: Physics at High Angular resolution in Nearby GalaxieS). IRAC provides a uniquely robust view of the stellar mass distribution, which in turn plays a key role in regulating the properties and behavior of the molecular gas. These are the only targets of our ALMA large program without such imaging. A modest investment of Spitzer time will allow us to measure the drivers of molecular cloud and star formation in these targets.

Spitzer Space Telescope - General Observer Proposal #60173

Fossil Hunting: Intracluster Stars in Virgo

Principal Investigator: Eric Murphy
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Co-Investigators:
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Science Category: galaxy clusters and groups(low-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 100.0

Abstract:
In dense clusters, galaxy interactions and mergers play a significant role in galaxy evolution. During these interactions, tidal forces can lead to the ejection of stars from their parent galaxies; these stars are a fossil record of environmentally-driven galaxy evolution. We propose to map the intracluster light (ICL) at 3.6 and 4.5um using IRAC over a square degree near the Virgo cluster core previously mapped in V-band by Mihos et al. (2005). While this study has illuminated the wealth and complexity of stellar structures in Virgo's core, the addition of IRAC data will allow us, for the first time, to: 1) accurately measure the stellar mass of the intracluster stars (ICS), constraining chemical enrichment models; 2) measure the colors of the ICS to constrain the relative ages and origins of the ICS structures; 3) identify and characterize the stellar counterparts of recently discovered gas filaments; and 4) make detailed comparisons between the atomic gas and stellar mass distribution of the cluster core, thereby providing a benchmark for cosmological simulations that trace structure formation. This program will help to elucidate our understanding of how cluster galaxies evolve, and how the ICM is affected by the removal of stars, metals, gas, and dust from in-falling galaxies.

Spitzer Space Telescope - General Observer Proposal #60160

An Exploration of Unique Mid-Infrared Variability around Transition Disks and Class I stars in IC 348

Principal Investigator: James Muzerolle
Institution: University of Arizona

Technical Contact: Kevin Flaherty, Steward Observatory, U. Arizona

Co-Investigators:
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Kevin Flaherty, Steward Observatory
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Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 21.5

Abstract:
We propose to obtain repeated 3.6 and 4.5 micron observations of IC 348 focusing on young stellar objects that show evidence of unique and unusual mid-infrared variability. Previous Spitzer observations have found variations in the mid-infrared flux in as little as a day along with a strong wavelength dependence. We focus on a handful of T Tauri stars that exhibit spectral energy distributions similar to transition disks and two class I stars that show the largest 24 micron variability of any young stellar object in the cluster. In the T Tauri disks the variability may be related to a change in the scale height of the inner edge of this disk. Repeated observations covering a range of timescales from hours to weeks will help to constrain the physical mechanism leading to this variable scale height. For the class I stars, our proposed observations will help to constrain the details of the envelope/disk structure and variable accretion. These data will provide an essential tool for understanding stellar mass build up, accretion and planet formation.

Spitzer Space Telescope - General Observer Proposal #10014

Spitzer unveils extreme Planck & Herschel lensed sources and their lenses

Principal Investigator: Nicole Nesvadba
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Technical Contact: Herve Dole, Universite Paris Sud XI

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Emeric Le Floc'h, CEA
Brenda Frye, UofA
Genevieve Soucail, IRAP
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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.0
Priority: 2

Abstract:
The brightest, most strongly gravitationally lensed galaxies on the high-redshift FIR/sub-mm sky are veritable gems for our understanding of intense star formation in the early Universe, but are exceedingly rare, and accordingly difficult to find. By exploiting the unique synergy of the Planck FIR/sub-mm all-sky survey and Herschel/SPIRE photometry, we have collected a small sample of strongly lensed high-z galaxies which are amongst the brightest such sources on the sky, with up to S_350 =1135 (!) mJy. All have spectroscopic redshifts from multiple (3 to 8) CO emission lines, and all are systematically brighter by factors of a few than the typical sources found with the large lensing surveys with Herschel and the South Pole Telescope. We have started a comprehensive multi-wavelength spectroscopic and photometric follow-up to characterize the stellar populations and star formation, dust, and molecular and atomic gas in these galaxies, down to the regime of individual star-forming regions (of order 100 pc) which can be reached for the highest magnification factors. This will provide the most direct constraints on how large-scale galaxy evolutionary processes, like gas accretion, galaxy interactions, and galactic winds from star formation and AGN, but also the high gas fractions and gas turbulence, gas and stellar mass densities, and intense star formation itself are setting the stage for the formation of new stars. Here we request IRAC 3.6 and 4.5 micron imaging of the 9 brightest gravitational lenses from our sample, in order to probe the stellar populations, stellar masses, and mass surface densities. Given the strong obscuration of our sources, IRAC is ideally suited to probe the stellar population, covering the rest-frame NIR right around the 1.6-micron 'bump', an important diagnostics of stellar populations older than few 100 Myr. These IRAC images are a unique probe of the stellar populations, and a key element of our overall multi-wavelength follow-up.

Spitzer Space Telescope - General Observer Proposal #60147

Gas without stars? Elucidating the nature of a highly unusual CO line emitter in the early universe.

Principal Investigator: Nicole Nesvadba
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Co-Investigators:
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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.2

Abstract:
We propose to obtain deep IRAC photometry at 3.6um to investigate the nature of a highly peculiar, luminous CO line emitter which does not appear to be associated with a significant stellar mass. TXS0828+193 SW1/2 is in the halo of the powerful radio galaxy (HzRG) TXS0828+193 at redshift z~2.6, at a radial distance of 85 kpc from the radio galaxy and near the hot spot of the radio jet. The CO(3-2) emission line luminosity of SW1/2 corresponds to a total mass of about 2x 10^10 M_sun in cold molecular gas, similar to that of strongly star-forming, massive submillimeter galaxies at similar redshifts. . Intriguingly, we do not find a counterpart at rest-frame UV to mid-infrared wavelengths, which suggests a much lower stellar mass of <few x10^9 M_sun and low star-formation rates. We propose two scenarios for the nature of this enigmatic source: (1) The gas may either be associated with an exceedlingly gas-rich, low-mass galaxy unlike any other high-redshift galaxy previously detected in CO. (2) The molecular gas may represent a cloud or filament in the gaseous halo surrounding the radio galaxy, and may be influenced by the nearby radio jet. In either case, the discovery of SW1/2 has the potential to significantly deepen our understanding of the role of molecular gas at high redshift. The proposed IRAC imaging is part of an extensive program of follow-up observations in different wavebands. SW1/2 is likely to be highly dust-enshrouded, and thus, our stellar mass limit may not be ideal. The main goal of the proposed observations is thus to obtain tighter and more robust limits on the stellar mass of SW1/2, which is obviously a critical aspect in elucidating the nature of this mysterious object.

Spitzer Space Telescope - General Observer Proposal #12003

Early Quiescent Galaxies Under the Magnifying Glass

Principal Investigator: Andrew Newman
Institution: Carnegie Institution for Science

Technical Contact: Andrew Newman, Carnegie Institution for Science

Co-Investigators:
R. Ellis, Caltech
S. Belli, Caltech

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.2
Priority: 1

Abstract:
By a redshift of z~2, half of the massive galaxy (>10^11 Msol) population consists of systems with little or no star formation and physical sizes that are remarkably small (~1 kpc) for their mass. Much effort has been devoted to understanding the star-forming progenitors of these "red nuggets" and their substantial growth in size over the last 11 Gyr. However, major questions remain. A key barrier is our inability to resolve the structure and dynamics of these compact galaxies, which are only marginally resolved even with HST. This proposal addresses this limitation by harnessing gravitational lensing. We propose observations of two spectroscopically confirmed quiescent galaxies at z=2-3 that are magnified by foreground clusters. By coupling this magnification with HST resolution, our proposed observations will allow us to: (1) Resolve the central stellar densities of these galaxies within half of the effective radius, thereby stringently testing the hypothesized "inside out" growth paradigm and constraining the physical mechanisms driving size growth; (2) Probe the homogeneity of the stellar populations of these compact galaxies by measuring color gradients within ~1 kpc; (3) Construct lens models to interpret existing spatially-resolved NIR spectroscopy and measure resolved stellar kinematics for the first time in these systems. Our proposed targets are rare and valuable resources that provide the only route toward better resolving the internal structure of z>2 quiescent galaxies in advance of JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12127

Weighing the NIR-Brightest Lensed Galaxy

Principal Investigator: Andrew Newman
Institution: Carnegie Observatories

Technical Contact: Andrew Newman, Carnegie Observatories

Co-Investigators:
Sirio Belli, MPE
Richard Ellis, ESO

Science Category: High-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.3

Abstract:
We are requesting DDT time to characterize the brightest gravitationally- lensed distant galaxy yet detected at near-infrared wavelengths. Whereas most high-redshift lensed galaxies are star-forming systems, our target at z=1.95 is a rare example of a massive compact quiescent galaxy. Such compact red galaxies present many puzzles if, as is thought, they grow into present day massive ellipticals. Importantly, it is unclear how and when these systems were quenched and what were their progenitors. As our target is gravitationally magnified into a spectacular 20'' arc, it offers a remarkable opportunity to secure spatially-resolved data on the stellar mass distribution to complement resolved kinematics and stellar ages available from recent Keck spectroscopy. 16 min will be sufficient to obtain suitable IRAC images for this remarkable source, which will be used to (i) robustly establish the stellar mass distribution which, in conjunction with our spectroscopic age, will connect the galaxy to a possible progenitor, (ii) compare the total stellar mass with the dynamical equivalent based on our resolved stellar kinematics, and (iii) examine stellar population gradients to discriminate amongst proposed formation histories.

Spitzer Space Telescope - General Observer Proposal #14011

Spitzer's window onto the evolution of young planets

Principal Investigator: Elisabeth Newton
Institution: Massachusetts Institute of Technology

Technical Contact: Elisabeth Newton, Massachusetts Institute of Technology

Co-Investigators:
Andrew Mann, Columbia
Aaron Rizzuto, UT Austin
Andrew Vanderburg, UT Austin

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 100.0
Priority: 1

Abstract:
Exoplanets in young associations provide an otherwise inaccessible window into how planetary systems form and evolve. We expect to discover 19 young exoplanets around bright stars through our TESS GI programs, which will provide a critical data set for studying planet formation and evolution into the next decade. Here, we propose to obtain transit observations of these young planets with Spitzer. We seek to use Spitzer because it enables us is to obtain precise photometric observations at wavelengths that will also mitigate the impact of stellar activity, which is expected to be high for these young stars. Using data from Spitzer, we will directly address two questions: how do the atmospheres of sub-Neptune sized planets evolve? And what is the mechanism by which planets migrate onto short orbits? We will do this by measuring minimum eccentricities via the photoeccentric effect and by accurately and precisely constraining the planetary properties. We will additionally improve transit ephemerides, ensuring that the transits of these planets are not lost as the community prepares for future observations with JWST, HST, and ground-based facilities. This is a target of opportunity program.

Spitzer Space Telescope - General Observer Proposal #70148

Atmospheric composition and thermal structure of super-Earth GJ~1214b

Principal Investigator: Madhusudhan Nikku
Institution: Massachusetts Institute of Technology

Technical Contact: Madhusudhan Nikku, Massachusetts Institute of Technology

Co-Investigators:
Heather Knutson, University of California, Berkeley
Jean-Michel Desert, Harvard University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.0

Abstract:
We propose to characterize the day-side atmospheric chemistry and temperature structure of the super-Earth GJ1214b. Our S/N noise estimates indicate that the dayside atmosphere of this planet is detectable with the two IRAC channels in Warm Spitzer. Based on observations at secondary eclipse in the 3.6 micron and 4.5 micron IRAC channels, we can constrain the atmospheric concentrations of methane and carbon dioxide remarkably well, apart from obtaining constraints on the presence of a thermal inversion (a ``stratosphere") in the atmosphere. Furthermore, the scientific impact of a non-detection in either of the two Warm Spitzer channels would be just as substantial as the detections, if not more. Specifically, our models show that observations in the two channels can distinguish between an atmosphere with equilibrium chemistry and one without. Similarly, we can also distinguish between an atmosphere with a thermal inversion and one without.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14255

Characterizing a new prototype Saturn-mass exoplanet with the clearest atmosphere yet

Principal Investigator: Nikolay Nikolov
Institution: JHU

Technical Contact: Nikolay Nikolov, JHU

Co-Investigators:
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Jonathan Fortney, UCSC
Drake Deming, University of Maryland
Tiffany Kataria, JPL
Nathan Mayne, University of Exeter
Benjamin Drummond, University of Exeter
Jayesh Goyal, University of Exeter

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.0
Priority: 1

Abstract:
Rarely in astrophysics does one have the chance to characterize an exoplanet atmosphere free of clouds. Transmission spectra of such exoplanets are the only way to constrain elemental abundances (e.g. Na, K, water, CH4 and CO) and metallicity objectively, as clouds and hazes obscure the amplitudes of absorption features. Cloud- free exoplanet atmospheres are therefore of very high value for the field. Our team has recently published the optical transmission spectrum of the hot Saturn WASP-96b (~1300K) obtained with VLT FORS2. Unlike the optical transmission spectrum of any other hot-Jupiter observed to date, the spectrum of WASP-96b shows very clear pressure-broadened wings of the sodium line, the signature of near-UV Rayleigh scattering slope, caused by H_2 and a full-amplitude H_2O feature in the near-infrared from recent HST observations. The near-UV Rayleigh scattering slope is defining the hydrogen continuum level and proving the planet has a clear atmosphere at the limb. The clear atmosphere of WASP-96b rivals the top three currently known such planets: WASP-39b, HD209458b and WASP-17b, each of which show narrow absorption features and non-negligible haze in their optical spectra. We propose to use Spitzer IRAC to measure the mid-infrared transmission and emission spectrum of WASP-96b, which will allow us to retrieve precise absolute carbon and metallicity abundance constraints and obtain a constraint of the planet temperature. Even today, few such constraints exist with well-measured Na, water and carbon abundances. The spectrum of WASP-96b can become a standard benchmark for the theory of irradiated gas-giants and an outstanding target for abundance measurements with the James Webb Space Telescope.

Spitzer Space Telescope - General Observer Proposal #60184

Probing Planetesimals in the Solar System: Ice and Organics in Kuiper Belt Binaries

Principal Investigator: Keith Noll
Institution: Space Telescope Science Institute

Technical Contact: Keith Noll, Space Telescope Science Institute

Co-Investigators:
Joshua Emery, University of Tennessee
Will Grundy, Lowell Observatory
Susan Benecchi, Space Telescope Science Institute

Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 14.1

Abstract:
We are proposing to use IRAC ch1 to obtain 3.6 um albedos for a sample of 9 Kuiper Belt binaries. Binaries offer the crucial advantage of linking spectrophotometric properties to physical properties including mass, albedo, density, and internal structure. We have selected targets with known orbits and with the most available ancillary data to get the maximum leverage for the new IRAC data. Our targets are nearly equally divided between the physically and dynamically distinct Cold population and assorted representatives of the dynamically Hot populations of the Kuiper Belt. We have also limited our sample to the less-processed, more-pristine 100-km-class objects that make up the vast majority of the Kuiper Belt that have been largely left out of earlier studies. These objects may be relatively unaltered since the end of planetary accretion in the protoplanetary disk and thus anearly direct link to the earliest epoch of the solar system and, by extension, to other planetary systems. The 3.6 um band of IRAC ch1 is a sensitive detector of both water ice and solid organics in Kuiper Belt objects.The surfaces of 100-km-class objects are likely a minimally processed mixture of silicates, water ice, and solid organics. Because the 3-4 um window contains strong absorptions, both from water ice and organics, a single IRAC photometric point, when combined with optical and near-IR data, can help constrain the range of possible compositions and microphysical textures for these objects.

Spitzer Space Telescope - General Observer Proposal #10076

The ultra-deep IRAC Legacy over GOODS: From the Earliest Galaxies to the Peak of Cosmic Star-Formation

Principal Investigator: Pascal Oesch
Institution: University of California, Santa Cruz

Technical Contact: Pascal Oesch, University of California, Santa Cruz

Co-Investigators:
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Rychard Bouwens, Universiteit Leiden
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Brad Holden, UCSC/Lick

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 200.0/612.5
Priority: 2/3

Abstract:
Ultra-deep Spitzer IUDF images have enabled the detection of a dozen individual z~8 galaxies in one IRAC field over the HUDF. This remarkable result demonstrated what can be done by combining deep matched HST WFC3/IR and Spitzer IRAC images. Obtaining large, statistically-robust samples of z~7-9 galaxies in the reionization epoch requires much larger Spitzer areal coverage to match the current deep HST data in the GOODS fields. Large samples of high-redshift galaxies with IRAC measurements would allow unbiased estimates of mass-to-light ratios, stellar masses, star formation histories, and provide age constraints. We propose to observe the CANDELS-Deep areas in GOODS-South and GOODS-North at 3.6 and 4.5 micron to 27.5 mag (AB, 3sigma) in 8 deep IRAC fields, reducing cosmic variance and guaranteeing IRAC detection of nearly every individual source found in the deep H<27.8 catalogs. Individual detections are essential for correcting for strong nebular emission lines. After modeling neighboring sources, clean IRAC photometry is recovered for ~80% of all sources. This will quadruple the number of IRAC-detected galaxies at z~7-9 to over 200 galaxies, many with significantly enhanced S/N. For these 200 z~7-9 galaxies rest-frame optical emission lines and rest-frame UV-optical colors can be measured, allowing us to investigate trends with luminosity, redshift, and far-UV slope to characterize the early build-up of galaxies. Our sample of individual detections will reach to ~10e8 Msun at z~4 and sample >50% of the total stellar mass density to z~8. The combined HST+Spitzer imaging will provide a unique legacy data set, unparalleled until the launch of JWST 5+ years from now, and will provide insurance as no space mission is 100% guaranteed. The star formation histories and mass densities of typical galaxies at all redshifts back to z~9-10 can be characterized through such a legacy dataset. This will be a stunning demonstration of the capabilities of Spitzer.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80264

Thermal Echo of Stripped Envelope PTF12gzk

Principal Investigator: Eran Ofek
Institution: Weizmann Institution for Science

Technical Contact: Mansi Kasliwal, Carnegie Institution for Science

Co-Investigators:
Mansi Kasliwal, Carnegie Institution for Science

Science Category: nearby galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.5

Abstract:
PTF12gzk is a nearby stripped-envelope supernova (SN Ic-BL), with extreme velocities. Given the unique properties of this SN, we are undertaking an extensive multi-wavelength campaign (including HST). We request 30min of Spitzer/IRAC observations to detect the thermal light echo. Such a detection will allow us to probe the circumstellar content out to large distances from the SN, and to estimate the shock breakout luminosity. Here we request for a short observation of this SN, before the observing window closes on September 1. This early observation is imperative in order to measure the early rise of the thermal light echo which depends mainly on the supernova luminosity.

Spitzer Space Telescope - General Observer Proposal #80053

Hunting Coreshines with Spitzer

Principal Investigator: Roberta Paladini
Institution: Spitzer Science Center

Technical Contact: Roberta Paladini, Spitzer Science Center

Co-Investigators:
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Juergen Steinacker, Max Planck Institute fur Astronomie
Sean Carey, Spitzer Science Center/Caltech
Mika Juvela, University of Helsinki
Isabelle Ristorcelli, IRAP, Toulouse
Veli-Matti Pelkonen, IPAC/Caltech
Ludovic Montier, IRAP, Toulouse
Alberto Noriega-Crespo, Spitzer Science Center/Caltech
Aurore Bacmann, IPAG, Grenoble
Peregrine McGehee, IPAC/Caltech
Douglas Marshall, IRAP, Toulouse

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 165.9

Abstract:
We propose deep Spitzer observations of a large sample of cold clumps selected from the newly released Planck Early Cold Cores Catalog. The proposed survey, characterized by uniform depth, will provide the first unbiased investigation of the coreshine effect in Galactic cold condensations.The coreshine effect, recently identified by Pagani et al. (2010) and Steinacker et al. (2010), is interpreted as direct evidence for dust growth in the dense, cold environments in the interior of molecular clouds. Understanding of the coagulation process is crucial for the investigation of further coagulation taking place in protostellar disks, and fundamental for improving our knowledge of the mechanisms regulating the formation of planets. In addition, grain coagulation in dense molecular environments could in principle change the global scenario of dust particles in the diffuse ISM, as a retransfer of grains from these cold condensations back into the diffuse medium is indeed likely (Ossenkopf 1993). Last but not least, the existence of a larger population of grains will have strong implications on our interpretation of both thermal continuum and emission line data, therefore impacting in a significant way our present view of how stars form. A by-product of the proposed observations will be an unbiased serendipitous survey of low-mass outflows, as well as candidate young stellar objects.

Spitzer Space Telescope - General Observer Proposal #90109

Shedding light on grain growth in Galactic star forming regions

Principal Investigator: Roberta Paladini
Institution: Spitzer Science Center

Technical Contact: Roberta Paladini, Spitzer Science Center

Co-Investigators:
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Veli-Matti Pelkonen, Finish Centre for Astronomy with ESO (FINCA)

Science Category: ISM
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 42.5

Abstract:
We request dedicated 4.5 micron observations of a selected sample of molecular cores which are known to be characterized by "coreshine". These observations will allow us to investigate the detailed distribution of grain sizes and its dependence on optical depth (or density profile) inside the cores. Investigating grain coagulation in dense molecular environments is not only relevant for planet formation. Assessing the existence of very large grains could potentially revolutionize our current knowledge of interstellar dust, as a retransfer of grains from these cold condensations back into the diffuse medium is indeed likely. Moreover, the existence of a larger population of grains would have strong implications on our interpretation of both thermal continuum and line emission data, as well as on the chemistry in the cores.

Spitzer Space Telescope - General Observer Proposal #80100

Spitzer-HETDEX Exploratory Large Area (SHELA) Survey

Principal Investigator: Casey Papovich
Institution: Texas A&M University

Technical Contact: Casey Papovich, Texas A&M University

Co-Investigators:
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Josh Adams, University of Texas
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Roelof de Jong, AIP
Niv Drory, MPE
Neal Evans, University of Texas
Maximilian Fabricius, MPE
Steven Finkelstein, Texas A&M University
Eric Gawiser, Rutgers University
Jenny Greene, University of Texas
Caryl Gronwall, Penn State University
Gary Hill, University of Texas
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Shardha Jogee, University of Texas
Mark Lacy, NRAO
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Sarah Tuttle, University of Texas
Rachel Somerville, STSCI
Matthias Steinmetz, AIP
Nicholas Suntzeff, Texas A&M University
Kim-Vy Tran, Texas A&M University
Risa Wechsler, Stanford University
Lutz Wisotzki, AIP

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 526.2

Abstract:
We propose IRAC imaging of a 28 sq deg field with deep optical imaging lying within the Hobby-Eberly Telescope Dark Energy Experiment (HETDEX) Survey. Our goal is to explore the relationship between galaxy stellar mass, dark halo mass, and environment during the important cosmic epoch (redshifts 2<z<3) where the star formation and AGN activity in galaxies peak. The combination of HETDEX spectroscopy and deep IRAC and optical imaging in our program will provide a uniquely powerful dataset enabling these goals. Working in blind spectroscopic mode, HETDEX will obtain redshifts in this field for approximately 200,000 galaxies and map out the cosmic web at redshifts 1.9<z<3.5, over a large comoving volume of approximately 0.2 Gpc^3, competitive with SDSS at low redshifts.This volume spans a broad range of environments within the cosmic web, representative of field, groups, and proto-clusters. The IRAC data will provide the key missing ingredient by allowing us to measure galaxy stellar masses down to values well below the characteristic mass of the stellar mass function at these redshifts. By combining the IRAC data with the halo mass and local density (environment) measured from clustering statistics in the spectroscopic and associated trained photometric dataset, we will obtain a detailed view of how galaxies grow their stellar mass within different dark matter halos and as a function of environment. Ultimately, this study will advance our understanding of the physical processes that drive the formation of stars in galaxies and the build up of stellar mass over cosmic time. In the spirit of Exploratory programs, SHELA will enable a broad range of scientific explorations beyond our immediate goals by delivering all science products (images, catalogs, spectra, and redshifts) to the public.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13234

Benchmarking GJ436b for JWST

Principal Investigator: Vivien Parmentier
Institution: University of Arizona

Technical Contact: Kevin Stevenson, STScI

Co-Investigators:
Ian Crossfield, MIT
Caroline Morley, Cfa Harvard
Jonathan Fortney, University of California Santa-Cruz
Adam Showman, University of Arizona
Nikole Lewis, STSCI
Mike Line, Arizona State University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 68.8

Abstract:
GJ436b is a slightly eccentric, Neptune size planet with an equilibrium temperature of approximately 770K, it is the only Neptune size planet with a thermal emission measurement. With the coming JWST GTO observations of it's emission spectrum, GJ436b will become a benchmark object of the population of Neptune-size planets that will be discovered by TESS and characterized by JWST in the coming years. The current set of 19 secondary eclipses observed by Spitzer points toward a metal-rich, well mixed, tidally heated atmosphere in disequilibrium chemistry. However, no self-consistent forward models are currently able to fit the dayside spectrum of the planet, whereas retrieval models lead to solutions that are inconsistent with the observed planet density. Clearly, some piece of the puzzle is missing to understand the atmospheric properties of this planet. Although the coming JWST observations will likely improve our understanding of this planet, it won't be able to break the degeneracies between metallicity, internal flux and energy redistribution. We propose to observe a full phase curve of GJ436b at 3.6 microns. We will obtain a measurement of the nightside flux of GJ436b at 3.6 microns. Combined with the already observed 8 microns phase curve, we will obtain the first low resolution spectrum of the nightside of a Neptune size exoplanet. By comparing the nightside flux at 3.6 and 8 microns, we will be able to place constraints on the tidal heating and the metallicity of GJ436b that will be complimentary to the the dayside spectrum that will be obtained with JWST. As seen with the example of hot Jupiters, for which much more data is available, measurements of the nightside spectrum is fundamental to understand the planet atmosphere as a whole and correctly interpret the dayside emission. As a consequence, the proposed observation is crucial for the interpretation of the coming JWST observations. As a secondary goal, our observation should be able to confirm the presence of a sub-Earth size planet candidate in the same system. Given the brightness of the host star, this planet could become a benchmark object in the study of hot and rocky planets with JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14325

Seeing through the haze of two mini-Neptunes with Spitzer

Principal Investigator: Vivien Parmentier
Institution: University of Oxford

Technical Contact: Tom Evans, MIT

Co-Investigators:
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Laura Kreidberg, Harvard
Maximilian Guenther, MIT
Maria Steinrueck, UofA
Ian Crossfield, MIT
Pat Irwin, Oxford
Suzanne Aigrain, Oxford
Mike Line, ASU
Vincent Van Eylen
Jake Taylor, Oxford

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 26.1
Priority: 1

Abstract:
With a radius between 2 and 3 Earth radii, sub-Neptune planets are, by far, the most likely outcome of planet formation. Whether they are a small version of Neptune or scaled-up version of Earth can only be determined through their atmospheric characterization. TOI-270c and d are two newly discovered sub-Neptune size planets orbiting a bright and inactive M star. We propose to observe 4 transits of TOI-270c with the Spitzer Space Telescope (3 with IRAC 1 and 1 with IRAC 2) and 1 transit of TOI-270d. These observations will complement 2 transits in IRAC2 for each planets and planned HST/WFC3 observations. Previous observations of other planetary systems showed that Spitzer can probe through the haze layer that forms in cold sub-Neptunes orbiting M dwarfs. Our observations will therefore provide crucial information to interpret the Hubble Space Telescope observations.They will characterize the haze properties and allow to measure how haze formation efficiency varies as a function of received UV flux. They will also detect the main carbon bearer molecule and provide a precise estimate of both metallicity and C/O ratio in one of the two planets, which will become a benchmark system to understand planet formation processes. Finally, our observations will significantly improve the ephemerides of the planets, an essential step to schedule the coming HST observations and plan future potential JWST ones.

Spitzer Space Telescope - General Observer Proposal #12106

A Double Dusty Dilemma - IRAC Flux Changes in Circumbinary Debris Disk

Principal Investigator: Steven Parsons
Institution: Valparaiso University

Technical Contact: Jay Farihi, University College London

Co-Investigators:
Jay Farihi, University College London
Boris Gaensicke, University of Warwick

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5
Priority: 1

Abstract:
We have serendipitously discovered the first metal-polluted white dwarf with what appears to be a circumbinary dust disk. Both the atmospheric metals and infrared excess were found by our team a few years ago, but only recently did we (surprisingly!) identify a spectroscopic periodicity of 2.27 hr which unambiguously identifies this peculiar system as a close binary. Most remarkable for this proposal is that the system must be dynamically unstable, as a companion and canonical (flat, opaque) dust disk occupy overlapping orbital regions. We thus strongly suspected the system must be in a state of relatively rapid change, and recent DDT observations confirmed our hypothesis. We now propose to observe the system over a complete binary orbit to further constrain the changes in infrared flux, and to distentangle dust emission variability from any changes induced by the binary orbit itself. Micron-size dust grains should be subject to PR drag within a decade, and imply dust depletion on yearly timescales -- consistent with the DDT data. Our third epoch observations will provide an direct test by searching for a continuing decrease in dust emission. If such a decrease is not confirmed, it would imply the circumbinary dust reservoir is being replenished on yearly timescales.

Spitzer Space Telescope - General Observer Proposal #11107

Spitzer IRAC imaging of the most extreme starbursts in the early Universe discovered with Herschel

Principal Investigator: Ismael Perez-Fournon
Institution: Instituto de Astrofisica de Canarias

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Stephen Serjeant, Open University
Michal Michalowski, ROE
Vinodiran Arumugam, ROE
Catherine Vlahakis, Joint ALMA Observatory
Marcella Massardi, INAF
Viktoria Asboth, University of British Columbia

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 25.6
Priority: 2

Abstract:
We have developed a technique to robustly select high-z (>4) dusty, massive, star forming galaxies using far-IR Herschel/SPIRE data. Follow up of the first handful of sources has proven this technique to be both efficient and reliable, yet the existence of these sources is emphatically not predicted by current models. mm spectroscopy of the first few sources has confirmed that they predominantly lie above z > 4, including one source at z=6.34, the current highest redshift for luminous dusty star forming galaxies. To constrain the stellar masses and populations of these extreme galaxies, IRAC is required.

Here we propose IRAC imaging of 31 Herschel/SPIRE high-z candidates selected from the HerMES and Herschel-ATLAS surveys to: 1) provide a complete census of star formation and stellar populations, and 2) contribute to the identification of LBG sources associated with the large scale structures that host these dusty starbursts.

Spitzer Space Telescope - General Observer Proposal #11116

The Spitzer/Swift Gamma-Ray Burst Host Galaxy Extended Legacy Survey

Principal Investigator: Daniel Perley
Institution: Caltech

Technical Contact: Daniel Perley, Caltech

Co-Investigators:
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John Graham, MPE
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Jens Hjorth, Dark Cosmology Centre
Leslie Hunt, INAF Osservatorio Astrofisico di Arcetri
Pall Jakobsson, University of Iceland
Thomas Kruehler, European Southern Observatory
Tanmoy Laskar, Harvard University
Emerich Le Floc'h, CEA Saclay
Andrew Levan, University of Warwick
Emily Levesque, University of Colorado
Owen Littlejohns, Arizona State University
Daniele Malesani, Dark Cosmology Centre
Michal Michalowski, Royal Observatory Edinburgh
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Nial Tanvir, University of Leicester
Antonio de Ugarte Postigo, IAA - CSIC
Susanna Vergani, CNRS - Observatoire de Paris/GEPI

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 292.3
Priority: 3

Abstract:
Long-duration gamma-ray bursts act as beacons to the sites of star-formation in the distant universe. GRBs reveal galaxies too faint and star-forming regions too dusty to characterize in detail using any other method, and provide a powerful independent constraint on the evolution of the cosmic star-formation rate density at high-redshift. However, a full understanding of the GRB phenomenon and its relation to cosmic star-formation requires connecting the observations obtained from GRBs to the properties of the galaxies hosting them. The large majority of GRBs originate at moderate to high redshift (z>1) and Spitzer has proven crucial for understanding the host population, given its unique ability to observe the rest-frame NIR and its unrivaled sensitivity and efficiency. We propose to complete a comprehensive public legacy survey of the Swift GRB host population to build on our earlier successes and push beyond the statistical limits of previous, smaller efforts. Our survey will enable a diverse range of GRB and galaxy science including: (1) to quantitatively and robustly map the connection between GRBs and cosmic star-formation to constrain the GRB progenitor and calibrate GRB rate-based measurements of the high-z cosmic star-formation rate; (2) to constrain the luminosity function of star-forming galaxies at the faint end and at high redshift; (3) to understand how the ISM properties seen in absorption in high-redshift galaxies unveiled by GRBs - metallicity, dust column, dust properties - connect to global properties of the host galaxies such as mass and age. Building on a decade of experience at

both observatories, our observations will create an enduring joint Swift-Spitzer legacy sample and provide the definitive resource with which to examine all aspects of the GRB/galaxy connection for years and possibly decades to come.

Spitzer Space Telescope - General Observer Proposal #13104

The Spitzer/Swift Gamma-Ray Burst Host Galaxy Legacy Survey

Principal Investigator: Daniel Perley
Institution: Copenhagen

Technical Contact: Daniel Perley, Copenhagen

Co-Investigators:
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Nathaniel Butler, Arizona State University
S. Bradley Cenko, Goddard Space Flight Center
Ranga-Ram Chary, Caltech
Antonino Cucchiara, Space Telescope Science Institute
Richard Ellis, University College, London
Wen-fai Fong, University of Arizona
Andrew Fruchter, Space Telescope Science Institute
Johan Fynbo, University of Copenhagen
Neil Gehrels, Goddard Space Flight Center
John Graham, MPE
Jochen Greiner, MPE
Jens Hjorth, University of Copenhagen
Leslie Hunt, INAF Osservatorio Astrofisico di Arcetri
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Tanmoy Laskar, University of California, Berkeley
Emerich Le Floc'h, CEA Saclay
Andrew Levan, University of Warwick
Emily Levesque, University of Washington
Owen Littlejohns, Arizona State University
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Antonio de Ugarte Postigo, IAA - CSIC
Susanna Vergani, CNRS - Observatoire de Paris/GEPI
Darach Watson, University of Copenhagen

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 200.0
Priority: 1

Abstract:
Long-duration gamma-ray bursts act as beacons to the sites of star-formation in the distant universe. GRBs reveal galaxies too faint and star-forming regions too dusty to characterize in detail using any other method, and provide a powerful independent constraint on the evolution of the cosmic star-formation rate density at high-redshift. However, a full understanding of the GRB phenomenon and its relation to cosmic star-formation requires connecting the observations obtained from GRBs to the properties of the galaxies hosting them. The large majority of GRBs originate at moderate to high redshift (z>1) and Spitzer has proven crucial for understanding the host population, given its unique ability to observe the rest-frame NIR and its unrivaled sensitivity and efficiency. We propose to complete a comprehensive public legacy survey of the Swift GRB host population to build on our earlier successes and push beyond the statistical limits of previous, smaller efforts. Our survey will enable a diverse range of GRB and galaxy science including: (1) to quantitatively and robustly map the connection between GRBs and cosmic star-formation to constrain the GRB progenitor and calibrate GRB rate-based measurements of the high-z cosmic star-formation rate; (2) to constrain the luminosity function of star-forming galaxies at the faint end and at high redshift; (3) to understand how the ISM properties seen in absorption in high-redshift galaxies unveiled by

GRBs - metallicity, dust column, dust properties - connect to global properties of the host galaxies such as mass and age. Building on a decade of experience at both observatories, our observations will create an enduring joint Swift-Spitzer legacy sample - providing the definitive resource with which to examine all aspects of the GRB/galaxy connection for years to come and setting the stage for intensive JWST follow-up of the most interesting sources from our sample.

Spitzer Space Telescope - General Observer Proposal #70036

The Host Galaxies of Dust-Obscured Gamma-Ray Bursts

Principal Investigator: Daniel Perley
Institution: University of California, Berkeley

Technical Contact: Daniel Perley, University of California, Berkeley

Co-Investigators:
Joshua Bloom, University of California, Berkeley
Andrew Levan, University of Warwick
Jens Hjorth, Dark Cosmology Centre
Nial Tanvir, University of Leicester
Johan Fynbo, Dark Cosmology Centre
Daniele Malesani, Dark Cosmology Centre
S. Bradley Cenko, University of California, Berkeley

Science Category: GRBs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 23.7

Abstract:
Recent observations have revealed that a significant fraction of gamma-ray bursts originate from highly dust-obscured regions. We propose to target the host galaxies of a subset of GRBs whose afterglows show evidence for a large amount (A_V > 2 mag) of extinction with IRAC for deep imaging at 3.6 and 4.5 microns to complement existing ground-based and HST optical and NIR imaging of these targets. At typical redshifts of z=1-4, this rest-frame NIR imaging (in complement with optical and UV data) provides an essential constraint in distinguishing highly extinguished starburst galaxies from galaxies with old stellar populations and allows us to measure or constrain the average extinction and stellar mass, both of which are critical for accurately comparing the properties of these galaxies with the hosts of unobscured gamma-ray bursts and with typical star-forming galaxies at these redshifts. The results will allow us to infer the distribution and nature of dust in star-forming galaxies at redshifts up to z=4 and constrain the extent to which gamma-ray bursts trace the overall (obscured+unobscured) star formation rate of the universe.

Spitzer Space Telescope - General Observer Proposal #80153

Understanding the Environmental Dependence of High-z Dust with GRB Hosts

Principal Investigator: Daniel Perley
Institution: University of California, Berkeley

Technical Contact: Daniel Perley, University of California, Berkeley

Co-Investigators:
Darach Watson, Niels Bohr Institute
Tayyaba Zafar, University of Copenhagen
Joshua Bloom, UC Berkeley
S. Bradley Cenko, UC Berkeley
Adam Morgan, UC Berkeley
Andrew Levan, University of Warwick
Nial Tanvir, University of Leicester
Jochen Greiner, MPE
Thomas Kruehler, MPE
Patricia Schady, MPE

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 19.1

Abstract:
Our understanding of interstellar dust properties in a cosmic context is currently being revolutionized. While traditional methods for measuring the most observationally fundamental important dust diagnostic (the extinction curve) have remained restricted to the Galaxy and Magellanic clouds for decades, a variety of new techniques has catapulted the detailed study of dust extinction from our local neighborhood out to the highest redshifts. Gamma-ray burst afterglows, perhaps the most capable of all such cosmological dust probes, have in the past five years provided many detailed extinction measurements of a large and growing sample of galaxies up to redshift z ~ 5. We propose to use the Spitzer Space Telescope to observe a statistically meaningful sample (17 objects) of these galaxies at 3.6 and 4.5 microns, to try to correlate the properties of the extinction law (such as the presence or absence of 2175-Angstrom absorption) with the properties of the host galaxy itself - in particular, the stellar mass, which is tightly coupled to dust production and is key to a host of other essential properties such as metallicity and specific star-formation rate.

Spitzer Space Telescope - General Observer Proposal #90062

Spitzer Observations of GRB Hosts: A Legacy Approach

Principal Investigator: Daniel Perley
Institution: Caltech

Technical Contact: Daniel Perley, Caltech

Co-Investigators:
Nial Tanvir, University of Leicester
Jens Hjorth, DARK Cosmology Centre
Edo Berger, Harvard University
Tanmoy Laskar, Harvard University
Michal Michalowski, University of Edinburgh
Ranga-Ram Chary, California Institute of Technology
Johan Fynbo, DARK Cosmology Centre
Andrew Levan, University of Warwick

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 224.0

Abstract:
The host galaxies of long-duration GRBs are drawn from uniquely broad range of luminosities and redshifts. Thus they offer the possibility of studying the evolution of star-forming galaxies without the limitations of other luminosity-selected samples, which typically are increasingly biased towards the most massive systems at higher redshift. However, reaping the full benefits of this potential requires careful attention to the selection biases affecting host identification. To this end, we propose observations of a Legacy sample of 70 GRB host galaxies (an additional 70 have already been observed by Spitzer), in order to constrain the mass and luminosity function in GRB-selected galaxies at high redshift, including its dependence on redshift and on properties of the afterglow. Crucially, and unlike previous Spitzer surveys, this sample is carefully designed to be uniform and free of optical selection biases that have caused previous surveys to systematically under-represent the role of luminous, massive hosts. We also propose to extend to larger, more powerfully constraining samples the study of two science areas where Spitzer observations have recently shown spectacular success: the hosts of dust-obscured GRBs (which promise to further our understanding of the connection between GRBs and star-formation in the most luminous galaxies), and the evolution of the mass-metallicity relation at z>2 (for which GRB host observations provide particularly powerful constraints on high-z chemical evolution).

Spitzer Space Telescope - General Observer Proposal #60181

Small Clusters Forming in Isolation? CB 34 and CB 58

Principal Investigator: Dawn Peterson
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Dawn Peterson, Harvard-Smithsonian Astrophysical Observatory

Co-Investigators:
Lori Allen, SAO
Robert Gutermuth, Smith College
Tyler Bourke, SAO

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.8

Abstract:
In our previous survey of Bok globules in search of small clusters forming within these isolated regions, we found evidence in the MIPS data for two small clusters forming near our original targets. We propose Spitzer IRAC observations of these small extensions of our current IRAC maps in CB 34 and CB 58 so that we will have a complete census of the young stellar objects (YSOs) in these regions. CB 34 appears to be a cluster forming in isolation, whereas CB 58 appears to have the morphology of a bright-rimmed cloud. With these observations, and combined with existing near-infrared and radio data, we will measure the star formation efficiency in these Bok globules. In addition, we will study the role environment plays in star formation by comparing the properties of YSOs in Bok globules, which are relatively isolated from outside influences, with bright-rimmed clouds, which are examples of triggered star formation.

Spitzer Space Telescope - General Observer Proposal #12107

Orbit and Atmospheric Composition of the Warm Sub-Saturn EPIC-2037b

Principal Investigator: Erik Petigura
Institution: California Institute of Technology

Technical Contact: Erik Petigura, California Institute of Technology

Co-Investigators:
Katherine Deck, California Institute of Technology
Bjoern Benneke, California Institute of Technology
Heather Knutson, California Institute of Technology
Drake Deming, University of Maryland
Michael Werner, JPL
John Livingston, JPL
Ian Crossfield, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 29
Priority: 1

Abstract:
We propose a joint Spitzer/HST proposal to observe transits of two warm, sub-Saturn sized planets orbiting EPIC-203771098 (EPIC-2037 hereafter), a bright G dwarf observed by K2. EPIC-2037b and c are 5.7±0.6 and 7.6±0.8 Earth-radii. Sine the two planets are close to the 2:1 mean-motion resonance, transit timing variations (TTVs) are expected to be large (several hours). Our proposed Spitzer transit observations will yield precise transit times for EPIC-2037b and c. We will model the TTVs to constrain the eccentricities of EPIC-2037b and c which are linked to the formation pathway for this system. EPIC-2037b and c have low densities of 0.4 g/cc and 0.2 g/cc, respectively. Their large size and low surface gravities make these planets favorable targets for transmission spectroscopy by Spitzer, HST, and JWST. In addition to their favorable observability, the planets have low equilibrium temperatures of ~710 K and ~560 K, respectively. These temperatures have not been well-explored in previous studies with transmission spectroscopy. While over a dozen HST+Spitzer transmission spectra have been published in the literature, only GJ1214b, GJ346b, HAT-P-11b, and HAT-P-12b have comparable temperatures. While Spitzer can detect wavelength-dependent variation in transit depth, the Spitzer measurements alone cannot discriminate between various atmospheric compositions. Therefore we propose to use HST/WFC3 to probe the atmosphere of EPIC-2037b. The HST transmission spectrum will probe water vapor in the atmosphere, which reflects the planet?s oxygen abundance, a proxy for the planet?s heavy element enrichment.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14280

Infrared imaging of massive high-redshift protoclusters from the SPT survey

Principal Investigator: Kedar Phadke
Institution: University of Illinois

Technical Contact: Kedar Phadke, University of Illinois

Co-Investigators:
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Anthony Gonzalez, U. Florida
Dan Marrone, U. Arizona
Matt Malkan, UCLA
Kaja Rotermund, Dalhousie University
Justin Spilker, U. Texas, Austin
Cassie Reuter, U. Illinois
Chris Fassnacht, UC Davis
Axel Weiss, MPIfR

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.6
Priority: 1

Abstract:
We propose to obtain Spitzer/IRAC imaging of two unique high-redshift protoclusters (PC) discovered with the 2500 square degree South Pole Telescope (SPT) survey. Unlike the majority of the SPT-detected high redshift galaxies, these objects are not gravitationally lensed and very rare on the sky. One of our first PCs we studied was recently published in Nature (SPT2340-56 at z=4.3) and another is at even higher redshift (z=5.6). These PCs are among the most massive and most compact ever found. These two sources were previously excluded from our followup campaign because they were extended in our APEX/LABOCA maps. However, in the last year, we have obtained deeper LABOCA imaging and defined a sample of 9 protoclusters from the full SPT survey. These final two PCs currently only have photometric redshifts (z~3-4) and have not yet been imaged in the NIR. Keeping in mind the launch of JWST in 2021, it will be scientifically restrictive to not have infrared imaging on these 2 objects for at least two more years given how the protocluster field is now expanding and becoming important to understand cluster formation and environments. We propose to observe the two newly discovered protocluster candidates SPT0303-59 and SPT2018-45 to constrain the stellar content in these systems.

Spitzer Space Telescope - General Observer Proposal #10135

A deep search for Y dwarfs to the WISE limit

Principal Investigator: David Pinfield
Institution: University of Hertfordshire

Technical Contact: David Pinfield, University of Hertfordshire

Co-Investigators:
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Joana Gomes, University of Hertfordshire, UK
Avril Day-Jones, University of Hertfordshire, UK
Maria Teresa Ruiz, University of Chile
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Mariusz Gromadski, University of Valparaiso, Chile
Jackie Faherty, University of Chile
James Jenkins, University of Chile
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Nicolas Lodieu, Institut de Astrofisica de Canaria (IAC), Tenerife
Mark Marley, NASA Ames
Caroline Morley, UC Santa Cruz
Didier Saumon, Los Alamos National Laboratory
Jonathan Fortney, UC Santa Cruz
Channon Visscher, Southwest Research Institute Boulder

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 52.8
Priority: 2

Abstract:
We will use Spitzer/IRAC to confirm and characterise a new deep sample of very late type objects identified using an optimised method to probe the faint limits of the WISE All-Sky survey. WISE has previously revealed a new spectral class beyond the T dwarfs, with 14 of these Y dwarfs currently known. However, recently measured parallax distances have shown that this population has Teff=400-450 K, and that the observed diversity amongst the known Y dwarfs must be due to other properties (e.g. gravity and/or metallicity). The surprisingly small Teff range of the known Y dwarfs suggests that cooler objects (300-400 K) may be significantly fainter than the existing sample, with a possible cause being the (recently modelled) emergence of water clouds and a resulting decrease in mid-infrared flux due to water cloud absorption. Our new WISE search probes to W2~16.5 (~1.5 magnitudes deeper than the WISE team's search), and we are thus exploring this fainter parameter space (Mw2<16.5) out to distances of ~10pc. The increased depth (and greater volume) of our new sample has already led to the identification of 2 halo/thick-disk T dwarfs (T8 and T9) just accepted for publication, and as we follow-up candidates with redder J-W2 color we expect to confirm intrinsically fainter and/or rarer Y dwarfs. IRAC [3.6] and [4.5] photometry of a 77 strong target list will allow us to confirm and characterise (through color and proper motion) the reddest objects from our programme, as well as the most challenging objects that are undetected by our near-infrared follow-up. Spitzer offers the capability to fully exploit our new search, and thus identify the faintest objects in the WISE sky.

Spitzer Space Telescope - General Observer Proposal #10128

Rotationally Resolved Study Of The Surface Of Pluto In Support Of NASA New Horizons Mission

Principal Investigator: Noemi Pinilla-Alonso
Institution: University of Tennessee

Technical Contact: Noemi Pinilla-Alonso, University of Tennessee

Co-Investigators:
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Bonnie Buratti, JPL
Dale P Cruikshank, Ames Research Center- NASA
Will M Grundy, Lowell Observatory
Joshua P Emery, University of Tennessee
Yan Fernandez, University of Central Florida
Casey M Lisse, Applied Physics Laboratory
John Stansberry, James Webb Space Telescope

Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.5
Priority: 1

Abstract:
We propose Warm Spitzer/IRAC GO observations of the Pluto system, as part of a worldwide observing campaign in support of the NASA New Horizons. The aim of this proposal is to characterize the surface heterogeneity of Pluto through photometric observations at the 3.6 and 4.5 ?m IRAC channels. We ask for observations at 18 longitudes (~ each 20 o). The surface of Pluto is formed by patches of CH4, N2 and CO. The differences in the visible albedo on the surface of Pluto pretty much span the range from the darkest to the brightest stuff in the solar system. Near-infrared and visible observations, performed over the last 30 years, show a dynamic and variable system, with a timescale on the order of months to years. Pluto is currently moving away from the sun and entering northern summer. Despite many model predictions that the atmosphere will collapse, it has significantly increased in density over the last ~20 years. Spitzer holds a unique place in the solar system to observe Pluto, above the Earth?s atmosphere in a stable Earth-trailing environment. By 2014 Pluto will be leaving the galactic background, allowing for better measurements than have been possible in the last 5 years. Relative differences in the albedo of Pluto in ch1 and ch2 is an effective tool to study the different mixing ratios of the materials on the surface. Both channels are sensitive to different ices. This is also promising for the search of other materials expected to be on the surface of Pluto but have not been identified in the vis/NIR, e.g CO2 that has its fundamental absorption band in the wavelength range of ch2. Finally these observations will also be used to check for secular differences on the surface by comparing those Spitzer observations of Pluto made in 2004 and the ones obtained through this program. The combination of these datasets with observations done at other wavelengths will place strong constraints on Pluto?s surface albedo, and shed some light on the local interaction between the surface and the atmosphere.

Spitzer Space Telescope - General Observer Proposal #11090

Rotationally resolved study of the surface of Pluto during NASA New Horizons flyby of the system

Principal Investigator: Noemi Pinilla-Alonso
Institution: University of Tennessee

Technical Contact: Noemi Pinilla-Alonso, University of Tennessee

Co-Investigators:
Joshua P. Emery, EPS-University of Tennessee
Dale P. Cruikshank, NASA Ames Research Center
James Bauer, Jet Propulsion Laboratory
Yan Fernandez, University of Central Florida
Will Grundy, Lowell Observatory, AZ
Carey M. Lisse, JHU-APL
John Stansberry, James Webb Space Telescope
Bonnie J Buratti, Jet Propulsion Laboratory

Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.5
Priority: 1

Abstract:
We propose Warm Spitzer/IRAC GO observations of the Pluto system, as part of a worldwide observing campaign in support of the NASA New Horizons. The aim of this proposal is to characterize the surface heterogeneity of Pluto through photometric observations at the 3.6 and 4.5 µm IRAC channels as close in time to the New Horizons encounter date of 14 July 2014 as possible. We ask for observations at 18 longitudes (~ each 20 o). The surface of Pluto, formed by patches of CH_4, N_2 and CO, is a dynamic and variable system, with a timescale on the order of months to years. Spitzer holds a unique place in the solar system to observe Pluto, above the Earth's atmosphere in a stable Earth-trailing environment. Relative differences in the albedo of Pluto in ch1 and ch2 is an effective tool to study the different mixing ratios of the ices on the surface. This is also promising for the search of other candidate materials that have not yet been identified in the vis/NIR, e.g CO_2 that has its fundamental absorption band in the wavelength range of ch2. In 2004, under a Spitzer program during the cryogenic mission (PI. Cruikshank), low-resolution light curves were obtained at 8 different longitudes. In 2014, under a Cycle 10 program (PI. Pinilla-Alonso) we obtained data at ch1 and ch2 at 18 longitudes. The analysis of these data shows clear indications not only of surface heterogeneity, but also on possible secular variations. These data are under analysis and show a great potential for the mapping of volatiles ices all over the surface of Pluto. Two parallel observational programs are in progress involving people in this group, one of near-infrared spectroscopy (~0.9-2.5 µm) at the NASA Infrared Telescope Facility (PI. Grundy) and one of visible spectroscopy (0.4-0.95 µm) at WHT, La Palma (PI. Pinilla-Alonso). The combination of these datasets, covering different wavelength regions, provide unique and complementary information, and is very important in deriving full benefit of data from the NASA New Horizons spacecraft

Spitzer Space Telescope - General Observer Proposal #12009

Study of the Surface Heterogeneity of icy dwarf planets and other medium size Kuiper Belt objects

Principal Investigator: Noemi Pinilla-Alonso
Institution: University of Tennessee

Technical Contact: Noemi Pinilla-Alonso, University of Tennessee

Co-Investigators:
Josh P Emery, university of Tennessee, Knoxville

Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 37.8
Priority: 1

Abstract:
We propose a comprehensive analysis of the surface heterogeneity of a selected sample of dwarf-planets and candidates to be considered as dwarf-planets. The sample has been carefully selected to reach the scientific goals with a relative low cost in observing time. The research proposed here will be based on the analysis of the light-curve of these objects obtained using IRAC/Spitzer photometry. KBOs likely retain some of the most primitive material in the Solar System. Models of the retention of volatiles by small-bodies in the Solar System show that dwarf-planets can retain most of the original inventory of volatiles. A good example is Pluto. The surface of this body is formed by patches of CH_4, N_2 and CO and exhibits a large degree of surface heterogeneity. Our preliminary results of the IRAC/Spitzer light curves of Pluto, obtained by this group in 2004 and 2014, show the potential of these data to map the surface distribution of the different species of ices on the surface of KBOs. For this project we have selected six objects (out of a list of 15) that are ideal for this study using Spitzer photometry. Our sample covers two classes of bodies: Eris, Makemake and Haumea, all large enough to retain volatiles and so how signs of sublimation and condensation cycles on their surfaces; and Quaoar, Varuna and Ixion (D<1000 km) that may not have retained volatiles. If signs of heterogeneity are detected on IRAC data from these medium bodies (as suggested by previous studies) this could be due to a combination of collisions and irradiation. By addressing the compositional heterogeneity of this sample of KBOs the proposed work will address gaps in the scientific knowledge of the chemical and dynamical history of the outer Solar System as well as other planetary systems.}

Spitzer Space Telescope - General Observer Proposal #12011

Rotationally Resolved Study Of The Surface Of Pluto: seasonal/secular variations

Principal Investigator: Noemi Pinilla-Alonso
Institution: University of Tennessee

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Co-Investigators:
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Dale P Cruikshank, Ames Research Center- NASA
Will M Grundy, Lowell Observatory
Joshua P Emery, University of Tennessee
Yan Fernandez, University of Central Florida
Casey M Lisse, Applied Physics Laboratory
John Stansberry, James Webb Space Telescope

Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6
Priority: 1

Abstract:
We propose Warm Spitzer/IRAC GO observations of the Pluto system, to monitorize the secular and/or seasonal changes on PlutoÍs surface composition. The aim of this proposal is to characterize the surface heterogeneity of Pluto through photometric observations at the 3.6 and 4.5 μm IRAC channels after the New Horizons encounter on July 2014. We ask for observations at 18 longitudes (~ every 20o). The surface of Pluto, formed by patches of CH4, N2 and CO, is a dynamic and variable system, with a timescale on the order of months to years. Spitzer holds a unique place in the solar system to observe Pluto, above the Earth's atmosphere in a stable Earth-trailing environment. Relative differences in the albedo of Pluto in ch1 and ch2 is an effective tool to study the different mixing ratios of the ices on the surface. This is also promising for the search of other candidate materials that have not yet been identified in the vis/NIR, e.g CO2 that has its fundamental absorption band in the wavelength range of ch2. In 2004, under a Spitzer program during the cryogenic mission (PI. Cruikshank), low-resolution light curves were obtained at 8 different longitudes. In 2014, under a Cycle 10 program (PI. Pinilla-Alonso) we obtained data at ch1 and ch2 at 18 longitudes. The analysis of these data shows clear indications not only of surface heterogeneity, but also on possible secular variations. These data are under analysis and show a great potential for the mapping of volatiles ices all over the surface of Pluto. Two parallel observational programs are in progress involving people in this group, one of near-infrared spectroscopy (~0.9-2.5 μm) at the NASA Infrared Telescope Facility (PI. Grundy) and one of visible spectroscopy (0.4-0.95 μm) at WHT, La Palma (PI. Pinilla-Alonso). The combination of these datasets, covering different wavelength regions, provide unique and complementary information, and is very important in deriving full benefit of data from the NASA New Horizons spacecraft.

Spitzer Space Telescope - General Observer Proposal #13145

Extended study of the Surface Heterogeneity of candidate dwarf-planets (II)

Principal Investigator: Noemi Pinilla-Alonso
Institution: Central Florida

Technical Contact: Noemi Pinilla-Alonso, Central Florida

Co-Investigators:
Joshua Emery, Univerity of Tennessee
Dale P. Cruikshank, NASA Ames Research Center

Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.0
Priority: 1

Abstract:
We propose to continue with our investigation of the volatile activity and migration of volatiles on dwarf-planets (DP) and some candidates to dwarf-planets (CDP). We also extend this study to cover the list of targets for the Kuiper Extended Mission (KEM, second phase of New horizons mission submitted by the New Horizons Team to NASA for extension, and yet to be approved) and extend our continuous monitoring of Pluto's surface. Surface heterogeneity on these bodies can be indicative of the presence of an atmosphere, and active collisional history, or even cometary activity. In cycle 12 we were awarded with ~ 38hr to study three DPs and three CDPs. Five of these objects have been announced in 2016 as targets of the KEM. On cycle 13 we ask for 145.5 hours to study 11 CDP plus five targets of the KEM (one object belongs to both lists but will be observed only once) plus Pluto. By using the proven capability of Spitzer to detect and map the presence of volatile ices, complex organics and silicates on the surface of these distant bodies, we will 1) test the hypothesis that KBOs on the scale of >450 km in diameter could retain a higher content of volatiles than the smaller and more abundant KBOs; 2) characterize the distribution of silicates/organics/ices on the surface of these bodies. These points are key to understanding chemical and dynamical history of the outer Solar System, which acts as a model for the new systems discovered around other stars. Our study will be be of special interest in the eve of James Webb Telescope operation, in 2019 and will pave the road for a detailed characterization of the targets of the Kuiper Extended Mission (if approved).

Spitzer Space Telescope - Directors Discretionary Time Proposal #13152

Mission Support - New Horizons Kuiper Extended Mission

Principal Investigator: Noemi Pinilla-Alonso
Institution: Central Florida

Technical Contact: Noemi Pinilla-Alonso, Central Florida

Co-Investigators:
Joshua Emery, Univerity of Tennessee
Dale P. Cruikshank, NASA Ames Research Center

Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 29.4
Priority: 1

Abstract:
We will observe four potential targets for the Kuiper Extended Mission (KEM): Chiron, Huya, 2010 JJ124, 2002 KX14.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14214

AU Mic - A young planetary system in formation

Principal Investigator: Peter Plavchan
Institution: George Mason University

Technical Contact: Patrick Lowrance, Caltech/IPAC

Co-Investigators:
Elisabeth Newton, Massachusetts Institute of Technology
Ian Crossfield, Massachusetts Institute of Technology
Patrick Lowrance, Caltech/IPAC

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 17.3

Abstract:
AU Mic (M1Ve, V=8.6) is the closest (d=9.9pc) M-dwarf star with a spatially resolved debris disc. The disc has previously been shown to possess an inner hole as well as clumps. The non-Keplerian motions of these clumps had suggested either the disc is impacted by the stellar wind or by dynamical interactions with unseen bodies. Using light curves from NASA's TESS mission together with near-infrared radial velocity measurements, we have discovered a two-planet system orbiting within the debris disk. The inner planet transits with an orbital period of ~17 days, has a radius of 0.4 Jupiter radii, and has a mass similar to that of Saturn. The outer planet is not yet observed to transit -- transits may yet be detected in follow-up observations -- but using radial velocities we have established it has an orbital period of 30.7 days, and a mass of 1.3 Jupiter masses. Now known to possess a system of planets whose radii and/or masses are directly measured, AU Mic offers a unique laboratory for studying dynamical interactions between debris discs and planets during the active planet formation and migration process. More specifically, the orbital periods of the two planets correspond approximately to a 5:9 resonance, a dynamically stable configuration. Unfortunately, TESS only observed one transit, which is insufficient for refining the ephemeris and transit depth. We propose to use Spitzer to accurately determine the planetary and orbital properties of the young planet orbiting AU Mic. There is no other known system that possesses all of these crucial pieces -- an M-dwarf star that is young, still surrounded by a debris disk within which are moving clumps, orbited by multiple planets in a resonance configuration, at least one of which has direct radius and mass measurement -- to be able to study and model the planet formation and evolution and migration processes.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14241

AU Mic - a young planet+disk system

Principal Investigator: Peter Plavchan
Institution: George Mason University

Technical Contact: Patrick Lowrance, Caltech/IPAC

Co-Investigators:
Elisabeth Newton, Massachusetts Institute of Technology
Ian Crossfield, Massachusetts Institute of Technology
Diana Dragomir, MIT Kavli Institute
Tom Barclay, NASA Goddard Space Flight Center
Patrick Lowrance, Caltech/IPAC

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 25.9
Priority: 1

Abstract:
AU Mic (M1Ve, V=8.6) is the closest (d=9.9pc) M-dwarf star with a spatially resolved debris disc. The disc has previously been shown to possess an inner hole as well as clumps. The non-Keplerian motions of these clumps had suggested either the disc is impacted by the stellar wind or by dynamical interactions with unseen bodies. Using light curves from NASA's TESS mission together with near-infrared radial velocity measurements, we have discovered a two-planet system orbiting within the debris disk. The inner planet transits with an orbital period of ~17 days, has an orbital radius of 0.1 AU, and has a mass of ~0.1 Jupiter masses. The outer planet has an orbital period of ~30 days, and orbital distance of 0.15AU and a mass of 0.7 Jupiter masses. Now known to possess a system of planets whose radii and/or masses can be directly measured, AU Mic offers a unique laboratory for studying dynamical interactions between debris discs and planets during the active planet formation and migration process. More specifically, the orbital periods of the two planets correspond approximately to a 5:9 resonance, a dynamically stable configuration. We propose to use Spitzer to further refine the planetary and orbital properties of the young planets orbiting AU Mic. There is no other known system that possesses all of these crucial pieces -- an M-dwarf star that is young, still surrounded by a debris disk within which are moving clumps, orbited by multiple planets in a resonance configuration, at least one of which has direct radius and mass measurement -- to be able to study and model the planet formation and evolution and migration processes.

Spitzer Space Telescope - General Observer Proposal #60109

Measuring YSO inner accretion disk sizes, structure and dynamics with staring mode observations of 14 YSOs in Rho Ophiuchus

Principal Investigator: Peter Plavchan
Institution: California Institute of Technology

Technical Contact: Peter Plavchan, California Institute of Technology

Co-Investigators:
John Stauffer, IPAC/SSC
Rachel Akeson, IPAC/NExScI
Sean Carey, IPAC/SSC
John Carpenter, Caltech
David Ciardi, IPAC/NExScI
Kevin Covey, CfA
Robert Gutermuth, CfA
Patrick Ogle, IPAC/SSC
Luisa Rebull, IPAC/SSC
Karl Stapelfeldt, JPL
Barbara Whitney, Space Science

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.0

Abstract:
Variability is almost a defining characteristic of young stellar objects (YSOs). We propose a program to monitor YSOs with IRAC channel 2 in staring mode for 3 sets of 8 hours. This proposal is complementary to our Exploration Science Spitzer program YSOVAR, which measures variability on timescales greater than 4 hours. With the proposed observations, we will probe disk accretion dynamics on timescales from ~1 minute to 4 hours. Furthermore, we will carry out a novel application of the AGN reverberation mapping technique to YSOs to measure inner disk edge sizes. Combined with ground-based contemporaneous near-IR monitoring, we will be able to measure light travel time delays as short as 25 seconds from the reprocessed dust emission (~0.05 AU). We have constructed a model that confirms the feasibility of measuring these short time-lags, and it requires high-precision mid-infrared photometry that only Spitzer can provide. We have selected a field of 8 nearby, bright Class I and II YSOs in Rho Ophiuchus that contains known near-infrared variables to carry out this pilot program.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10174

First long-term Spitzer microlens parallax; planet mass measurement

Principal Investigator: Radoslaw Poleski
Institution: Ohio State University

Technical Contact: Radoslaw Poleski, Ohio State University

Co-Investigators:
Andrew Gould, Ohio State University
Andrzej Udalski, University of Warsaw
Jennifer Yee, Harvard-Smithsonian Center for Astrophysics

Science Category: Extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.8

Abstract:
We propose additional observations of the continuing microlensing event OGLE-2014-BLG-0298, one of two planetary-anomaly events that were previously observed by Spitzer. The event is very long and exhibits both the lens-rotation and parallax effects. The degeneracy between these two effects can be broken only using satellite photometry. Breaking this degeneracy is crucial in establishing the planet mass, separation, and other properties.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13156

Spitzer Microlens Parallaxes for Long Events as a Preparatory Step for WFIRST

Principal Investigator: Radoslaw Poleski
Institution: The Ohio State University

Technical Contact: Radoslaw Poleski, The Ohio State University

Co-Investigators:
Sebastiano Calchi Novati, NExSI
Andrew Gould, MPIA
Andrzej Udalski, University of Warsaw
Jennifer Yee, Harvard-Smithsonian

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 14.6

Abstract:
We propose additional observations of eight long microlensing events that were observed this year by Spitzer or K2. Spitzer December observations will increase the number of microlensing parallax measurements used for determination of the Galactic distribution of planets. These events are the first for which satellite photometry is obtained in two well-separated windows, hence, as we explain below, they will serve as an empirical test of the ability to extract parallax measurements of microlensing events observed from the WFIRST satellite.

Spitzer Space Telescope - General Observer Proposal #70045

Is there a fallback disk around RX J0720.4-3125?

Principal Investigator: Bettina Posselt
Institution: Harvard-Smithsonian Astrophysical Observatory

Technical Contact: Bettina Posselt, Harvard-Smithsonian Astrophysical Observatory

Co-Investigators:
George Pavlov, Pennsylvania State University
Markus Hohle, Friedrich-Schiller University Jena

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.0

Abstract:
The nearby neutron star RX J0720.4-3125 is the 2nd-brightest of the so-called "Magnificient Seven" and a promising candidate to search for a circumstellar, dusty disk due to its unique observational properties: It exhibits long-term X-ray spectral variability and accretion of debris produced by an asteroid collision is discussed as cause of these spectral changes. Recently, Hambaryan et al. 2009 found an X-ray absorption feature which they suggested originates from Oxygen in a slab close to the neutron star. The Magnificient Seven have very distinctive properties compared to other neutron stars - their X-ray spectrum is purely thermal and they are not detected at radio wavelengths. These objects are slow rotators with strong magnetic fields. Due to their properties these objects are discussed as link to other neutron star populations, and the possession of a circumstellar disk, created from supernova fallback material, is one key parameter in understanding the different populations. We propose to observe the particular promising RX J0720.4-3125 with IRAC to test for the presence of a disk around this enigmatic object.

Spitzer Space Telescope - General Observer Proposal #90140

The Infrared Excess in the Spectrum of the Vela Pulsar

Principal Investigator: Bettina Posselt
Institution: Pennsylvania State University

Technical Contact: Bettina Posselt, Pennsylvania State University

Co-Investigators:
George Pavlov, Pennslyvania State University
Yura Shibanov, Ioffe Institute, St. Petersburg
Oleg Kargaltsev, George Washington University
Andrey Danilenko, Ioffe Institute, St. Petersburg
Dmitriy Zyuzin, Ioffe Institute, St. Petersburg

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.5

Abstract:
Our previous Spitzer observations of the young Vela pulsar in IRAC channels 1 and 3 has shown a significant infrared excess over the extension of the flat UV-optical-NIR spectrum toward longer wavelengths. Such an excess could be caused by a fallback disk around the pulsar, formed by supernova ejecta that failed to escape. Another source of this excess could be an unresolved element of the pulsar wind nebula, such as the one detected previously at NIR wavelengths within 1.5 arcsec from the pulsar. Finally, it could also be emitted by a population of magnetospheric particles with a steep energy spectrum. To distinguish between these three interpretations, we propose new observations of the Vela pulsar. The proposed deep observations in the IRAC channels 1 and 2 will measure the spectral slope and probe the source variability. Together with constraints from new NIR data these results will shed light on the puzzle of the Vela IR excess.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14207

High Resolution MIR Imaging of a Flaring AGN using Spitzer

Principal Investigator: Abhishek Prakash
Institution: California Institute of Technology

Technical Contact: George Helou, California Institute of Technology

Co-Investigators:
Ranga Ram Chary, California Institute of Technology

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
We propose high-resolution MIR observations of a flaring AGN WISE J030654.88+010833.6 hosted by a ULIRG at an estimated redshift of z~0.3 using Spitzer IRAC imager. The AGN identified using red MIR color in WISE data shows extremely interesting characteristics at MIR (WISE W1 and W2) wavelengths which includes extreme AGN variability, an intense starburst, and hot dust emission. The extreme variability displayed in MIR channels is not seen in optical light curve take by Catalina Real-time Transient Survey(CRTS) over overlapping time periods. Using MIR observations from IRAC we aim to extend the light curve by ~1 year which is critical for understanding the origin of variability. ULIRGs in the low-z universe are typically formed by gas-rich mergers. We do not see an obvious evidence of merger activity in optical and WISE images. Using Spitzer IRAC high-resolution observation, we seek to investigate and rule out a possible alignment with a high redshift background source which is not detected in WISE and optical surveys due to low (6'') spatial resolution and brightness, respectively.

Spitzer Space Telescope - General Observer Proposal #10158

Mid-Infrared Variability of Our New Nearby Neighbor

Principal Investigator: Jacqueline Radigan
Institution: University of Toronto

Technical Contact: Jacqueline Radigan, University of Toronto

Co-Investigators:
Esther Buenzli, MPIA
Daniel Apai, University of Arizona
Nicholas Cowan, CIERA/Northwestern
Adam Burgasser, UC San Diego
Amaury Triaud, MIT
Michael Gillon, Universite de Liege
Jacqueline Faherty, U de Chile
Peter Plachvan, IPAC
Yuri Beletsky, LCO
Nidia Morrell, LCO

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 63.5
Priority: 1

Abstract:
Recently, the discovery of a brown dwarf binary only 2 parsecs from the sun was announced, making it our 3rd closest neighbor after Alpha-Centauri and Barnard's star (Luhman et al. 2013). Incredibly, large-amplitude variability (11% in an i+z filter) was announced for the secondary ~T0 component shortly after (Gillon et al. 2013), indicative of patchy clouds. Here we propose to obtain time series observations of this benchmark system with Spitzer to probe cloud structure in its upper atmosphere. As the only brown dwarf system whose mass can be independently constrained from an orbital measurement, and whose 3D clouds structure can be probed from time-domain studies, the Luhman 16 system provides singular opportunity to investigate the sensitive dependence of cloud structure at the L/T transition on effective temperature and surface gravity.

Spitzer Space Telescope - General Observer Proposal #11132

Constraining Dust Hazes at the L/T Transition via Variability

Principal Investigator: Jacqueline Radigan
Institution: Space Telescope Science Institute

Technical Contact: Jacqueline Radigan, Space Telescope Science Institute

Co-Investigators:
Daniel Apai, University of Arizona
Hao Yang, University of Arizona
Kay Hiranaka, AMNH
Kelle Cruz, AMNH
Esther Buenzli, MPIA
Mark Marley, NASA Ames

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 14.5
Priority: 1

Abstract:
The T2 dwarf SIMP 1629+03 is a variable L/T transition dwarf, with a normal near-infrared spectrum. However, it is remarkable in that the wavelength dependence of its variability differs markedly from that of other L/T transition brown dwarfs. In particular, the absence of a water absorption feature in its variability spectrum indicates that a patchy, high-altitude haze, rather than a deeper cloud layer is responsible for the observed variations. We propose to obtain Spitzer+HST observations of SIMP1629+02 over two consecutive rotations periods in order to simultaneously map it?s spectral variability across 1-5 um. The wide wavelength coverage will provide a suitable lever-arm for constraining the particle size distribution in the haze. A truly flat spectrum across this wavelength range would indicate large particle sizes in comparison to those inferred for red L-dwarf hazes, and would therefore provide direct evidence of grain growth with decreasing effective temperature and/or a grain-size dependence on surface gravity in brown dwarf atmospheres.

Spitzer Space Telescope - General Observer Proposal #80213

Weather on Substellar Worlds: Mapping the Atmospheres of Cool Brown Dwarfs

Principal Investigator: Jacqueline Radigan
Institution: University of Toronto

Technical Contact: Jacqueline Radigan, University of Toronto

Co-Investigators:
Nicholas Cowan, Northwestern University
Ray Jayawardhana, University of Toronto
Daniel Apai, Space Telescope Science Institute
Stanimir Metchev, Stony Brook
Adam Showman, University of Arizona
Etienne Artigau, Universite de Montreal
Mark Marley, NASA Ames
Bertrand Goldman, Heidelberg
Adam Burgasser, UC San Diego

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 130.0

Abstract:
While Spitzer has already contributed significantly to the study of winds and weather on highly irradiated extrasolar planets, the atmospheres of free-floating brown dwarfs probe weather in an entirely different physical regime, where global atmospheric flows arise primarily from a combination of rapid rotation and internal convection, without external forcing. We propose to use Warm Spitzer to monitor evolving weather patterns for a subset of brown dwarfs displaying large-amplitude, quasi-periodic variability, indicative of discrete and heterogeneous cloud features in their atmospheres. We plan to obtain continuous light curves for our targets spanning several consecutive rotations in order to map the evolution of cloud features over time and obtain an empirical characterization of their atmospheric dynamics, including: the spatial frequencies and timescales of cloud features, evidence for differential rotation and wind speeds, and the dependence of weather patterns on rotation period. In turn, the data can be used to inform atmospheric circulation models in a mass/rotation regime never before probed, potentially shedding light on competing circulation models for Solar System gas giant planets.

Spitzer Space Telescope - General Observer Proposal #80066

Completing the IRAC coverage of the Herschel Lensing Survey

Principal Investigator: Tim Rawle
Institution: Steward Observatory, U. Arizona

Technical Contact: Tim Rawle, Steward Observatory, U. Arizona

Co-Investigators:
Eiichi Egami, Steward Observatory
Marie Rex, Steward Observatory
Johan Richard, DARK Cosmology Centre, Niels Bohr Institute

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.0

Abstract:
``The Herschel Lensing Survey'' (HLS; PI: E. Egami; 292.3 hrs) is imaging a sample of 44 massive galaxy clusters in five far-infrared bands 100-500 um. The goal is to surpass the nominal confusion-limited depth of Herschel observations by taking advantage of the gravitational lensing power of massive clusters. IRAC imaging enables a simple and robust method of excluding low redshift interlopers from the lensing sample, provides two additional datapoints for full photometric redshifts and offers a measure of the stellar mass for cluster sources. Furthermore, IRAC provides an intermediate band with relatively precise source astrometry, which is useful for locating the optical counterparts of Herschel-detected galaxies, and hence facilitates the short-wavelength follow-up spectroscopy necessary for redshifts. This is crucial, as our ability to accurately determine galaxy dust properties, and hence total infrared luminosity, from the Herschel SEDs is curtailed by the degeneracy between dust temperature and galaxy redshift. Forty-two HLS clusters already have existing IRAC data. Here we propose a short (2 hour) program to complete the IRAC coverage by observing the remaining two clusters (A368, A3088).

Spitzer Space Telescope - General Observer Proposal #60050

Smog Check for Comets: Measuring cometary CO2, CO, and particulate emissions

Principal Investigator: William Reach
Institution: Caltech

Technical Contact: William Reach, Caltech

Co-Investigators:
Michael Kelley, University of Maryland
Jeremie Vaubaillon, IMCCE Paris
Carey Lisse, APL/Johns Hopkins

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 46.2

Abstract:
We propose to measure the CO2, CO, and dust emission from a sample of comets. This study is in the spirit of the A'Hearn et al. compilation of the OH, C2, and dust production rates for 85 comets, wherein the only widely accepted, physically-based taxonomic types of comets were identified. Specifically, C-chain-poor comets, which are predominantly dynamically short-period comets that formed in the Kuiper Belt, are distinct from the C-chain-rich comets that tend to be long-period comets arriving from the Oort cloud and having formed formed in the Jupiter-Saturn region. Spitzer/IRAC observations are unique in their sensitivity to CO2 and CO gas. CO and CO2 have prominent spectral bands that fall within IRAC channel 2, while dust strongly dominates IRAC channel 1. Despite being the second and third most abundant compositions of cometary ice, their high abundance in the Earth's atmosphere makes ground-based observations exceptionally difficult.

Spitzer Space Telescope - General Observer Proposal #12024

A New Cousin of KH15D?

Principal Investigator: Luisa Rebull
Institution: Spitzer Science Center

Technical Contact: Luisa Rebull, Spitzer Science Center

Co-Investigators:
John Stauffer, IPAC/SSC
David Barrado y Navascues, INTA-CSIC
Herve Bouy, INTA-CSIC
Ann Marie Cody, NASA Ames
Lynne Hillenbrand, Caltech
Neal Turner, JPL

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.3
Priority: 2

Abstract:
The photometric variability of young stellar objects (YSOs) can be due to a number of different physical mechanisms, but there are only a few sources known where the orbital geometry results in an occultation of the star by the disk, providing information about the radial structure of the dust in the inner disk. The most famous such object is KH15D, but this type of system is not alone. We believe we may have found another of these rare systems, Mon-31236. It has very large amplitude, abrupt changes in its IRAC light curves at both [3.6] and [4.5]. We are proposing to continue to monitor this star during both of the upcoming visibility windows, with more intensive monitoring during the window where we can obtain simultaneous ground-based data. Our proposal is necessarily exploratory at this time. With the proposed data in hand, we will be in a much better position to determine how Mon-31236 fits in among KH15D and its cousins and what new things we can learn from it about YSO circumstellar disks.

Spitzer Space Telescope - General Observer Proposal #13035

The Connection between Stellar Populations and the Baryon Cycle and Ionizing Escape Fractions of Galaxies at High Redshift

Principal Investigator: Naveen Reddy
Institution: UC Riverside

Technical Contact: Naveen Reddy, UC Riverside

Co-Investigators:
Charles Steidel, California Institute of Technology

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.1
Priority: 1

Abstract:
We propose Spitzer IRAC 3.6 micron observations to cover the three remaining fields of a large spectroscopic survey of galaxies, AGN, and QSOs in the same cosmic volumes at z~2-3. The IRAC data will be used to probe the stellar populations in these galaxies and to understand how galaxy properties (e.g., stellar masses, ages, reddening, star-formation rates) depend on the flow of baryons into and out of galaxies, as well as identify those properties of galaxies that are conducive to the escape of ionizing radiation at high redshift. The dense spectroscopic sampling of the targeted fields have provided unique insights into metal enrichment as a function of galactocentric radius and the statistical correlation between galaxies and metals in the inter-galactic medium. Our goal is to quantify how the distribution of metals in the circum-galactic and inter-galactic media (CGM/IGM) depend on the stellar masses, ages, and star formation rates of galaxies. Moreover, in an effort to clarify the role of galaxies in reionizing the Universe (and keeping it ionized), we wish to understand the types of stellar populations (e.g., stellar masses, ages) that influence the propensity of galaxies to leak ionizing radiation. Our preliminary observations suggest that bluer galaxies with lower star-formation rates have larger escape fractions, but the results are tentative without the inclusion of the IRAC data proposed here. A modest investment of just 13.1 hours (including overhead), divided among the three fields will cover a total of approximately 200 spectroscopically-confirmed z~2-3 galaxies that span two orders of magnitude in bolometric luminosity and stellar mass. The proposed IRAC imaging will allow us to fully leverage the existing spectroscopic samples that form the backbone of our survey of the baryon cycle and escaping ionizing radiation at high redshift.

Spitzer Space Telescope - General Observer Proposal #60177

Direct Stellar Mass Determinations for Individual Lyman Alpha Emitters at z~2

Principal Investigator: Naveen Reddy
Institution: National Optical Astronomy Observatory (NOAO)

Technical Contact: Naveen Reddy, National Optical Astronomy Observatory (NOAO)

Co-Investigators:
Arjun Dey, NOAO
Moire Prescott, University of Arizona
Mark Brodwin, Harvard-CfA

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 21.4

Abstract:
We propose to obtain deep IRAC 3.6 micron imaging of fields where we have conducted a survey of low redshift (z~1.9) Lyman-alpha emitters (LAEs), in order to measure directly their individual stellar masses. The targeted sample includes ~25 spectroscopically-confirmed LAEs at z=1.7-2.1 and roughly twice as many candidates, for a total sample size of ~75 objects. This would constitute perhaps the largest sample of homogeneously selected LAEs with individual measurements of their masses, allowing for a unique opportunity to correlate such measurements with other galaxy properties. In particular, the proposed imaging enables us to quantify the actual stellar mass distribution in of LAEs (as opposed to a stacked average) and, using these data, we will (1) determine whether stellar mass anti-correlates with Lyman-alpha emission, suggesting that Ly-alpha may be a signpost of young galaxies; (2) combine clustering and stellar mass measurements to infer duty cycles of LAEs and if they are triggered in the presence of larger scale structures; (3) combine number density and stellar masses to infer a stellar mass function of LAEs, which when compared with the mass function of all galaxies will shed new light on the importance of the LAE phase at different galaxy mass scales; and (4) quantify the ages of LAEs as inferred from the stellar mass and star formation rate measurements to ascertain the age distribution of low-z LAEs and compare with their higher redshift (z>3) counterparts, and compare the ages to the duty cycles of LAEs. IRAC imaging is a unique tool to pursue these investigations since 3.6 micron samples the peak of the stellar continuum and is less contaminated by current star formation at z~1.9 than at z>3 (where almost all studies have been focused). Thus, a first step to understanding the physical properties of LAEs as function of cosmic time hinges on our ability to rigorously investigate their nature at lower redshifts where the observations are more amenable.

Spitzer Space Telescope - General Observer Proposal #70108

The Dependence of Galaxy Feedback on Stellar Populations at z~2-3

Principal Investigator: Naveen Reddy
Institution: NOAO

Technical Contact: Naveen Reddy, NOAO

Co-Investigators:
Charles Steidel, California Institute of Technology
Alice Shapley, University of California at Los Angeles
Dawn Erb, University of California at Santa Barbara
Max Pettini, Institute of Astronomy, Cambridge University
Gwen Rudie, California Institute of Technology
Ryan Trainor, California Institute of Technology

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 40.4

Abstract:
We propose Spitzer IRAC 3.6 micron observations in fields where we have been conducting a large spectroscopic survey of galaxies, AGN, and QSOs in the same cosmic volumes at z~2-3. The IRAC data will be used to probe the stellar populations in these galaxies and to understand how galaxy properties (e.g., stellar masses, ages, star formation rates) depend on the flow of baryons into and out of galaxies. The dense spectroscopic sampling of the targeted fields have provided unique insights into the metal enrichment as a function of galactocentric radius and the statistical correlation between galaxies and metals in the inter-galactic medium. Our goal is to quantify how the distribution of metals in the circum-galactic and inter-galactic media (CGM/IGM) depend on the stellar masses, ages, and star formation rates of galaxies. An economical investment of just 40.4 hours (including overhead), divided among nine proposed pointings with IRAC, will cover a total of 900 spectroscopically-confirmed z~2-3 galaxies that span two orders of magnitude in bolometric luminosity and stellar mass. Future MOSFIRE multi-object near-IR spectroscopy will be used to compare galaxy chemistry with that of the nearby CGM/IGM with an even denser spectroscopic sampling of the same survey fields, thus adding greatly to the legacy value of the requested IRAC observations.

Spitzer Space Telescope - General Observer Proposal #14101

Three Transits for the Price of One: Super-Earth Transits of the Nearest Planetary System Discovered By Kepler/K2

Principal Investigator: Seth Redfield
Institution: McDonald Observatory, University of Texas

Technical Contact: Seth Redfield, McDonald Observatory, University of Texas

Co-Investigators:
Prajwal Niraula, Wesleyan University
Christina Hedges, NASA Ames
Ian Crossfield, MIT
Laura Kreidberg, Harvard-Smithsonian Center for Astrophysics
Tom Greene, NASA Ames
Joey Rodriguez, Harvard-Smithsonian Center for Astrophysics
Andrew Vanderburg, University of Texas
Gregory Laughlin, Yale University
Sarah Millholland, Yale University
Songhu Wang, Yale University
William Cochran, University of Texas
John Livingston, University of Tokyo
Davide Gandolfi, University of Torino
Eike Guenther, Thuringer Landessternwarte
Malcolm Fridlund, Chalmers University of Technology
Judith Korth, Universitat zu Koln

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.6
Priority: 2

Abstract:
We propose primary transit observations of three Super-Earth planets in the newly discovered planetary system around a bright, nearby star, GJ 9827. We recently announced the detection of three super-Earth planets in 1:3:5 commensurability, the inner planet, GJ 9827 b having a period of 1.2 days. This is the nearest planetary system that Kepler or K2 has found, at 30 pc, and given its brightness is one of the top systems for follow-up characterization. This system presents a unique opportunity to acquire three planetary transits for the price of one. There are several opportunities in the Spitzer visibility windows to obtain all three transits in a short period of time. We propose 3.6 micron observations of all three Super-Earth transits in a single 18-hour observation window. The proximity to a 1:3:5 resonance is intriguing from a dynamical standpoint as well. Indeed, anomalous transit timing offsets have been measured for planet d in Hubble observations that suffer from partial phase coverage. The short cadence and extended coverage of Spitzer is essential to provide a firm determination of the ephemerides and characterize any transit timing variations. Constraining these orbital parameters is critical for follow-up observations from space and ground-based telescopes. Due to the brightness of the host star, this planetary system is likely to be extensively observed in the years to come. Indeed, our team has acquired observations of the planets orbiting GJ9827 with Hubble in the ultraviolet and infrared. The proposed observations will provide infrared atmospheric measurements and firm orbital characterization which is critical for planning and designing future observations, in particular atmospheric characterization with JWST.

Spitzer Space Telescope - General Observer Proposal #60176

The Spitzer Lyman Alpha Survey

Principal Investigator: James Rhoads
Institution: Arizona State University

Technical Contact: James Rhoads, Arizona State University

Co-Investigators:
Sangeeta Malhotra, Arizona State University
Steven Finkelstein, Texas A&M
Norman Grogin, STScI
Norbert Pirzkal, STScI
Junxian Wang, USTC

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 91.1

Abstract:
Determining the star formation history of high-redshift galaxies is vital for understanding galaxy formation and reionization. These galaxies are typically selected using their rest-frame ultraviolet (UV) fluxes, thus their old stellar populations can be missed. Spitzer Imaging at 3.6 microns is essential to measure the rest-frame optical fluxes of high redshift galaxies and therefore estimate the total stellar mass. Lyman-alpha galaxies form fully half of the known galaxies at z=3-6. The strength of the Lyman-alpha line, at first glance, indicates a young (~10 million years old) and dust-free population. This picture of Lyman-alpha galaxies as a class of less massive and young objects is simultaneously being confirmed and challenged thanks to Spitzer data. While most of the Lyman-alpha galaxies are young and low-mass, a subset of them are more massive and/or dusty. That there may be two types of Lyman-alpha emitters, is based on the only those few studies that analyze individual galaxies, and not co-addition of a sample of non-detections. In order to robustly investigate the statistical fraction of older and younger Lyman-alpha galaxies at any given redshift and to find out the redshift evolution of this fraction, we simultaneously need a large sample at many redshifts, and we need deep imaging so we can study individual objects. We propose a systematic IRAC 3.6 imaging survey of a spectroscopically confirmed sample of about 100 Lyman-alpha galaxies between redshifts 3.1<z<6.6. Deep broad-band imaging of all the galaxies in B,V,R,I and Z; and J and H imaging of a subset with NICMOS already exists. By fitting Spectral energy distributions we will measure accurately (1) The total stellar mass in these objects, including old stars which may have formed at redshifts > 8; (2) The dust extinction in the UV, and therefore a correction to their present star-formation rates; (3) The fraction of galaxies with old stellar populations as a function of redshift.

Spitzer Space Telescope - General Observer Proposal #60139

Leveraging Spitzer's Legacy: Quasars and Feedback at High Redshift

Principal Investigator: Gordon Richards
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Co-Investigators:
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Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 48.5

Abstract:
Recent research efforts to understand the evolution of galaxies and quasars are beginning to form a consistent picture. Galaxies and their supermassive black holes grow through mergers, but with decreasing characteristic mass scales over time. Much less, however, is known about the evolution of galaxies at high redshifts and the role played by energy injection from the onset of active black hole growth. Understanding these events requires investigating a statistically significant number of high-redshift quasars and crossing the L* boundary in luminosity. To construct an appropriate data set requires both relatively wide-areas (to find these rare objects) and moderate-depth imaging (to probe below L* in luminosity). Unfortunately, existing optical and MIR surveys fail to meet both of these requirements. Furthermore, both optical and MIR quasar selection are blindest at the most crucial redshifts. Here we propose to address these gaps with targeted IRAC observations of a few hundred high-redshift quasars from the Sloan Digital Sky Survey. Such a sample will enable the construction of a proper training set for the discovery of $2.5<z<5$ quasars through combined optical+MIR (from IRAC channels 1 and 2) selection methods that overcome the limitations inherent to optical and MIR selection alone. By concentrating on SDSS Stripe 82, with sensitivity of $i\sim23$, we will learn how to identify high-redshift quasars in other fields over a large range in luminosity. With this knowledge, we will crack open the high-z quasar discovery space within existing IRAC legacy surveys (SWIRE, XFLS, Bootes, COSMOS). With a large sample of high-redshift quasars spanning a large range in luminosity, we can turn the quasar luminosity function and quasar clustering analysis into tools for distinguishing between different evolutionary models and feedback prescriptions. In all, we will observe 330 SDSS quasars using 307 pointings/AORs, totaling 48.5 hours of IRAC time.

Spitzer Space Telescope - General Observer Proposal #90045

SpIES: The Spitzer-IRAC Equatorial Survey

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Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 800.0

Abstract:
The Spitzer Space Telescope has opened up entirely new realms of astronomy, but unlike ground-based optical and NIR surveys, it has not yet conducted a wide-area survey that samples enough volume to perform investigations of quasar clustering and the quasar luminosity function at $z>3$. We propose to remedy this situation by performing a moderately deep Spitzer-IRAC survey of 175 sq. deg. along the Celestial Equator (SDSS "Stripe 82"), complemented with one of the CFHT Legacy Survey wide fields with which it overlaps. With this dataset, we will 1) probe quasar clustering and the luminosity function in order to test different "feedback" models of galaxy evolution; 2) identify obscured and unobscured AGNs with a combination of mid-IR, optical, and variability selection---taking advantage of ancillary multi-wavelength, multi-epoch data to produce accurate photometric redshifts; 3) identify ~25 $6<z<7$ quasars, which are important probes of reionization; and 4) support other wide-field ancillary science. We show that SWIRE-depth exposures (120s) are an optimal choice for our investigations. Stripe 82 is the premier large-area, multi-wavelength extragalactic region of sky, with deep imaging in the optical (SDSS, CFHT), ultraviolet (GALEX), NIR (UKIDSS), FIR (Herschel), radio (VLA), and millimeter

(ACT), as well as extensive spectroscopy (SDSS I/II, SDSS-III/BOSS, 2dF, WiggleZ, VVDS, DEEP2). We therefore propose Spitzer-IRAC imaging to complete the wavelength coverage in Stripe 82, to provide a wide-area survey of lasting value. At our optimal depth, covering this area (~175 sq. deg.) will require 1270 hours of new observations. Such a survey will complement existing Spitzer Legacy programs and provide crucial input for future missions such as JWST. Reduced images and catalogs will be made available to the public using the existing SDSS, NVO, and IRSA database structures.

Spitzer Space Telescope - General Observer Proposal #80120

Reverberation Mapping of the size of the Dusty Tori in Active Galactic Nuclei.

Principal Investigator: David Axon
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Co-Investigators:
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Andrew Robinson, Rochester Instute of Technology
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Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 196.0

Abstract:
Despite its central role in AGN unification models and its importance for studies of supermassive black hole demographics, our current understanding of the size and structure of AGN tori is weak. We propose to use the unique opportunity provided by the warm phase of Spitzer to determine the sizes of circum-nuclear dust tori in AGN. To accomplish this we will carry out a monitoring campaign, coordinated with ground-based observations, to measure the "light echo" as the dust emission responds to variations in the AGN optical/UV continuum. We have selected a sample of 12 bright type 1 nuclei in close proximity to the Spitzer Continuous Viewing Zone which can be observed repeatedly with visibility windows for at least 70% of the ~400 day cycle and generally > 90% (10 objects)of the ~400 day cycle. We will observe each AGN with 3 day sampling on Spitzer for the whole of Cycle 8. We have in place a plan for a supporting ground based monitoring program using a variety of conventional and robotic telescopes, which will allow ?world-wide? coverage, to determine the AGN light-curves in the B band. These observations will more than double the number of AGN with simultaneous optical and NIR time-series data, providing well-sampled, high signal-to-noise light curves of both S1 and NLS1. Such high fidelity, continuously sampled lR light curves covering hundreds of days cannot be obtained from the ground, and are needed because the expected reverberation time scales are many tens of days (30-150). We will apply well developed techniques to determine the reverberation lag and therefore obtain the characteristic size of the torus in this sample which has diverse properties and samples a range of black hole mass and Eddington ratio. Our team contains many leading experts in reverberation mapping of AGN and in the observational study and theoretical modeling of the physics of the dusty torus. We are requesting a total of 196 hrs in the cycle to perform our observations.

Spitzer Space Telescope - General Observer Proposal #90209

Reverberation Mapping of the Dusty Tori in Active Galactic Nuclei

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Technical Contact: Michael Richmond, Rochester Institute of Technology

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Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.8

Abstract:
Our current understanding of the size and structure of AGN tori is weak, despite their central role in AGN unification models and their importance for studies of supermassive black hole demographics. We propose to use the warm phase of Spitzer to determine the sizes of circum-nuclear dust tori in AGN. To accomplish this we will extend an existing Spitzer monitoring campaign, coordinated with ground-based observations, to measure the "light echo" as the dust emission responds to variations in the AGN optical/UV continuum. We have selected a sample of 12 bright type 1 nuclei in close proximity to the Spitzer Continuous Viewing Zone which can be observed for at least 70% of the 365 day cycle. We will observe each AGN every 30 days for the whole of Cycle 9, roughly doubling our existing baseline of one year, permitting us to identify optical-IR time lags of many months. We will continue our current ground based monitoring program using a variety of telescopes to determine the AGN light-curves in the optical. These observations will sample the torus more faithfully than previous measurements made in the K-band. Such high fidelity, continuously sampled IR light curves covering ~years cannot be obtained from the ground, and are needed because the expected reverberation timescales are hundreds of days. We will apply well developed techniques to determine the reverberation lag and therefore obtain the characteristic size of the torus in this sample which spans a range of black hole mass and Eddington ratio. Our team contains many leading experts in reverberation mapping of AGN and in the observational study and theoretical modeling of the physics of the dusty torus. We are requesting a total of 14 hours in the cycle to perform our observations. These observations will provide a stringent observational test of current models for the obscuring torus in AGN. The required measurements - long timescales, continuous monitoring in the near-infrared - are possible only with the Spitzer Space Telescope.

Spitzer Space Telescope - General Observer Proposal #10157

Extrasolar Giant Impacts in Real Time

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Huan Meng, Arizona

Co-Investigators:
Huan Meng, University of Arizona
Kate Su, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 99.0

Abstract:
Spitzer observations in the previous cycles have revealed 3.6 and 4.5 um variability and periodicity in extreme debris disks on timescales of weeks or even shorter. Such disks typically have warm temperatures and strong crystalline silicate emission, indicative of very fine dust particles in the terrestrial planet zone and below the blowout sizes of the stars. Many of the disks are around solar-like stars in the age range of 30 - 100+ Myr, the expected time for the final buildup of terrestrial planets through massive collisions. These young extrasolar systems are probably going through this phase with series of violent collisions, or possible analogs of the Moon-forming impact, providing rare opportunities to investigate terrestrial planet formation and collision in real time, and put our own Solar System in context. Here we propose to continue the monitoring of three such systems with daily sampling cadence. The observations will provide insight into the physical and dynamical processes of the planet-forming disks.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13211

Advancing Absolute Calibration for JWST and Other Applications

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: George Rieke, The University of Arizona

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Kathleen Kraemer, Boston College
Massimo Marengo, Iowa State Univ.
Everett Schlawin, Univ. of Ariz.
Kate Su, Univ. of Ariz.
Greg Sloan, STScI
Kevin Volk, STScI

Science Category: dark matter
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.0

Abstract:
We propose to exploit the unique optical stability of the Spitzer telescope, along with that of IRAC, to (1) transfer the accurate absolute calibration obtained with MSX on very bright stars directly to two reference stars within the dynamic range of the JWST imagers (and of other modern instrumentation); (2) establish a second accurate absolute calibration based on the absolutely calibrated spectrum of the sun, transferred onto the astronomical system via alpha Cen A; and (3) provide accurate infrared measurements for the 11 (of 15) highest priority stars with no such data but with accurate interferometrically measured diameters, allowing us to optimize determinations of effective temperatures using the infrared flux method and thus to extend the accurate absolute calibration spectrally. This program is integral to plans for an accurate absolute calibration of JWST and will also provide a valuable Spitzer legacy.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14226

Ongoing Planetesimal Collisions in the Terrestrial Planet Zone of V488 Per

Principal Investigator: George Rieke
Institution: University of Arizona

Technical Contact: Kate Su, University of Arizona

Co-Investigators:
Kate Su, Steward Observatory
Huan Meng, Steward Observatory

Science Category: Debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 5.5
Priority: 42

Abstract:
The formation of Earth-like planets is a key aspect of our efforts to understand habitable worlds. Theory has been our main - almost only - means to study planet formation in the 10 - 150 MYr range when Terrestrial planets grow from embryos to their current sizes through violent planetesimal collisions. Spitzer observations have provided the first demanding tests of this theory. They have revealed systems with rapid fluctuations in infrared excess indicating very active collisional episodes among massive planetesimals. NGC 2547-ID8 is the prototype; the speed of its fluctuations is almost completely unanticipated in the theory. We propose intensive monitoring of the second well-established example of this behavior, V488 Per, to compare with ID8 and understand the process in a broader context.

Spitzer Space Telescope - General Observer Proposal #80113

Absolute Calibration of Infrared Standard Stars to the 1% Level

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: George Rieke, The University of Arizona

Co-Investigators:
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Karl Gordon, STScI
Dean Hines, STScI
Mary Elizabeth Kaiser, Johns Hopkins
Marcia Rieke, University of Arizona
Kate Su, University of Arizona

Science Category: stellar populations
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 7.1

Abstract:
A number of high-priority programs will benefit from a near-infrared absolute calibration at the 1% level. This requirement has been emphasized by the Dark Energy Task Force and in Astro2010 with regard to reducing systematic errors in dark energy studies. It also will improve our understanding of stellar effective temperatures (and radiative transfer), and of the mass-radius relation and equation of state of white dwarfs (as examples). We propose to establish a 3.6 micron absolute calibration at this level for 33 prime calibration stars. These stars have been selected: 1.) as targets for the optical/NIR absolute calibration programs ACCESS and under NIST; 2.) as JWST prime calibrators; or 3.) as prime calibration stars for HST or SDSS. Our program includes fitting the measurements with theoretical models to generate full spectral energy distributions that allow extending the calibration to any infrared band through synthetic photometry. We will observe these stars in a manner that also allows the calibration to be transferred to an all-sky network of more than 1500 stars for which we are obtaining 3.6 micron measurements in another program.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80260

Infrared Variability of Extreme Debris Disks

Principal Investigator: George Rieke
Institution: Arizona

Technical Contact: Huan Meng, Arizona

Co-Investigators:
Huan Meng, Arizona
Kate Su, Arizona

Science Category: debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.8

Abstract:
Debris disks with extremely large infrared excesses (fractional luminosities > 10^{-2}) are rare. Those with ages between ~30 and 100+ Myr are of interest because their evolution has progressed well beyond that of protoplanetary disks (which dissipate with a timescale of order 3 Myr), yet they represent a period when dynamical models suggest that terrestrial planet building may still be progressing through large, violent collisions that could yield large amounts of debris and large infrared excesses. For example, our Moon was formed through a violent collision of two large proto-planets during this age range. In a recent paper, we reported the discovery of two disks around the solar-like stars ID8 in NGC 2547 and HD 23514 in the Pleiades in this age range where the 24 um infrared excesses vary on timescales of a few years, even though the stars are not variable in the optical. The observed variability is too rapid to be explained readily if the debris is produced by collisional cascades, which decay on the order of Myr as is the case for most planetary debris disks. Examining existing Spitzer and WISE photometry data reveals a couple of additional similar IR variable stars, and suggests that the variations of this type of debris disks can also be observed at shorter wavelengths, e.g. 4.5 um. Here we propose a pilot program to make regular 4.5 um time-series observations for one of the variable debris disks, ID8 in NGC 2547, and a few one-time observations of other disks for confirmation purposes. ID8 has been confirmed to be variable at 4.5 um, and has a sufficiently long visibility window for Spitzer. Our proposed observations will provide crucial information about the variability (e.g., possible periodicity and/or decay timescale) of this type of debris disks that could facilitate further research and observation planning.

Spitzer Space Telescope - General Observer Proposal #90192

Lightcurves of Extreme Debris Disks

Principal Investigator: George Rieke
Institution: The University of Arizona

Technical Contact: Huan Meng, Arizona

Co-Investigators:
Huan Meng, University of Arizona
Kate Su, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 40.4

Abstract:
We have recently discovered that some planetary debris disks with extreme fractional luminosities are variable on the timescale of a few years. This behavior opens a new possibility to understand planet building. Two of the known variable disks are around solar-like stars in the age range of 30 to 100+ Myr, which is the expected era of the final stages of terrestrial planet building. Such variability can be attributed to violent collisions (up to ones on the scale of the Moon-forming event between the proto-Earth and another proto-planet). The collisional cascades that are the aftermaths of these events can produce large clouds of tiny dust grains, possibly even condensed from silica vapor. A Spitzer pilot program has obtained the lightcurve of such a debris disk and caught two minor outbursts. Here we propose to continue the lightcurve monitoring with higher sampling rates and to expand it to more disks. The proposed time domain observations are a new dimension of debris disk studies that can bring unique insight to their evolution, providing important constraints on the collisional and dynamical models of terrestrial planet formation.

Spitzer Space Telescope - Directors Discretionary Time Proposal #90262

Diagnosing the Variation of an Extreme Debris Disk

Principal Investigator: George Rieke
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Technical Contact: Meng Huan, University of Arizona

Co-Investigators:
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Science Category: Debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 15.0

Abstract:
We have found several planetary debris disks with mid-infrared variations on timesc ales of years, while their solar-like host stars show no variation in the optical. Most interestingly, such systems are mostly in the age range expected for the final stages of terrestrial planet formation (30 - 100+ Myr), representing an episode of violent collisions in the terrestrial planet forming zone. One of the prototype stars, ID8 in NGC 2547, has been regularly monitored at both 3.6 and 4.5 micron with Spitzer, and shows steep rising and sharp drops in the light curve with an indication of periodicity and color changes. Here we propose to use a higher cadence rate for monitoring in the existing program to better characterize the shape of the light curve. The proposed observations will provide stringent constraints on the rate of violent collisions in dynamical models of a planet-forming disk.

Spitzer Space Telescope - General Observer Proposal #12001

The Ultimate Emission Line Diagnostics Study at z=1.4

Principal Investigator: Jane Rigby
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Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.1
Priority: 1

Abstract:
we propose the ultimate WFC3 grism spectroscopy, in terms of spatial resolution, signal-to-noise ratio, and diagnostic emission line coverage, at z=1.4. The targets are two extremely bright lensed galaxies at redshifts of 1.329 and 1.420. These redshifts place all of rest-frame optical diagnostic emission lines, from [O II] 3727 to [S II] 6731 A, in the WFC3 G102 and G141 grisms. On spatial scales down to 100 pc, we will map the star formation rate, metallicity, extinction, and excitation across these two galaxies, and thereby measure not only the physical conditions of star formation, but how those conditions vary spatially. For the target that currently lacks HST and Spitzer imaging, we propose 2 orbits of WFC3/UVIS imaging to enable creation of a lensing map, and 1 hr of Spitzer to obtain a stellar mass estimate. This program will be a legacy for HST, the most rigorous in situ test yet of strong-line nebular line diagnostics in the distant universe, and will establish a benchmark for far larger grism surveys in which HST has invested some 700 orbits.

Spitzer Space Telescope - General Observer Proposal #90232

Precise Stellar Masses at 1<z<3 in Strongly Lensed Galaxies Observed by HST

Principal Investigator: Jane Rigby
Institution: NASA Goddard Space Flight Center

Technical Contact: Jane Rigby, NASA Goddard Space Flight Center

Co-Investigators:
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Keren Sharon, University of Michigan
Eva Wuyts, MPE

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 61.5

Abstract:
We propose IRAC imaging of 22 strong lensing fields to a depth complementary to upcoming HST Cycle 20 imaging. All but four of these fields have extant but shallow IRAC imaging; here we seek here the depth necessary to fully exploit the investment in HST imaging, and extensive ground-based spectroscopy. With this ensemble of data we will characterise the nature of star formation in galaxies at 1<z<3, with a spatial resolution and S/N not acheived even in deep fields, and over a broader mass range. The proposed IRAC data provide a critically important handle on stellar mass; as such, IRAC reveals the canvas of established older stars, on which HST will paint the detailed picture of current star formation.

Spitzer Space Telescope - General Observer Proposal #13125

Ultra-diffuse Galaxies in Clusters and the Field: Masses and Stellar Populations

Principal Investigator: Aaron Romanowsky
Institution: San Jose State University

Technical Contact: Aaron Romanowsky, San Jose State University

Co-Investigators:
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Jessica Krick, Spitzer Science Center
Pieter van Dokkum, Yale University
Alexa Villaume, University of California, Santa Cruz
Jean Brodie, University of California, Santa Cruz

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.4
Priority: 1

Abstract:
Ultra-diffuse galaxies (UDGs) were recognized only last year as a novel class of galaxies, with luminosities like dwarfs but sizes like giants. Although some UDGs appear to be just unusually extended dwarfs, others show evidence of being very different and unexpected: their dark matter halos are overmassive by factors of ~10, with one UDG even being arguably a "failed Milky Way." These exotic galaxies might be a byproduct of environmental processes within galaxy clusters, but UDGs have also now been found in the field. It is crucial for understanding their origins to test if UDGs have the same properties in cluster and field environments. Here we propose studying the stellar populations (ages and metallicities) of seven UDGs using Spitzer/IRAC 3.6- and 4.5-micron imaging combined with optical photometry, along with mass estimation of three of the UDGs using HST/ACS imaging to provide globular cluster number counts and colors (proxies for halo mass). This ultra low surface brightness photometry in the near infrared, on an important new class of galaxies, could become a legacy result from the Spitzer mission.

Spitzer Space Telescope - General Observer Proposal #14114

A Survey of Stellar Populations in Ultra-Diffuse Galaxies

Principal Investigator: Aaron Romanowsky
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Bob Abraham, University of Toronto
David Martinez-Delgado, University of Heidelberg
Johnny Greco, Princeton University
Jenny Greene, Princeton University

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 50.1
Priority: 1

Abstract:
Ultra-diffuse galaxies (UDGs) are a recently identified, mysterious class of galaxies with luminosities like dwarfs, but sizes like giants. Quiescent UDGs are found in all environments from cluster to isolated, and intensive study has revealed three very distinctive sub-types: low surface brightness dwarfs, "failed galaxies", and low-dark-matter UDGs. Following up on our recent, successful Spitzer pilot work to characterize the stellar populations (ages and metallicities) of UDGs, we propose a survey of 25 UDGs with a range of optical properties and environments, in order to understand the formation histories of different the different UDG sub-types.

Spitzer Space Telescope - General Observer Proposal #11097

Thermal Emission Light-Curves of Rapidly Rotating Asteroids

Principal Investigator: Ben Rozitis
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Co-Investigators:
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Agata Rozek, University of Kent
Stephen Wolters, The Open University
Colin Snodgrass, The Open University
Simon Green, The Open University

Science Category: asteroids
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 50.0
Priority: 1

Abstract:
We propose to use Spitzer/IRAC to obtain simultaneous 3 and 4 um light-curves of 23 rapidly rotating asteroids (rotation periods of less than 3 hrs) to determine thermal inertia and surface roughness spatial variations. These observations will probe asteroid geophysics and constrain the origin of their rapid rotation. Rapidly rotating asteroids are unusual bodies where their own self-gravity is balanced or exceeded by rotational centrifugal forces, and are thought to have acquired their fast rotation rates through the YORP effect - a radiative torque induced by exposure to sunlight. For each target asteroid, we will measure thermal flux in both IRAC bands for a full rotation. When combined with shapes and spin axes derived from our ground-based programme, and a thermophysical model, we will be able to identify any temperature variations resulting from thermal inertia and/or surface roughness variation, and be able to constrain theoretical predictions of YORP rotational acceleration. The thermal property variations will be compared against models of surface gravity in order to provide insights into the physical processes by which asteroids retain and lose surface material. 16 of our target asteroids are being observed at optical wavelengths in a European Southern Observatory (ESO) Large Programme (LP) awarded 82 nights to constrain rotation period changes induced by the YORP effect (PI Stephen Lowry; Program IDs 185.C-1033, 185.C-1034). Approximately 80 additional nights on a range of other facilities has also been awarded for this programme. The ESO LP will support the Spitzer programme by providing shape and spin axis information necessary to search for surface property variations in the thermal emission light-curves of these asteroids. Likewise, the Spitzer/IRAC thermal emission light-curves will allow us to derive the physical properties that drive the YORP effect on the ESO LP asteroids.

Spitzer Space Telescope - General Observer Proposal #11125

Quantifying the line-of-sight mass distributions for time-delay lenses with stellar masses

Principal Investigator: Cristian Rusu
Institution: University of California, Davis

Technical Contact: Cristian Rusu, University of California, Davis

Co-Investigators:
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Frederic Courbin, Ecole Polytechnique Federale de Lausanne
Stefan Hilbert, Max Planck Institute for Astrophysics
Georges Meylan, Ecole Polytechnique Federale de Lausanne
Dominique Sluse, University of Bonn

Science Category: cosmology
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.4
Priority: 1

Abstract:
Measuring cosmological parameters with a realistic account of systematic uncertainties is currently one of the principal challenges of physical cosmology. Building on our recent successes with two gravitationally lensed systems, we have started a program to achieve accurate cosmographic measurements from five gravitationally lensed quasars. We aim at measuring H_0 with an accuracy better than 4%, comparable to but independent from measurements by current BAO, SN or Cepheid programs. The largest current contributor to the error budget in our sample is uncertainty about the line-of-sight mass distribution and environment of the lens systems. In this proposal, we request wide-field u-band imaging of the only lens in our sample without already available Spitzer/IRCA observations, B1608+656. The proposed observations are critical for reducing these uncertainties by providing accurate redshifts and in particular stellar masses for galaxies in the light cones of the target lens system. This will establish lensing as a powerful and independent tool for determining cosmography, in preparation for the hundreds of time-delay lenses that will be discovered by future surveys.

Spitzer Space Telescope - General Observer Proposal #14081

Adding the missing piece: Spitzer imaging of the HSC-Deep/PFS fields

Principal Investigator: Anna Sajina
Institution: Haverford College

Technical Contact: Anna Sajina, Haverford College

Co-Investigators:
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Duncan Farrah, Virginia Tech
Jenny Greene, Princeton
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Yoshiaki Ono, University of Tokyo
Masami Ouchi, University of Tokyo
Marcin Sawicki, St. Mary's University
Michael Strauss, Princeton
Jason Surace, IPAC
Katherine Whitaker, University of Connecticutt

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 488.3
Priority: 1

Abstract:
We propose to observe a total of 7sq.deg. to complete the Spitzer-IRAC coverage of the HSC-Deep survey fields. These fields are the sites of the PrimeFocusSpectrograph (PFS) galaxy evolution survey which will provide spectra of wide wavelength range and resolution for almost all M* galaxies at z~0.7-1.7, and extend out to z~7 for targeted samples. Our fields already have deep broadband and narrowband photometry in 12 bands spanning from u through K and a wealth of other ancillary data. We propose completing the matching depth IRAC observations in the extended COSMOS, ELAIS-N1 and Deep2-3 fields. By complementing existing Spitzer coverage, this program will lead to an unprecedended in spectro-photometric coverage dataset across a total of 15 sq.deg. This dataset will have significant legacy value as it samples a large enough cosmic volume to be representative of the full range of environments, but also doing so with sufficient information content per galaxy to confidently derive stellar population characteristics. This enables detailed studies of the growth and quenching of galaxies and their supermassive black holes in the context of a galaxy's local and large scale environment.

Spitzer Space Telescope - General Observer Proposal #80159

Beyond the 'acronym populations': Halpha-selected galaxies at z~2

Principal Investigator: Samir Salim
Institution: Indiana University

Technical Contact: Samir Salim, Indiana University

Co-Investigators:
Janice Lee, Carngeie Observatories
Daniel Dale, University of Wyoming

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 59.6

Abstract:
We propose to obtain deep IRAC photometry for a new Halpha survey of galaxies at z~2. The selection of our galaxy sample is closely tied to a physical quantity (the instantaneous star formation rate), and complements continuum color-based selection methods that have dominated the current census of galaxies at these redshifts. Our observed SFR limits are 4, 8 and 16 Msun/yr for the ultra-deep, deep and shallow components of our survey respectively, and we expect to detect ~500 emission-line galaxies at z=2.2 in total. IRAC, which samples the rest-frame near-IR at that redshift, will provide crucial constraints on the stellar mass. The combination of the proposed IRAC observations with measurements of the recent star formation activity from our Halpha survey will enable us to determine how a range of star formation properties change as a function of stellar mass and how they evolve to the present day. More specifically, IRAC observations will allow us to explore the relation between the instantaneous SFR and stellar mass at z~2 and to determine the dominant mode of star formation at this epoch (starbursts vs. continuous SF). In addition, IRAC photometry will help produce more precise Halpha SFR measurements by improving the constraints on the shape of the underlying continuum. For each of the three tiers of our Halpha survey we require IRAC observations of matching depth (20 min, 80 min and 6 hr per pixel). Such IRAC data are available for our shallow fields (from S-COSMOS) and the ultra-deep field (from SEDS), but not for our two deep fields, the key components of the survey. For these, we propose quadrupling (in COSMOS) and doubling (in UDS) the existing observing time in order to reach the sensitivities required for the robust measurement of stellar masses of Halpha sources. Considering the location of our fields, the new observations will also have a lasting legacy value.

Spitzer Space Telescope - Snapshot Proposal #10046

Completing the Deep IRAC1,2 Imaging of the (U)LIRG Merger Sequence: the pre-merger galaxies and post-merger remnants

Principal Investigator: David Sanders
Institution: Insitute for Astronomy, University of Hawaii

Technical Contact: Jason Surace, Spitzer Science Center

Co-Investigators:
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Jason Surace, Spitzer Science Center
Vivian U, Harvard-Smithsonian CfA / IfA, University of Hawai

Science Category: ULIRGS/LIRGS/HLIRGS
Hours Approved: 230.6
Priority: 2

Abstract:
We propose to obtain deep IRAC1,2 observations (~1400 sec) of a large sample (~250 targets) of putative (U)LIRG precursors and remnants, in order to measure the full extent and internal structure of their debris fields. These new data will be combined with our Cycle 7+8 deep IRAC1,2 imaging of ~200 (U)LIRGs, allowing us to compare the properties of the debris fields across all merger stages, and to better assess the current merger paradigm whereby mergers of gas-rich L* spirals produce (U)LIRGs, which then evolve into IR-QSOs and eventually pass through a "K+A" phase on their way to becoming "red and dead" Ellipticals. Our ~100 pre-merger targets are gas-rich spirals chosen from the Great Observatories All-Sky LIRGs Survey (GOALS), for which we are obtaining both spacecraft and ground-based data at a wide range of wavelengths (radio thru X-ray). Our ~150 post-merger targets have been chosen from a variety of surveys that are likely to include many (U)LIRG remnants, as well as a sample of nearby ellipticals with measured fine structure indices. These new IRAC observations will allow us to fully characterize the extent and morphology of faint debris at every stage of the merger process, and thereby test the tidal origins of these debris fields. If the tidal hypothesis is confirmed, we will use "IDENTIKIT" (Barnes & Hibbard, 2009) models of major and minor mergers to interpret the observations and place our precursors, (U)LIRGs, and remnants on an consistent evolutionary time-line. We also plan to combine our new IRAC1,2 data with deep optical (Subaru and VLT) and NIR (HST-NIC and WFC3) data to determine spectral energy distributions, measure stellar masses, and look for warm dust in these extended features. The new Spitzer data will allow us to obtain a clearer picture of tidal debris fields (e.g. putative tidal dwarf galaxies, and other previously disconnected arms, shells, etc.) that are produced over the complete merger history of (U)LIRGs.

Spitzer Space Telescope - Snapshot Proposal #70038

Deep IRAC1,2 Imaging of the Extended Tidal Debris Fields for the Complete HST-GOALS Sample of (U)LIRGs

Principal Investigator: David Sanders
Institution: University of Hawaii

Technical Contact: Jason Surace, Spitzer Science Center

Co-Investigators:
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Vivian U, Harvard-Smithsonian CfA / IfA, University of Hawai

Science Category: ULIRGS/LIRGS/HLIRGS
Hours Approved: 82.0

Abstract:
We propose to obtain IRAC1,2 observations (~1400 sec) of a flux-limited sample of 88 luminous infrared galaxies (LIRGs) originally selected from the IRAS Revised Bright Galaxy Survey, in order to measure the full extent and internal structure of the large tidal debris fields that have recently been revealed (~70-130 kpc diameter) in deep optical imaging of these objects using the Subaru 8m Telescope on Mauna Kea. Our 88 targets are part of the Great Observatories All-Sky LIRGs Survey (GOALS), for which we are obtaining both spacecraft and ground-based data at a wide range of wavelengths (radio thru X-Rays). All of our targets have previous shallow (~150 sec) IRAC observations, which are insufficient for detecting all but the brightest, and much less extended tidal features. Our deeper IRAC observations will allow us to better characterize the history, geometry and morphology of the interaction for comparison with new sets of model calculations using "IDENTIKIT" (Barnes & Hibbard, 2009). We also plan to combine our new IRAC1,2 data with deep optical (Subaru and VLT) and NIR (HST-NIC, -WFC3) data to determine spectral energy distributions, and to measure stellar masses as well as detect warm dust in these extended features. These new data will also allow us for the first time to obtain a clearer picture of the possible interrelatedness of nearby objects (e.g. putative tidal dwarf galaxies, and other previously disconnected arms, shells, etc.) to the merger history of this complete sample of local (U)LIRGs.

Spitzer Space Telescope - Snapshot Proposal #80089

Deep IRAC1,2 Imaging of the Extended Tidal Debris Fields for the Complete GOALS Sample of LIRGs (Part 2)

Principal Investigator: David Sanders
Institution: Insitute for Astronomy, University of Hawaii

Technical Contact: Jason Surace, Spitzer Science Center

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Science Category: ULIRGS/LIRGS/HLIRGS
Hours Approved: 106.1

Abstract:
We propose to obtain IRAC1,2 observations (~1400 sec) to complete our flux-limited sample of luminous infrared galaxies (LIRGs), selected from the IRAS Revised Bright Galaxy Survey, in order to measure the full extent and internal structure of the large tidal debris fields that have recently been revealed (~70-130 kpc diameter) in deep optical imaging of these objects using the Subaru 8m Telescope on Mauna Kea. Our 115 targets represent the lower luminosity objects in the Great Observatories All-Sky LIRGs Survey (GOALS), defining the important transition region between LIRGs and ULIRGs, for which we are obtaining both spacecraft and ground-based data at a wide range of wavelengths (radio thru X-Rays). All of our targets have previous shallow (~150 sec) IRAC observations, which are insufficient for detecting all but the brightest, and much less extended tidal features. Our deeper IRAC observations will allow us to fully characterize the history, geometry and morphology of the interaction (major and minor mergers) for comparison with new sets of model calculations using "IDENTIKIT" (Barnes & Hibbard, 2009). We also plan to combine our new IRAC1,2 data with deep optical (Subaru and VLT) and NIR (HST-NIC, -WFC3) data to determine spectral energy distributions, and to measure stellar masses as well as detect warm dust in these extended features. These new data will also allow us for the first time to obtain a clearer picture of the possible interrelation of nearby objects (e.g. putative tidal dwarf galaxies, other disconnected debris arms, shells, etc.) to the merger history of our complete sample of local (U)LIRGs.

Spitzer Space Telescope - General Observer Proposal #10154

Following Up the First Light Curves of the Dustiest, Most Extreme Asymptotic Giant Branch Stars in the LMC and SMC

Principal Investigator: Benjamin Sargent
Institution: Rochester Institute of Technology

Technical Contact: Benjamin Sargent, Rochester Institute of Technology

Co-Investigators:
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David Riebel, United States Naval Academy
Uma Vijh, University of Toledo
Joe Hora, Harvard, Center for Astrophysics
Martha Boyer, NASA Goddard Space Flight Center
Kem Cook, LLNL-IGPP
Martin Groenewegen, Royal Observatory of Belgium
Patricia Whitelock, SAAO & University of Cape Town
Yoshifusa Ita, Tohoku University
Michael Feast, University of Cape Town
Ciska Kemper, ASIAA
Massimo Marengo, Iowa State University
Masaaki Otsuka, ASIAA
Sundar Srinivasan, ASIAA

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 11.3
Priority: 1

Abstract:
Asymptotic giant branch (AGB) variable stars are, together with supernovae, the main sources of enrichment of the interstellar medium (ISM) in processed material, particularly carbon, nitrogen and heavy s-process elements. The dustiest, extreme AGB stars contribute the largest enrichment per star. We propose to measure the first light curves for 8 and 5 of the dustiest, most extreme AGB variable stars in the bar regions of Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC), respectively, using the warm Spitzer mission's IRAC 3.6 and 4.5 micron imaging for monthly imaging measurements. Though we know they are variable based on dual-epoch observations from the Spitzer Surveying the Agents of Galaxy Evolution (SAGE) surveys of the LMC and SMC, the periods of these extreme AGB stars have NOT been measured before because they are too faint in the optical and near-infrared to have been captured in the ground based synoptic surveys such as MACHO, OGLE and IRSF. Only Spitzer will be able to measure the light curve of this key phase of the AGB: the dustiest and indeed final stage of the AGB. Without this information, our developing picture of AGB evolution is decidedly incomplete. The observations we propose will test the validity of AGB evolution models, and, thus, their predictions of the return of mass and nucleosynthetic products to the ISM. A value-added component to this study is that we will obtain variability information on other AGB stars that lie within the fields of view of our observations. This proposal follows up on the Cycle 9 proposal pid 90219 to observe the other extreme AGB stars from the Gruendl et al 2008 study, which together dominate the total mass return to the LMC. In addition, we ask to obtain further epochs of observation of the 5 SMC sources from our 90219 proposal to define the periods if the periods are 1000 days or more.

Spitzer Space Telescope - General Observer Proposal #11163

Spitzer Light Curves of Dusty AGB Stars in the Small Magellanic Cloud

Principal Investigator: Benjamin Sargent
Institution: Rochester Institute of Technology

Technical Contact: Benjamin Sargent, Rochester Institute of Technology

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Joe Hora, Harvard, Center for Astrophysics
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Kem Cook, LLNL-IGPP
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Sundar Srinivasan, ASIAA

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 28.4
Priority: 1

Abstract:
Asymptotic giant branch (AGB) variable stars are, together with supernovae, the main sources of enrichment of the interstellar medium (ISM) in processed material, particularly carbon, nitrogen and heavy s-process elements. The dustiest, extreme AGB stars contribute the largest enrichment per star. We propose to measure the first light curves for 32 of the dustiest AGB variable stars in the Small Magellanic Cloud (SMC) using the warm Spitzer mission's IRAC 3.6 and 4.5 micron imaging for monthly imaging measurements. We know most are variable based on dual-epoch observations from the Spitzer Surveying the Agents of Galaxy Evolution (SAGE) surveys of the SMC and ground-based near-infrared observations, but we have not observed these dusty SMC stars at the mid-infrared wavelengths available to Spitzer. Only Spitzer will be able to measure the light curve of this key phase of the AGB: the dustiest and indeed final stage of the AGB. Without this information, our developing picture of AGB evolution is decidedly incomplete. The observations we propose will test the validity of AGB evolution models, and, thus, their predictions of the return of mass and nucleosynthetic products to the ISM. A value-added component to this study is that we will obtain variability information on other AGB stars that lie within the fields of view of our observations. This proposal continues the studies we have begun with our Cycle 9 program (pid 90219) and our Cycle 10 program (pid 10154).

Spitzer Space Telescope - General Observer Proposal #12097

Probing the Long-Term Variability of Evolved Stars in the Magellanic Clouds

Principal Investigator: Benjamin Sargent
Institution: Rochester Institute of Technology

Technical Contact: Benjamin Sargent, Rochester Institute of Technology

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Olivia Jones, Space Telescope Science Institute

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 36.3
Priority: 1

Abstract:
Asymptotic giant branch (AGB) variable stars are, together with supernovae, the main sources of enrichment of the interstellar medium (ISM) in processed material, particularly carbon, nitrogen and heavy s-process elements. The dustiest, extreme AGB stars contribute the largest enrichment per star. We propose to measure the first light curves for 23 and 9 of the dustiest, most extreme AGB variable stars in the bar regions of Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC), respectively, and we propose to continue our measurements of 28 and 5 extreme AGB variable stars from the LMC and SMC, respectively, from Cycles 9 and 10, using the warm Spitzer mission's IRAC 3.6 and 4.5 micron imaging for monthly imaging measurements. Though we know they are variable based on dual-epoch observations from the Spitzer Surveying the Agents of Galaxy Evolution (SAGE) surveys of the LMC and SMC, the periods of these extreme AGB stars have NOT been measured before because they are too faint in the optical and near-infrared to have been captured in the ground based synoptic surveys such as MACHO, OGLE and IRSF. Only Spitzer will be able to measure the light curve of this key phase of the AGB: the dustiest and indeed final stage of the AGB. Without this information, our developing picture of AGB evolution is decidedly incomplete. The observations we propose will test the validity of AGB evolution models, and, thus, their predictions of the return of mass and nucleosynthetic products to the ISM. A value-added component to this study is that we will obtain variability information on other AGB stars that lie within the fields of view of our observations. This proposal follows up on the Cycle 9 proposal pid 90219 and on the Cycle 10 proposal pid 10154.

Spitzer Space Telescope - General Observer Proposal #14065

Characterizing the Norma Overdensity

Principal Investigator: Benjamin Sargent
Institution: Space Telescope Science Institute

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Martha Boyer, Space Telescope Science Institute
Rodolfo Angeloni, University of La Serena
Ata Sarajedini, Florida Atlantic University
Raja Guhathakurta, University of California at Santa Cruz

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.5
Priority: 1

Abstract:
We recently discovered receding, clustered Cepheid candidates towards the Norma constellation that may mark a new dwarf galaxy of the Milky Way. If this dwarf galaxy is confirmed, this would be a breakthrough in near-field cosmology, as it would represent the first dwarf galaxy that was predicted by a dynamical analysis to be subsequently discovered. Underlying the search for this dwarf galaxy is the hope that one could characterize dark-matter dominated dwarf galaxies from analysis of disturbances in Galactic disks, i.e., Galactoseismology. At b ~ 1, it would also be the closest dwarf galaxy to the Galactic plane. Aside from its expected distinct kinematics, another signature of a dwarf galaxy is an excess of stars in the CMD. When we correct for extinction the VVV photometry of the area where we saw the Cepheid candidates and subtract out a control field (i.e. a Galactic background field), we see an excess of stars that may correspond to red-clump stars at a distance of ~ 80 kpc. However, we used the Bonifacio et al. (2000) extinction prescription that is known to be inaccurate close to the Galactic plane. Majewski et al. (2011) have shown that the combination of NIR and MIR colors, namely H-4.5 micron or K_s - 3.6 micron, can produce a far better extinction correction than prior extinction maps. To extinction correct the VVV data, we need Spitzer data that is complete down to 17 mag in 4.5 um. Deep MIR data are crucial for us to do the extinction correction properly, and Spitzer is the only instrument that can enable this effort. By appropriately correcting the VVV and F2 photometry for extinction following Majewski et al. (2011), we should be able to separate the stellar populations of the expected dwarf galaxy candidate.

Spitzer Space Telescope - General Observer Proposal #90219

The First Light Curves of the Dustiest, Most Extreme Asymptotic Giant Branch Stars in the LMC and SMC

Principal Investigator: Benjamin Sargent
Institution: Rochester Institute of Technology

Technical Contact: Benjamin Sargent, Rochester Institute of Technology

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Martha Boyer, NASA Goddard Space Flight Center
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Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 23.2

Abstract:
Asymptotic giant branch (AGB) variable stars are, together with supernovae, the main sources of enrichment of the interstellar medium (ISM) in processed material, particularly carbon, nitrogen and heavy s-process elements. The dustiest, extreme AGB stars contribute the largest enrichment per star. We propose to measure the first light curves for 25 and 5 of the dustiest, most extreme AGB variable stars in the bar regions of Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC), respectively, using the warm Spitzer mission's IRAC 3.6 and 4.5 micron imaging for monthly imaging measurements. Though we know they are variable based on dual-epoch observations from the Spitzer Surveying the Agents of Galaxy Evolution (SAGE) surveys of the LMC and SMC, the periods of these extreme AGB stars have NOT been measured before because they are too faint in the optical and near-infrared to have been captured in the ground based synoptic surveys such as MACHO, OGLE and IRSF. Only Spitzer will be able to measure the light curve of this key phase of the AGB: the dustiest and indeed final stage of the AGB. Without this information, our developing picture of AGB evolution is decidedly incomplete. The observations we propose will test the validity of AGB evolution models, and, thus, their predictions of the return of mass and nucleosynthetic products to the ISM. A value-added component to this study is that we will obtain variability information on other AGB stars that lie within the fields of view of our observations.

Spitzer Space Telescope - General Observer Proposal #60055

Direct Observation of Circumstellar Clumps in High Mass X-Ray Binaries

Principal Investigator: Gordon Sarty
Institution: University of Saskatchewan

Technical Contact: Gordon Sarty, University of Saskatchewan

Co-Investigators:
Zoltan Balog, University of Arizona
Laszlo Kiss, University of Sydney
Kinwah Wu, University College London

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.5

Abstract:
The direct observation of clumpy circumstellar material in high mass X-ray binaries (HMXBs) is proposed. We propose to observe the two HMXBs V420 Aur and LS 5039, based on our optical data obtained over the past four years. With precision time- series photometry from the post-cryo IRAC instrument we expect the following scientific return: (i) Characterization of the size and distribution of circumstellar clumpy material as derived from modeling the light curve variations produced as the clumps disappear behind the star. (ii) Characterization of the temperature of the clumps as inferred from the 3.6 - 4.5 micrometer color of the clumps disappearing behing the primary star. (iii) Serendipitous observation of clumpy accretion events produced as clumps heat up on their way to accretion on the neutron star or black hole.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14235

The Euclid Deep Field South

Principal Investigator: Claudia Scarlata
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Jonathan Gardner, NASA
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Pascal Oesch, Dark Center Copenhagen
Gabe Brammer, Dark Center Copenhagen
Simona Mei, Paris Observatory
Henry McCracken, IAP
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Herve Dole, IAS
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Science Category: High-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 687.1
Priority: 1 (150.0); 2 (537.1)

Abstract:
We propose a 687hr IRAC survey of the definitive southern continuous viewing zone deep field of the 2020s. This field was chosen as the optimal deep field near the south ecliptic pole following a joint analysis by Euclid, LSST, and WFIRST at the end of January 2019 . It is the 20 deg2 region closest to the south ecliptic pole, and hence the darkest southern area of the sky, free of bright stars, with low galactic extinction and low stellar density.It is in the continuous viewing zone of WFIRST and JWST. In this field, Euclid will provide high spatial-resolution near-IR imaging (Y, J, and H), spectroscopy (0.92<lambda<1.85 um), and coverage with monthly cadence from 2022 to 2028. Additionally, the field position and geometry are optimized to maximize the synergy with future surveys, such as the Euclid, LSST, WFIRST, and eROSITA surveys (as discussed in a series of white papers: Capak et al. 2018, Scolnic et al. 2018, Foley et al. 2018). The primary goal of this proposal is to secure legacy data that will allow a broad range of science over the next decade with Spitzer, Euclid, WFIRST, JWST, and ALMA. The proposed data in the 3-5um wavelength range are essential to measure stellar masses at z>3 and the addition of this southern field to the existing Spitzer archive will triple the number of extremely rare, massive, sources that will be observable by ALMA.

Stellar mass, together with environment, is the most important physical property regulating the evolution of galaxies. Additionally, these new data will enable new science and improve cosmological constraints from the dark energy surveys. Finally, the observing strategy optimizes Spitzer's scheduling flexibility by observing a field near the south ecliptic pole, enabling a minimal impact despite the large time request. Besides Spitzer, no current or planned future missions can conduct deep yet wide area surveys at these wavelengths.

Spitzer Space Telescope - General Observer Proposal #80039

The Spitzer IRAC-MIPS Extragalactic Survey: imaging of the South Ecliptic Pole

Principal Investigator: Claudia Scarlata
Institution: University of Minnesota

Technical Contact: Claudia Scarlata, University of Minnesota

Co-Investigators:
Harry Teplitz, IPAC
Mark Devlin, UPENN
Casey Papovich, Texas A&M
Brian Siana, Caltech
James Colbert, SSC
Attila Kovacs, University of Minnesota
Kimberly Scott, UPENN
Matthew Hayes, Observatoire Midi-Pyrenees
Jason Surace, SSC
Giulia Rodighiero, Padova University
Karin Menendez-Delmestre, Carnegie
Peter Capak, SSC
J. Davy Kirkpatrick, IPAC
Vandana Desai, SSC
Hakim Atek, SSC
Matt Malkan, UCLA
Tanya Urrutia, SSC
Nick Scoville, Caltech
Sandra Behncke, Catholic University of America
Mara Salvato, Max Planck Institute for Plasma Physics
Carrie Bridge, Caltech

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 78.7

Abstract:
There is one large area - the South Ecliptic Pole (SEP) - that has excellent MIPS coverage but has no accompanying IRAC data. This field is a primary target of far-infrared, sub-millimeter and millimeter telescopes, both from the ground and from space. What makes SEP unique among other fields with comparable area and data coverage is its highly elongated geometry (4:1), which substantially reduces its susceptibility to cosmic variance. In terms of deep photometric coverage over the broadest wavelength range (from far-UV to mm) the SEP field is the largest remaining significant field that is still lacking IRAC imaging. We therefore propose 78 hours of IRAC observations to cover this important region (7 square degrees) to 5-sigma depths of 3.8 and 5.6microJy in channels 1 and 2, respectively. We waive the proprietary period and will provide high quality mosaics as well as band-merged catalogs for use by general community. The proposed IRAC data are critical for determining accurate stellar mass, star-formation histories and redshifts for the sources that can only be identified with observations at longer wavelengths: obscured AGN, dusty ultra-luminous galaxies, and high redshift galaxy clusters. Combining these data with the wealth of UV, optical, infrared, submm, and mm data will allow for an unprecedented investigation of the dusty early universe and will significantly enhance the legacy of the Spitzer mission for years to come.

Spitzer Space Telescope - General Observer Proposal #13018

Probing Cloud-Driven Variability on Two of the Youngest, Lowest-Mass Brown Dwarfs in the Solar Neighborhood

Principal Investigator: Adam Schneider
Institution: University of Toledo

Technical Contact: Adam Schneider, University of Toledo

Co-Investigators:
Michael Cushing, University of Toledo
J. Davy Kirkpatrick, Infrared Processing and Analysis Center

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 41
Priority: 1

Abstract:
Young, late-type brown dwarfs share many properties with directly imaged giant extrasolar planets. They therefore provide unique testbeds for investigating the physical conditions present in this critical temperature and mass regime. WISEA 1147-2040 and 2MASS 1119-1137, two recently discovered late-type (~L7) brown dwarfs, have both been determined to be members of the ~10 Myr old TW Hya Association (Kellogg et al. 2016, Schneider et al. 2016). Each has an estimated mass of 5-6 MJup, making them two of the youngest and lowest-mass free floating objects yet found in the solar neighborhood. As such, these two planetary mass objects provide unparalleled laboratories for investigating giant planet-like atmospheres far from the contaminating starlight of a host sun. Condensate clouds play a critical role in shaping the emergent spectra of both brown dwarfs and gas giant planets, and can cause photometric variability via their non-uniform spatial distribution. We propose to photometrically monitor WISEA 1147-2040 and 2MASS 1119-1137 in order to search for the presence of cloud-driven variability to 1) investigate the potential trend of low surface gravity with high-amplitude variability in a previously unexplored mass regime and 2) explore the angular momentum evolution of isolated planetary mass objects.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13160

IRAC Imaging of LSB Galaxies

Principal Investigator: James Schombert
Institution: Univ. of Oregon

Technical Contact: James Schombert, Univ. of Oregon

Co-Investigators:
Stacy McGaugh, Case Western
Federico Lelli, ESO

Science Category: nearby galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 34.8

Abstract:
We propose a program to observe a large sample of Low Surface Brightness (LSB) galaxies. Large galaxy surveys conducted with Spitzer suffer from the unavoidable selection bias against LSB systems (e.g., the S4G survey). Even those programs thathave specifically targeted LSB galaxies have usually been restricted objects of intermediate surface brightness (between 22 and 23 B mag/ []). Our sample is selected to be of a more extreme LSB nature (with central surface brightness fainter than 23 Bmag/[]). Even warm, Spitzer is the ideal instrument to image these low contrast targets in the near infrared: our sample goes a considerable way towards remedying this hole in the Spitzer legacy archive, also increasing coverage in terms of stellar mass, gas mass, and SFR. The sample will be used to address the newly discovered radial acceleration relation (RAR) in disk galaxies. While issues involving the connection between baryons and dark matter have been known since the development of the global baryonic Tully-Fisher (bTF) relation, it is only in the last six months that the particle physics and theoretical communities have recognized and responded to the local coupling between dark and baryonic matter represented by the RAR. This important new correlation is effectively a new natural law for galaxies. Spitzer photometry has been at the forefront of resolving the stellar mass component in galaxies that make-up the RAR and is the primary reason for the discovery of this new kinematic law.

Spitzer Space Telescope - Snapshot Proposal #80093

Sensitive Spitzer Photometry of Supermassive Black Holes at the Final Stage of Adolescence

Principal Investigator: Ohad Shemmer
Institution: University of North Texas

Technical Contact: Ohad Shemmer, University of North Texas

Co-Investigators:
Hagai Netzer, Tel Aviv University
Rivay Mor, Tel Aviv University
Benny Trakhtenbrot, Tel Aviv University

Science Category: AGN/quasars/radio galaxies
Hours Approved: 10.9

Abstract:
We propose to obtain sensitive Spitzer snapshot observations of a unique sample of 35 Sloan Digital Sky Survey quasars at redshift 4.8 for which we obtained reliable, Mg II-based determinations of the supermassive black hole (SMBH) mass and normalized accretion rate (L/L_Edd). These quasars appear to mark the final stage of SMBH 'adolescence' in the history of the Universe as their SMBHs are significantly less massive and their L/L_Edd values are significantly higher with respect to their counterparts at lower redshifts. Our observations will provide both 1) deep coverage of the fields around these quasars which will be utilized as crucial priors for our approved Herschel/SPIRE observations of these sources, and 2) coverage of the rest-frame optical SEDs of these fast accreting quasars. The results will maximize our ability to measure the star-formation rate in the host galaxies of these quasars using Herschel. We will thus be able to investigate correlations between SMBH growth and star-forming activity in the early Universe. The Spitzer photometry will also provide invaluable information about the shape of the rest-frame optical continuum in these quasars which will be used to search for extreme disk properties that may be signatures of the remarkably high accretion rates in these sources.

Spitzer Space Telescope - General Observer Proposal #10043

Not Dead Yet! Completing Spitzer's Legacy with Early Type Galaxies

Principal Investigator: Kartik Sheth
Institution: NRAO

Technical Contact: Kartik Sheth, NRAO

Co-Investigators:
Lee Armus, Caltech
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Albert Bosma, Aix Marseille Universite, CNRS, LAM
Dimitri Gadotti, European Southern Observatory
Juan Carlos Munoz-Mateos, NRAO
Joannah Hinz, University of Arizona, MMTO
Michael Regan, Space Telescope Science Institute
Eija Laurikainen, University of Oulu & Turku
Tom Jarrett, University of Cape Town
Dennis Zaritsky, University of Arizona
Karin Menendez-Delmestre, University of Valongo, Brazil
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Debra Elmegreen, Vassar College
Johan Knapen, Instituto de Astrofisica de Canarias
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Eva Schinnerer, MPIA, Heidelberg
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Bruce Elmegreen, IBM
Ron Buta, University of Alabama
Mauricio Cisternas, Instituto de Astrofisica de Canarias
Jarkko Laine, University of Oulu, Finland
Sebastien Comeron, University of Oulu, Finland
Jennifer Donovan Meyer, National Radio Astronomy Observatory
Elena D'Onghia, University of Wisconsin
Samir Salim, Indiana University

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 188.1
Priority: 1

Abstract:
The study of early type galaxies (ellipticals and lenticulars) is undergoing a renaissance with new observations that are confronting our notions of these systems as being old, dead and red. Observations are revealing stellar substructure, gas and dust, star formation and tidal debris in these galaxies, all of which are challenging our understanding of the formation and evolution of these "simple" systems. Here we propose to assemble a complete survey of all nearby early type galaxies (ETGs) using archival and new observations for all ETGs at d < 40 Mpc (v < 3000.0 km/s), m_B < 15.5, D_25 > 1 arcminute and |b| > 30 degrees. We request 188.1 hrs to map 465 ETGs at 3.6 and 4.5 microns -- this will provide a statistically robust and complete sample of ETGs with sufficient numbers in each mass, type and environment to study their structure, reconstruct their evolution through stellar populations, assess their recent merger history and ultimately constrain their origins. These data will be the most sensitive probe to date for faint stellar structures such as nuclear cusps, large scale shells and rings, and stellar disks in the largest sample of ETGs ever assembled, providing an extremely sensitive test of current and future models for the formation and evolution of ETGs over cosmic time.

Spitzer Space Telescope - General Observer Proposal #60007

The Spitzer Survey of Stellar Structure in Galaxies (S4G)

Principal Investigator: Kartik Sheth
Institution: California Institute of Technology

Technical Contact: Kartik Sheth, California Institute of Technology

Co-Investigators:
Joannah Hinz, University of Arizona
Armando Gil de Paz, UCM, Madrid
Michael Regan, STScI
Karin Menendez-Delmestre, Carnegie Observatories
Eva Schinnerer, Max-Planck-Institut fur Astronomie, Heidelberg
Bruce Elmegreen, IBM
Debra Elmegreen, Vassar College
Lia Athanassoula, OAMP, France
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Albert Bosma, OAMP, France
Tom Jarrett, Caltech
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Lee Armus, Caltech
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Chien Peng, NRC, Canada
Jason Surace, Caltech
Karen Masters, University of Portsmouth
Patrick Ogle, Caltech
Bahram Mobasher, University of California at Riverside
Mark Seibert, Carnegie
Jin Koda, Caltech
Peter Capak, Caltech
Eija Laurikainen, University of Oulu, Finland
Heikki Salo, University of Oulu, Finland
Johan Knapen, Instituto de Astrofisica de Canarias, Spain

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IracPostCryoMap
Hours Approved: 637.2

Abstract:
We propose the ultimate survey of the distribution of stellar structure in the nearby universe using IRAC's 3.6 and 4.5 micron channels. Deep observations of the stellar mass distribution, down to 0.1 Msun per sq. pc for a sample of ~2,300 nearby (d<40Mpc) galaxies, will provide an unprecedented dataset for studies of structure formation during galaxy evolution. Such observations will provide answers to some of the most fundamental questions of our field: how are outer disks and halos formed? how do galaxy interactions affect the formation and evolution of galactic structures? which structural parameters govern internal galaxy evolution? Our large unbiased sample of all Hubble types ranging from dwarfs to spirals to ellipticals will allow for such structural studies, not only as a function of stellar mass, but also as a function of environment, and the output of such an immense survey will serve as a vital testbed for cosmological simulations predicting the mass properties of present-day galaxies.

Data from this program was split into multiple PIDs. You can find the data in program IDs 60007, 61064, 61060, 61065, 61061, 61066, 61062, 61067, 61063, 61068

Spitzer Space Telescope - General Observer Proposal #13096

Spitzer's Last Look at the Small Magellanic Cloud

Principal Investigator: Greg Sloan
Institution: Cornell University

Technical Contact: Kathleen Kraemer, Boston College

Co-Investigators:
K. E. Kraemer, Boston College
J. D. Kirkpatrick, Caltech
K. D. Gordon, STScI
A. D. Bolatto, University of Maryland
M. L. Boyer, NASA Goddard
M. Groenewegen, Koninklijke Sterrenwacht van Belgie
O. C. Jones, STScI
F. Kemper, Academia Sinica
J. P. Lloyd, Cornell University
I. McDonald, University of Manchester
M. Meixner, STScI
J. M. Oliveira, Keele University
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M. Sewilo, NASA Goddard
S. Srinivasan, Academia Sinica
J. Th. van Loon, Keele University
A. A. Zijlstra, University of Manchester

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 172.1
Priority: 1

Abstract:
We will map 30 square degrees of sky covering the Small Magellanic Cloud (SMC) and the Bridge toward the LMC at 3.6 and 4.5 um, in two epochs in late 2017. Coupled with similar maps obtained in 2008 and surveys in the core of the SMC starting in 2005, the new epochs will give us a temporal baseline of 12 years in the heart of the SMC and 9 years in its outer regions. The Spitzer observations probe deeper than WISE and at higher resolution, allowing us to study fainter sources and sources in more crowded regions in this nearby metal-poor dwarf galaxy. We will use these data to better characterize how variability and dust production are intertwined in the final evolutionary stages of a star's lifetime. The long temporal baseline also enables searches for brown dwarfs near the Sun which are undetectable with Gaia or WISE, and the crowded background formed by the SMC makes any newly discovered brown dwarfs excellent candidates for microlensing studies which would reveal their masses. The long baseline may also reveal transients in star-forming regions in the SMC and in the population of background galaxies. We request 172.1 hours, with no proprietary period, to complete this project.

Spitzer Space Telescope - General Observer Proposal #14108

Studying the Fading Infrared Evolution of SN 1978K

Principal Investigator: Ian Smith
Institution: Rice University

Technical Contact: Ian Smith, Rice University

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.5
Priority: 2

Abstract:
SN 1978K in the nearby barred spiral galaxy NGC 1313 is a remarkable Type IIn supernova that remains bright at X-ray through radio wavelengths 40 years after its explosion. Our long-term program of multi-wavelength observations is probing the dense medium that was ejected by the progenitor star, possibly a Luminous Blue Variable. Only SN 1978K was detected in a search for warm dust in supernovae in the transitional phase (age 10-100 years). Thus SN 1978K is a prime target for studying whether supernovae such as this are important contributors to the Universal dust budget and how the dust reacts to the strong and varying UV and X-ray emissions. Our analysis of the previous Spitzer observations shows a rapid fading of the warm dust emission. Here we request one Spitzer observation at 3.6 and 4.5 microns to continue to monitor the infrared evolution. This will serve as a bridge to future monitoring with JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10170

Frontier Field RXCJ2248

Principal Investigator: Tom Soifer
Institution: Spitzer Science Center

Technical Contact: Peter Capak, Spitzer Science Center

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 200

Abstract:
After considering valuable advice from the astronomical community and broad range of open questions in galaxy evolution an advisory committee unanimously recommended HST undertake a program of six deep fields centered on strong lensing galaxy clusters in parallel with six deep "blank fields". The key science goals of these twelve new frontier fields are: 1) to reveal hitherto inaccessible populations of z = 5 - 10 galaxies that are 10 - 50 times fainter intrinsically than any presently known. 2) to solidify our understanding of the stellar masses and star formation histories of sub-L* galaxies at the earliest times 3) to provide the first statistically meaningful morphological characterization of star forming galaxies at z > 5 4) to find z > 8 galaxies stretched out enough by cluster lensing to discern internal structure and/or magnified enough by cluster lensing for spectroscopic follow-up. Spitzer data are essential to meeting these goals because it enables mass and physical parameter estimates for the high redshift sources and differentiates between low and high redshift galaxies. As a result Spitzer has committed to observing these fields as a major DDT program. The first 4 galaxies clusters and the first 4 deep "blank fields" will be observed by Spitzer over cycles 9 and 10.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10171

Frontier Field A2744

Principal Investigator: Tom Soifer
Institution: Spitzer Science Center

Technical Contact: Peter Capak, Spitzer Science Center

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 200

Abstract:
After considering valuable advice from the astronomical community and broad range of open questions in galaxy evolution an advisory committee unanimously recommended HST undertake a program of six deep fields centered on strong lensing galaxy clusters in parallel with six deep "blank fields". The key science goals of these twelve new frontier fields are: 1) to reveal hitherto inaccessible populations of z = 5 - 10 galaxies that are 10 - 50 times fainter intrinsically than any presently known. 2) to solidify our understanding of the stellar masses and star formation histories of sub-L* galaxies at the earliest times 3) to provide the first statistically meaningful morphological characterization of star forming galaxies at z > 5 4) to find z > 8 galaxies stretched out enough by cluster lensing to discern internal structure and/or magnified enough by cluster lensing for spectroscopic follow-up. Spitzer data are essential to meeting these goals because it enables mass and physical parameter estimates for the high redshift sources and differentiates between low and high redshift galaxies. As a result Spitzer has committed to observing these fields as a major DDT program. The first 4 galaxies clusters and the first 4 deep "blank fields" will be observed by Spitzer over cycles 9 and 10.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12123

Spitzer Lensing Cluster Legacy Survey

Principal Investigator: Tom Soifer
Institution: SSC/IPAC

Technical Contact: Lee Armus, SSC/IPAC

Co-Investigators:
M. Bradac
P. Capak
D. Coe
B. Siana
T. Treu
J. Vieira

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 290.0

Abstract:
Cluster-scale gravitational lenses act as cosmic telescopes, enabling the study of otherwise unobservable galaxies. They are critical in answering the questions such as what is the star formation history at z > 7, and whether these galaxies can reionize the Universe. Accurate knowledge of stellar masses, ages, and star formation rates at this epoch requires measuring both rest-frame UV and optical light, which only Spitzer and HST can probe at z>7-11 for a large enough sample of typical galaxies. To address this cosmic puzzle, we propose a program that obtains shallow Spitzer/IRAC imaging of a large sample of cluster lenses, followed by deep imaging of those clusters with the largest number of z > 7 candidate galaxies. This proposal will be a valuable Legacy complement to the existing IRAC deep surveys, and it will open up a new parameter space by probing the ordinary yet magnified population. Furthermore, it will enable the measurements of the stellar mass of the galaxy cluster population, thereby allowing us to chart the build-up of the cluster red sequence from z~1 to the present and to determine the physical processes responsible for this stellar mass growth.

Spitzer Space Telescope - Directors Discretionary Time Proposal #90257

Frontier Field A2744

Principal Investigator: Tom Soifer
Institution: Spitzer Science Center

Technical Contact: Peter Capak, Spitzer Science Center

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 223.1

Abstract:
After considering valuable advice from the astronomical community and broad range of open questions in galaxy evolution an advisory committee unanimously recommended HST undertake a program of six deep fields centered on strong lensing galaxy clusters in parallel with six deep "blank fields". The key science goals of these twelve new frontier fields are: 1) to reveal hitherto inaccessible populations of z = 5 - 10 galaxies that are 10 - 50 times fainter intrinsically than any presently known. 2) to solidify our understanding of the stellar masses and star formation histories of sub-L* galaxies at the earliest times 3) to provide the first statistically meaningful morphological characterization of star forming galaxies at z > 5 4) to find z > 8 galaxies stretched out enough by cluster lensing to discern internal structure and/or magnified enough by cluster lensing for spectroscopic follow-up. Spitzer data are essential to meeting these goals because it enables mass and physical parameter estimates for the high redshift sources and differentiates between low and high redshift galaxies. As a result Spitzer has committed to observing these fields as a major DDT program. The first 4 galaxies clusters and the first 4 deep "blank fields" will be observed by Spitzer over cycles 9 and 10.

Spitzer Space Telescope - Directors Discretionary Time Proposal #90258

Frontier Field MACS J0416

Principal Investigator: Tom Soifer
Institution: Spitzer Science Center

Technical Contact: Peter Capak, Spitzer Science Center

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 217

Abstract:
After considering valuable advice from the astronomical community and broad range of open questions in galaxy evolution an advisory committee unanimously recommended HST undertake a program of six deep fields centered on strong lensing galaxy clusters in parallel with six deep "blank fields". The key science goals of these twelve new frontier fields are: 1) to reveal hitherto inaccessible populations of z = 5 - 10 galaxies that are 10 - 50 times fainter intrinsically than any presently known. 2) to solidify our understanding of the stellar masses and star formation histories of sub-L* galaxies at the earliest times 3) to provide the first statistically meaningful morphological characterization of star forming galaxies at z > 5 4) to find z > 8 galaxies stretched out enough by cluster lensing to discern internal structure and/or magnified enough by cluster lensing for spectroscopic follow-up. Spitzer data are essential to meeting these goals because it enables mass and physical parameter estimates for the high redshift sources and differentiates between low and high redshift galaxies. As a result Spitzer has committed to observing these fields as a major DDT program. The first 4 galaxies clusters and the first 4 deep "blank fields" will be observed by Spitzer over cycles 9 and 10.

Spitzer Space Telescope - Directors Discretionary Time Proposal #90259

Frontier MACS J0717

Principal Investigator: Tom Soifer
Institution: Spitzer Science Center

Technical Contact: Peter Capak, Spitzer Science Center

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 161.2

Abstract:
After considering valuable advice from the astronomical community and broad range of open questions in galaxy evolution an advisory committee unanimously recommended HST undertake a program of six deep fields centered on strong lensing galaxy clusters in parallel with six deep "blank fields". The key science goals of these twelve new frontier fields are: 1) to reveal hitherto inaccessible populations of z = 5 - 10 galaxies that are 10 - 50 times fainter intrinsically than any presently known. 2) to solidify our understanding of the stellar masses and star formation histories of sub-L* galaxies at the earliest times 3) to provide the first statistically meaningful morphological characterization of star forming galaxies at z > 5 4) to find z > 8 galaxies stretched out enough by cluster lensing to discern internal structure and/or magnified enough by cluster lensing for spectroscopic follow-up. Spitzer data are essential to meeting these goals because it enables mass and physical parameter estimates for the high redshift sources and differentiates between low and high redshift galaxies. As a result Spitzer has committed to observing these fields as a major DDT program. The first 4 galaxies clusters and the first 4 deep "blank fields" will be observed by Spitzer over cycles 9 and 10.

Spitzer Space Telescope - Directors Discretionary Time Proposal #90260

Frontier Field MACS J1149

Principal Investigator: Tom Soifer
Institution: Spitzer Science Center

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 161.2

Abstract:
After considering valuable advice from the astronomical community and broad range of open questions in galaxy evolution an advisory committee unanimously recommended HST undertake a program of six deep fields centered on strong lensing galaxy clusters in parallel with six deep "blank fields". The key science goals of these twelve new frontier fields are: 1) to reveal hitherto inaccessible populations of z = 5 - 10 galaxies that are 10 - 50 times fainter intrinsically than any presently known. 2) to solidify our understanding of the stellar masses and star formation histories of sub-L* galaxies at the earliest times 3) to provide the first statistically meaningful morphological characterization of star forming galaxies at z > 5 4) to find z > 8 galaxies stretched out enough by cluster lensing to discern internal structure and/or magnified enough by cluster lensing for spectroscopic follow-up. Spitzer data are essential to meeting these goals because it enables mass and physical parameter estimates for the high redshift sources and differentiates between low and high redshift galaxies. As a result Spitzer has committed to observing these fields as a major DDT program. The first 4 galaxies clusters and the first 4 deep "blank fields" will be observed by Spitzer over cycles 9 and 10.

Spitzer Space Telescope - General Observer Proposal #13150

Characterising the atmosphere of a uniquely low-density, sub-Saturn mass planet

Principal Investigator: Jessica Spake
Institution: University of Exeter

Technical Contact: Jessica Spake, Exeter

Co-Investigators:
D. Anderson, University of Keele
J. Barstow, University College London
T. Evans, University of Exeter
M. Gillon, Universite de Liege
G. Hebrard, CNRS, Institut d'Astrophysique de Paris
C. Hellier, University of Keele
T. Kataria, Jet Propulsion Laboratory
K. Lam, The University of Warwick
N. Nikolov, University of Exeter
D. Sing, University of Exeter
A. Triaud, University of Cambridge
H. Wakeford, NASA Goddard Space Flight Center

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.0
Priority: 1

Abstract:
We propose to use HST and Spitzer to measure the transmission spectrum of the recently discovered, hot sub-Saturn mass exoplanet WASP-127b. Its low mass (0.19 Mj) and large radius (1.39 Rj) give it the lowest density of any exoplanet with a radial velocity measured mass. It has the largest predicted atmospheric scale height of any planet, and orbits a bright (V~10.2) star, making it an exceptional target for atmospheric characterisation via transmission spectroscopy. With HST and Spitzer, we will measure the full transmission spectrum from 0.3 to 5 microns, covering water, sodium, and potassium absorption features, and scattering by molecular hydrogen or haze. The Spitzer transit photometry at 3.6 and 4.5 microns will be used alongside the HST spectrum to break the low abundance/cloud degeneracy which prevents constraints being made on atmospheric metallicity. With a low mass of 0.19 Mj, this planet sits in an unexplored mass range at the very low-end of gas giant planets, making WASP-127b strategecally important for constraining the planetary mass-metallicity relationship, which is important for understanding planet formation mechanisms.

Spitzer Space Telescope - General Observer Proposal #80096

The SPT-Spitzer Deep Field

Principal Investigator: Spencer Stanford
Institution: University of California, Davis

Technical Contact: Spencer Stanford, University of California, Davis

Co-Investigators:
Mark Brodwin, Harvard-CfA
Joe Mohr, University of Munich
Peter Eisenhardt, JPL
James Bartlett, University of Paris
Casey Papovich, Texas A&M
Gil Holder, McGill
Simona Mei, University of Paris
Vy Tran, Texas A&M
Daniel Stern, JPL
Dan Kelson, Carnegie
Piero Rosati, ESO
Will High, University of Chicago
Arjun Dey, NOAO
Tom Crawford, University of Chicago
John Carlstrom, University of Chicago
Adam Muzzin, Yale
Leonidas Moustakas, JPL
Matt Ashby, Harvard CfA
John Mulchaey, Carnegie
Joaquin Vieira, Caltech
Laurie Shaw, Yale
Shantanu Desai, University of Illinois
Dan Marrone, University of Chicago
Alan Dressler, Carnegie
Marguerite Pierre, CEA Saclay
Florian Pacaud, University of Bonn
Brad Benson, University of Chicago
Anthony Gonzalez, University of Florida
Audrey Galametz, ESO
Brad Holden, Lick Observatory
Buell Jannuzi, NOAO
Bob Armstrong, University of Illinois
Lloyd Knox, UC-Davis

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 766.0

Abstract:
We propose to conduct an IRAC survey of a contiguous 100 deg^2 area within the deepest South Pole Telescope survey field. The resulting IRAC dataset will be used in combination with Sunyaev-Zel'dovich information from the SPT to study the complete baryon budget in dense environments at all redshifts, to measure halo masses at 1 < z< 2 via lensing of the CMB, and to cross calibrate SZ, X-ray, and optical-IR methods of constructing galaxy cluster catalogs and estimating galaxy cluster masses. The target field will contain a publicly-available suite of X-ray, optical, NIR, FIR, and millimeter data, making it an ideal location to conduct a wide-field IRAC extragalactic legacy survey.

Spitzer Space Telescope - General Observer Proposal #12012

Fleshing Out the TNO Compositional Library: Spitzer's Legacy, JWST's Future

Principal Investigator: John Stansberry
Institution: The University of Arizona

Technical Contact: John Stansberry, The University of Arizona

Co-Investigators:
Noemi Pinilla-Alonso, Florida Space Institute - UCF
Josh Emery, University of Tennessee
Will Grundy, Lowell Observatory
Emmanuel Lellouch, Observatoire de Paris, Meudon
Thomas Mueller, Max Planck Institute, Garching

Science Category: Kuiper belt objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 41.1
Priority: 1

Abstract:
We propose to obtain IRAC 3.6 micron photometry for 17 TNOs and Centaurs, (and 4.5 micron data for 7 of those). The data will be used to detect absorption features in their reflectance spectra, allowing us to constraint their their surface compositions. The targets either lack IRAC data (7 objects), or have low-quality data from previous programs. They are selected based on the availability of existing Spitzer and or Herschel thermal meausurements, HST near-IR photometry, and binarity. Any one of these supporting measurements significantly enhance the importance of the IRAC measurements we propose. The Spitzer and Herschel thermal measurements (available for 13 of our targets) constrain their visible albedo, a key parameter for accurately determining composition based on colors and/or spectra. The near-IR HST photometry (available for 3 of our targets) also significantly leverages the value of the IRAC data (and vice-versa) by extending wavelength coverage; this too significanly enhances the accuracy of compositional interpretation. Binary TNOs are intrinsically interesting, and so gathering additional or improved IRAC measurements for them is important. In addition, the mass determinations for these objects can be converted into albedo constraints by assuming bulk density; the plausible albedos that result can be used to constrain spectrocopic models, although the error bars are typically larger than for albedos determined radiometrically. These data will help cement Spitzer's contributions to our understanding of the composition of TNOs, and will provide a firm footing for studying objects in the Kuiper Belt using JWST.

Spitzer Space Telescope - General Observer Proposal #80135

Characterization of New Herbig-Haro Flows in the Taurus Star Formation Region

Principal Investigator: Karl Stapelfeldt
Institution: Jet Propulsion Laboratory

Technical Contact: Karl Stapelfeldt, Jet Propulsion Laboratory

Co-Investigators:
Gillian Knapp, Princeton University
Alberto Noriega-Crespo, Spitzer Science Center
Deborah Padgett, Spitzer Science Center
Marc Audard, Geneva Observatory

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.2

Abstract:
Forty-three square degrees of the nearby Taurus star-forming region were mapped as a Spitzer legacy science program using IRAC and MIPS. While the survey primarily targeted young stellar object point sources, it also detected 37 extended Herbig-Haro object emission nebulosities tracing shock waves in bipolar outflows. Sloan Digital Sky Survey images, specially obtained for part of the survey field, detect many of the same HH objects. Twenty-two sources overall are new discoveries, showing morphologies that range from small knots to large bowshocks. Many of the most interesting new objects have proven to be either undetectable, much fainter, or structurally different in groundbased followup imaging. The best approach to fully characterize these new outflows is thus new, deep imaging with Spitzer itself. We propose IRAC band1 and band2 imaging of the best six of these new outflow systems. The new images will be at least 10x more sensitive than the original survey data, which consisted of only 2x12 sec exposures. They will 1) Define the flow kinematics by measuring proper motions over the >6.5 year time baseline since the original survey data; 2) Provide sufficient signal-to-noise to allow meaningful conclusions on shock strength using the ratio of the band1/band2 images; and 3) Better reveal the overall flow structures by detecting fainter features such as outflow cavity walls, outer bowshock wings, or additional knots along the flow. The results will define the energetics and collimation of these new flows (two of which are giant flows more than two parsecs across) - unique new information on bipolar flows in the mid-IR.

Spitzer Space Telescope - General Observer Proposal #90250

Resetting the Star: Uncovering New Warm Debris Disks using High-acccuracy IRAC Photometry

Principal Investigator: Karl Stapelfeldt
Institution: NASA Goddard Space Flight Center

Technical Contact: Karl Stapelfeldt, NASA Goddard Space Flight Center

Co-Investigators:
Deborah Padgett, NASA Goddard Space Flight Center
Kate Su, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 41.3

Abstract:
Debris disks trace the collisional breakdown of asteroid and comet parent bodies orbiting nearby main sequence stars. The most common type is a cold analog of our Kuiper belt with emission peaking near 70 microns wavelength. Less than 10% of known debris disks show warm emission at 22 or 24 microns. Warm debris disks are especially interesting because they trace material in the terrestrial planet zones analogous to our inner solar system. Their short dynamical time scales make them proxies stellar youth, for high levels of gravitational stirring by massive planets, or as tracers of recent collisions between large planetesimals. The Wide-Field Infrared Survey Explorer (WISE) has completed a new, sensitive all-sky mapping in the 3.3, 4.6, 12, and 22 micron bands. Using the WISE photometry alone, Padgett et al. (2013) were able to identify 346 Hipparcos stars as new, warm debris disk sources with 22 micron emission > 4 sigma above the stellar photosphere. A substantial additional number of nearby Hipparcos stars show excess emission at the 3 sigma level but require confirmation. IRAC subarray photometry at S/N of >= 100 provides a way to achieve this confirmation by measuring the stellar photospheric brightness to 3-4 times better accuracy at 3.6 microns than WISE itself has done at the same wavelength. We propose to make such measurements for 421 Hipparcos stars which show indications of WISE 22 micron excess, and for which the improved 3.6 micron photometry would result in a 4 sigma excess detection. An additional 131 stars with Spitzer/MIPS 24 micron photometry will be observed toward the same goal of enabling the detection of weaker excesses through better characterization of the stellar photospheric emission. This program should almost double the number of warm debris disks discovered by WISE around nearby Hipparcos stars. This expanded sample will provide prime targets for imaging of self-luminous exoplanets and for spectroscopic characterization of mineralogical features using JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #539

Tests of Warm Spitzer Astrometry and Proper Motion Determination

Principal Investigator: John Stauffer
Institution: SSC

Technical Contact: John Stauffer, SSC

Co-Investigators:
Adam Kraus, IfA, Hawaii

Science Category: brown dwarfs/very low mass stars
Observing Modes: IracPost-Cryo Mapping
Hours Approved: 1.8

Abstract:

Spitzer has, to date, not been used in a significant degree for proper motions or other astrometric purposes. However, as we enter the sixth year of observing, the time baseline available for proper motion studies makes proper motion studies more attractive. We propose two observations. The first is a 3rd epoch observation of three hyades brown dwarfs, meant to clearly demonstrate Spitzer's ability to measure proper motions of stars with modest proper motion. The second observation will be to obtain images of two rich, dense open clusters in order to help better determine the IRAC distortion map, and thereby help improve all astrometric science with Warm Spitzer.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12122

Confirmation of the Presence of Asteroid Collisional Debris in Pleiades Low Mass Stars using IRAC

Principal Investigator: John Stauffer
Institution: SSC/IPAC

Technical Contact: John Stauffer, SSC/IPAC

Co-Investigators:
Luisa Rebull, IRSA/SSC/IPAC
Jessica Krick, SSC/IPAC

Science Category: debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 17.2

Abstract:
We have identified four late type dwarfs in the Pleiades with unusual periodic, transit-like flux dips in their early-2015 K2 light curves. The dips are too long in duration to be due to solid bodies (lower mass stars or planets), but too short in duration to be due to star-spots on the stellar photosphere. Their most likely origin is in clouds of material orbiting the star at or near the star's corotation radius. We propose to obtain a single IRAC long-duration staring mode observation of one of these stars, in order to determine if the flux dips are also present at 4.5 microns (as they would be if the flux dips are due to dust extinction, for example). The AOR length is set to slightly longer than the measured period of the flux dips for the target star, HHJ 135.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12125

Neptune Variability with Spitzer

Principal Investigator: John Stauffer
Institution: SSC

Technical Contact: Sean Carey, SSC

Co-Investigators:
Luisa Rebull, IRSA/SSC/IPAC
Jessica Krick, SSC
Sean Carey, SSC
Mark Marley, Ames

Science Category: Planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 37.8

Abstract:
During Campaign 3 of the repurposed Kepler mission (dubbed K2), Kepler was used to obtain a long-duration, high-accuracy, fast cadence, optical light curve for Neptune. That light curve shows variability with peak-to-peak amplitude of order 2% and with remarkable structure due to the "beating" of several signals with similar periods. The data have been interpreted to be dominated by rotational modulation of discrete "clouds" in the planet's atmosphere, with the different periods corresponding to spots at different latitudes. Because approximately contemporaneous HST and Keck imaging of Neptune exists, it is possible to connect specific spots at specific latitudes to the specific periods identified in the periodogram. As a proof of concept for what could be a longer-duration observation that would be proposed in Cycle 13, we propose to obtain light curves for Neptune in both IRAC channels with the duration set equal to the planet's equatorial rate. Neptune has strong methane absorption bands that fall within Ch1 of IRAC; it also has strong emission lines from flourescently excited CO that fall in the Ch2 wavelength range. It is therefore possible that there could be rotational modulation of similar or larger amplitude in the IRAC channels as in the optical. If detected, the shape and amplitude of these variations could help constrain the vertical structure and composition of Neptune's atmosphere. Our proposed observation of Neptune is best done when Neptune shows as little apparent motion on the sky as possible. As seen from Spitzer, this next occurs on about Feb. 19 and Feb. 20, 2016.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13162

Spitzer Light Curves of Young M Dwarfs Rotating Near Breakup

Principal Investigator: John Stauffer
Institution: Caltech/IPAC-Spitzer

Technical Contact: Luisa Rebull, Caltech/IPAC-IRSA

Co-Investigators:
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Jessica Krick, Caltech/IPAC-Spitzer
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Trevor David, Caltech
Andrew Collier Cameron, St. Andrews
David Barrado y Navascues, INTA-CSIC
Maria Morales-Calderon, INTA-CSIC
Ann Marie Cody, NASA Ames
Todd Henry, GSU
David Ciardi, Caltech/IPAC-NExScI
Eric Mamajek, JPL
Josch Hambsch, ROAD
Brad Carter, Univ. Southern Queensland

Science Category: YSOs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 23.4

Abstract:
In Fall 2014, Kepler K2 light curves were obtained for ~1000 low mass stars in the 8 Myr old Upper Sco association. A dozen of these stars have photometric periods less than 0.65 days and have very unusual phased light curve morphologies. At least several of these stars are rotating at or very near the theoretical breakup velocity. We propose here to obtain Spitzer 4.5 um staring mode light curves covering one full rotation period for two of these stars, in combination with new ground-based V band light curves, in order to: (a) determine the wavelength dependence of the light curve amplitudes; and (b) determine the long term (~ 3 year) stability of the light curve morphologies. These data will help better constrain the physical mechanism driving the photometric variability of this class of objects and thus help us better understand the angular momentum evolution (and early environments) of M dwarfs.

Spitzer Space Telescope - General Observer Proposal #60014

Young Stellar Object Variability (YSOVAR): Mid Infrared Clues to Accretion Disk Physics and Protostar Rotational Evolution

Principal Investigator: John Stauffer
Institution: Spitzer Science Center

Technical Contact: Luisa Rebull, Spitzer Science Center

Co-Investigators:
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Kevin Covey, CfA
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Kevin Flaherty, U. Arizona
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Susan Terebey, CSULA
Fred Vrba, USNO
Mike Werner, JPL
Barbara Whitney, Space Science Institute
Elaine Winston, CfA
Kenny Wood, University of St. Andrews

Science Category: young stellar objects
Observing Modes: IracPostCryoMap
Hours Approved: 550.0 +20 hrs DDT

Abstract:
Spitzer/IRAC in the warm mission is the only facility now existing or planned capable of carrying out an extensive, accurate time series photometric monitoring survey of star-forming regions in the thermal infrared. The demonstrated sensitivity and stability of IRAC allows measurement of the relative fluxes of YSO's down to the substellar mass limit to 1-2% accuracy in star-forming regions out to >500 pc. We propose a time series monitoring exploration science survey of the Orion Nebula Cluster and 11 very young, populous embedded star-forming cores which will provide >= 80 epochs of data for > 1500 YSO's. We will complement these observations with contemporaneous optical and near-IR monitoring data in order to allow comparison of the phase, amplitude and light-curve shape as a function of wavelength. These data will allow us to: (a) provide otherwise unobtainable constraints on the structure of the inner disks in Class I and II YSOs - and hence, perhaps, provide clues to the formation and migration of planets at young ages; (b) measure the short and long-term stability of hot spots on the surfaces of YSO's of all evolutionary

stages; and (c) determine rotational periods for the largest sample to date of Class I YSO's and hence obtain the best measure of the initial angular momentum distribution of young stars.

Data from this program was split into multiple PIDs.
You can find the data in program IDs 60014, 61020, 61021, 61022, 61023, 61024, 61025, 61026, 61027, 61028, 61029, 61030

Spitzer Space Telescope - General Observer Proposal #70025

Non-Axisymmetric Structure in the Inner Disks of YSOs -- Signposts of Planet Formation?

Principal Investigator: John Stauffer
Institution: Spitzer Science Center

Technical Contact: Luisa Rebull, Spitzer Science Center

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Mansur Ibrahimov, Ulugh Beg Astronomical Institute, Tashkent, Uzbeki
David James, U Hawaii, Hilo
S.Tom Megeath, U Toledo
Mike Skrutzkie, UVA
Fred Vrba, USNO-Flagstaff
Lawrence Wasserman, Lowell
Barb Whitney, SSI

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 31.1

Abstract:
We have identified a well-populated class of young stellar objects (YSOs) in the Orion Nebula cluster whose light curves show narrow (few day timescale) flux dips. Based on comparison to the only previously well-documented member of this class (AA Tau), we believe these flux dips are due to "clouds" in the inner circumstellar disk of these stars that pass through our line of sight. Our 2009 data suggest that most YSO disks have similar structures and that those which exhibit these flux dips are simply those whose disks are close to edge-on to our line of sight. We propose here to obtain IRAC time series data of much higher cadence and significantly better RMS noise for twelve members of this class over a 10 day timespan. These data will allow us to constrain better the size distribution of the occulting bodies, their grain properties and their internal density structure. These data will therefore provide quantitative inputs to realistic models of circumstellar disk evolution and planet formation/migration.

Spitzer Space Telescope - General Observer Proposal #80040

YSOVAR II: Mapping YSO Inner Disk Structure in NGC 2264 with Simultaneous Spitzer and CoRoT Time Series Photometry

Principal Investigator: John Stauffer
Institution: Spitzer Science Center

Technical Contact: Luisa Rebull, Spitzer Science Center

Co-Investigators:
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Laura Affer, INAF
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Alan Watson, UNAM
Barbara Whitney, SSI
Elaine Winston, Exeter
Kenny Wood, St. Andrews

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 630.0

Abstract:
We propose a simultaneous, continuous 30 day observation of the star forming region NGC2264 with Spitzer and CoRoT. NGC2264 is the only nearby, rich star-forming region which can be observed with CoRoT; it is by definition then the only nearby, rich star-forming region where a simultaneous Spitzer/CoRoT campaign is possible. Fortunately, the visibility windows for the two spacecraft overlap, allowing this program to be done in the Nov. 25, 2011 to Jan. 4, 2012 time period. For 10 days, we propose to map the majority of the cluster (a 35'x35' region) to a depth of 48 seconds per point, with each epoch taking 1.7 hours, allowing of order 12 epochs per day. For the other 20 days, we propose to obtaining staring-mode data for two positions in the cluster having a high density of cluster members. We also plan to propose for a variety of other

ground and space-based data, most of which would also be simultaneous with the Spitzer and CoRoT observing. These data will allow us to address many astrophysical questions related to the structure and evolution of the disks of young stars and the interaction of those disks with the forming star. The data may also help inform models of planet formation since planets form and migrate through the pre-main sequence disks during the 0.5-5 Myr age range of stars in NGC2264. The data we collect will also provide an archive of the variability properties of young stars that is unmatched in its accuracy, sensitivity, cadence and duration and which therefore could inspire investigation of phenomena which we cannot now imagine. The CoRoT observations have been approved, contingent on approval of a simultaneous Spitzer observing program (this proposal).

Spitzer Space Telescope - Directors Discretionary Time Proposal #80257

Confirmation and Characterization of a 3 Myr Old Hot, Transiting Jupiter

Principal Investigator: John Stauffer
Institution: SSC

Technical Contact: John Stauffer, SSC

Co-Investigators:
David Ciardi, IPAC
Sean Carey, SSC
Julian van Eyken, IPAC
Maria Morales, SSC
Andy Boden, Caltech
Nuria Calvet, U. Michigan

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 12.0

Abstract:
We believe we have discovered the first transiting hot-Jupiter whose host star is a few-million year old Pre-Main sequence star. We propose a 12 hour, "full-phase" staring mode observation of this star in order to confirm that it is indeed host to a transiting hot Jupiter. The Spitzer light curve will allow us to obtain a much more secure measure of the planet's radius via the shape and depth of the primary transit at 4.5 microns. Our light curve should also detect the secondary eclipse - which will allow us to determine the orbital eccentricity and brightness temperature of the day side of the planet. Spitzer is by far the best telescope to provide these observations. We did not propose this in the last GO cycle because we had not yet completed our analysis of the PTF data and other confirmatory observations we have now collected.

Spitzer Space Telescope - General Observer Proposal #90098

Completing the Census of NGC 2264 Light Curve Morphologies

Principal Investigator: John Stauffer
Institution: Spitzer Science Center

Technical Contact: Luisa Rebull, Spitzer Science Center

Co-Investigators:
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Lee Hartmann, U. Michigan
Rob Gutermuth, University of Massachusetts
Inseok Song, UGA
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Sean Carey, SSC

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30.3

Abstract:
We propose to obtain 80 epochs of Spitzer imaging photometry over a 20 day time period for a sample of 15 young stellar objects (YSOs) in NGC2264. These targets were selected based on the December 2011 Spitzer and CoRoT observations obtained of NGC2264 as part of the Spitzer Exploration Science program YSOVAR2: Mapping YSO Inner Disk Structure in NGC2264. Our GO9 program is designed to obtain multi-band photometry and high-resolution spectroscopy for a carefully chosen set of YSOs whose 2011 data were incomplete. In particular, ten of these stars have light curve variability which appears to be dominated by stochastically variable mass accretion rates from the disk to the star. Our Cycle 8 observations are the first to be able to clearly identify and characterize this type of photometric variability in classical T Tauri stars. The GO9 observations will increase the number of well-characterized members of this class by 40% and extend the membership into the substellar mass regime. The other five target stars are additional YSOs with rare light curve morphologies and incomplete data from 2011, including a PMS eclipsing binary whose components are likely to both be substellar.

Spitzer Space Telescope - General Observer Proposal #14039

Deciphering Periodic Methanol Masers

Principal Investigator: Bringfried Stecklum
Institution: Thueringer Landessternwarte

Technical Contact: Bringfried Stecklum, Thueringer Landessternwarte

Co-Investigators:
Alessio Caratti o Garatti, DIAS Dublin
Thomas Henning, MPIA Heidelberg
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Ulrich Hopp, MPIE Garching
Alex Kraus, MPIfR Bonn
Hendrik Linz, MPIA Heidelberg
Alberto Sanna, MPIfR Bonn
Andrej Sobolev, Ural Federal University Observatory
Verena Wolf, TLS Tautenburg

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.1
Priority: 1

Abstract:
Impressive progress has been made in recent years on massive star formation, yet the involved high optical depths even at submm/mm wavelengths make it difficult to reveal its details. Recently, accretion bursts of massive YSOs have been identified to cause flares of Class II methanol masers (methanol masers for short) due to enhanced mid-IR pumping. This opens a new window to protostellar accretion variability, and implies that periodic methanol masers hint at cyclic accretion. Pinning down the cause of the periodicity requires joint IR and radio monitoring. We derived the first IR light curve of a periodic maser host from NEOWISE data. The source, G107.298+5.639, is an intermediate-mass YSO hosting methanol and water masers which flare every 34.5 days. Our recent joint K-band and radio observations yielded first but marginal evidence for a phase lag between the rise of IR and maser emission, respectively, and revealed that both NEOWISE and K-band light curves are strongly affected by the light echo from the ambient dust. Both the superior resolution of IRAC over NEOWISE and the longer wavelengths compared to our ground-based imaging are required to inhibit the distractive contamination by the light echo. Thus, we ask for IRAC monitoring of G107 to cover one flare cycle, in tandem with 100-m Effelsberg and 2-m Wendelstein radio and NIR observations to obtain the first high-quality synoptic measurements of this kind of sources. The IR-maser phase lag, the intrinsic shape of the IR light curves and their possible color variation during the cycle allow us to constrain models for the periodic maser excitation. Since methanol masers are signposts of intermediate-mass and massive YSOs, deciphering their variability offers a clue to the dynamics of the accretion-mediated growth of massive stars and their feedback onto the immediate natal environment. The Spitzer light curve of such a maser-hosting YSO would be a legacy science product of the mission.

Spitzer Space Telescope - General Observer Proposal #14045

COMPLETE2: Completing the Legacy of Spitzer/IRAC over COSMOS

Principal Investigator: Mauro Stefanon
Institution: Yale University

Technical Contact: Mauro Stefanon, Yale University

Co-Investigators:
Ivo Labbe, Swinburne University of Technology
Karina Caputi, Kapteyn Astronomical Institute
Rychard Bouwens, Leiden Observatory
Pascal Oesch, Observatoire de Geneve
Matthew Ashby, Harvard-Smithsonian Center for Astrophysics
James Dunlop, The Royal Observatory, Edinburgh
Marijn Franx, Leiden Observatory
Johan Fynbo, University of Copenhagen - Dark Cosmology Center
Garth Illingworth, Lick Observatory
Olivier Le Fevre, Laboratoire d'Astrophysique de Marseille
Danilo Marchesini, Tufts University
Henry Joy McCracken, Institut d'Astrophysique de Paris
Bo Milvang Jensen, University of Copenhagen
Adam Muzzin, York University
Pieter van Dokkum, Yale University

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 500.0, 500.0
Priority: 2, 3

Abstract:
We propose to complete the legacy of Spitzer/IRAC over COSMOS by extending the deep coverage to the full 1.8 sq degree field, producing a nearly homogenous and contiguous map unparalleled in terms of area and depth. We were previously awarded only half of the requested ~3000 hours in cycle 13 to complete this legacy (due to scheduling constraints), and here we propose for the second half. Ongoing and scheduled improvements in the supporting optical-to-NIR data down to ultradeep limits have reconfirmed COSMOS as a unique field for probing the bright end of the z=6-11 universe and the formation of large-scale structures. However, currently only one-third of the field has received sufficiently deep IRAC coverage to match the new optical/ near-IR limits. Here we request deep matching IRAC data over the full 1.8 sq degree field to detect almost one million galaxies. The proposed observations will allow us to 1) constrain the galaxy stellar mass function during the epoch of re-ionization at z=6-8 with about 10,000 galaxies at these redshifts, 2) securely identify the brightest galaxies at 9 < z < 11, 3) trace the growth of stellar mass at 1<z<8 and the co-evolution of galaxies and their dark matter halos, 4) identify (proto)clusters and large scale structures, and 5) reveal dust enshrouded starbursts and the first quiescent galaxies at 3 < z < 6. The Spitzer Legacy over COSMOS will enable a wide range of discoveries beyond these science goals owing to the unique array of multi-wavelength data from the X-ray to the radio. COSMOS is a key target for ongoing and future studies with ALMA and for spectroscopy from the ground, and with the timely addition of the Spitzer Legacy it will prove to be a crucial treasury for efficient planning and early follow-up with JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14253

GO^2LF: The Great Observatories Square-degree Legacy Fields

Principal Investigator: Mauro Stefanon
Institution: Leiden Observatory

Technical Contact: Mauro Stefanon, Leiden Observatory

Co-Investigators:
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Rychard Bouwens, Leiden Observatory (the Netherlands)
Ivo Labbe, Swinburne Center for Astrophysics and Supercomputing (Australia)
Pascal Oesch, University of Geneva (Switzerland)
Adam Burgasser, UC San Diego (USA)
Danilo Marchesini, Tufts University (USA)
Sune Toft, Niels Bohr Institute (DAWN) (Denmark)
Benne Holwerda, University of Louisville (USA)
Pieter van Dokkum, Yale University (USA)

Science Category: High-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 612.3
Priority: 1 (150.0); 2 (462.3)

Abstract:
The Spitzer and Hubble Space Telescopes working in consort have revealed sources as luminous as our own Milky Way as early as 400 Myr after the Big Bang, highlighting a potentially very efficient regime for star formation in L>L* galaxies at early times. Such luminous galaxies are rare, however: it is imperative to probe very wide areas to constrain their volume density and properties. We have identified a complete square degree of *existing* archival Hubble imaging with the depth and filter coverage amenable to identification of rare, red sources. Heretofore unexplored in a uniform and systematic way, fully half of this area is outside of well-studied survey fields and comprises more than 2200 Hubble orbits. Here we propose the GO^2LF program to obtain the 3.6+4.5um imaging over the full Hubble area where it is not already available (1150 arcmin^2). Moderate depth Spitzer/IRAC imaging is essential for robust characterization of the sources of interest. These >5-band Spitzer+Hubble data will yield an unprecedented view of early galaxy growth with ~20 bright z~9-10 galaxies and dozens of ultra-massive galaxies at z>2, and also robust spectral types of cool stars in the Galaxy.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14304

Maximizing Future Samples of Brightz~9-10 Galaxies for JWST through Targeted Follow-up of Sources Identified from 500 separate HST Fields (0.8 deg**2)

Principal Investigator: Mauro Stefanon
Institution: Leiden Observatory

Technical Contact: Mauro Stefanon, Leiden Observatory

Co-Investigators:
Rychard Bouwens, Leiden Observatory

Science Category: High-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.3
Priority: 1

Abstract:
The discovery and subsequent spectroscopic confirmation of very bright star-forming galaxies in the z>~9 universe was initially a great surprise, but very exciting. Not only do these galaxies give us a measure of how rapidly galaxies can assemble a huge mass of stars, gas, and dust in the early universe, but also they represent fantastic targets for dedicated follow-up efforts. Nevertheless, current samples of z>8.5 galaxies still remain quite limited in number, particularly at >L* luminosities, with no more than 5-10 sources known. Through a systematic search of 500 separate fields with multi-band HST data (0.8 deg^2), we have identified 40 bright sources which show a robust Lyman-break consistent with their being bright z~9-10 galaxies. At present, however, each of these fields lack sensitive observations redward of 1.5 microns needed to determine if sources are more likely z~9-10 galaxies or evolved galaxies at z~2. We have already successfully demonstrated the effectiveness of this approach through successful proposals obtained on bright z~9-10 candidates in cycles 12, 13, and 14. As a continuation of these programs and to ensure the community is ready with the best target lists for the JWST cycle 1 GO call (and also the next ALMA call), we request priority-1 observations of 35 fields with the best z~9-10 candidates. Relation with previous proposals: For some of the fields targeted in our program, we already have approved priority 2 time from our Spitzer GO^2LF program. However, as some fraction of the approved time is priority 2, here we are proposing for the fields again to ensure priority 1 targeting.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14305

Preparing for JWST by Securing a Sample of Very Bright z~8-10 Galaxies Identified over >1 deg^2

Principal Investigator: Mauro Stefanon
Institution: Leiden Observatory

Technical Contact:Mauro Stefanon, Leiden Observatory

Co-Investigators:
Rychard Bouwens, Leiden Observatory

Science Category: High-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 34.0
Priority: 1

Abstract:
While initially surprising, the recent discovery and confirmation of very bright galaxies in the z~9-11 universe has been very exciting scientifically. Not only does the existence of bright sources allow us to measure the rate at which galaxies build up, but the identification of such bright sources provide us with high-value targets for detailed follow-up studies. To study the build of high-mass galaxies in more detail, we have done a careful search over both the UltraVISTA and VIDEO-XMM fields to identify the brightest and most reliable galaxies at z~7-10. While such identifications can be fairly securely at z~7, higher redshift identifications are more uncertain due to the shallower depths of the redder data and the shorter wavelength baselines. Fortunately, we can dramatically improve the robustness of brightest z~8-10 galaxies identified over wide areas with a 40-hour program, requesting just 4 hours of Spitzer/IRAC data per source (only 40 minutes is available now). Not only would the requested integrations allow us to securely detect sources with IRAC (greatly improving mass estimates), but our bright z~8-10 candidates would then be easily distinguishable from possible lower-redshift contaminants like dwarf stars. Obtaining maximally secure selections of bright z~8-10 galaxies is clearly a high priority, given great interest from the community in following up such sources with JWST in cycle 1 and also with ALMA and other facilities.

Spitzer Space Telescope - Directors Discretionary Time Proposal #543

IRAC warm observations of epsilon Aurigae, first half of eclipse

Principal Investigator: Robert Stencel
Institution: University of Denver

Technical Contact: Robert Stencel, University of Denver

Co-Investigators:
Donald Hoard, SSC
Steve Howell, NOAO

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.2

Abstract:
Epsilon Aurigae is one of the most unusual and famous eclipsing binary stars in all of astronomy, the subject of studies since 1824, and long defying explanation. We are requesting less than one total hour of Spitzer IRAC time to obtain a pair of IRAC channels 1 & 2 observations, during the 2010 April window, of the enigmatic binary, epsilon Aurigae, now in totality for the first time in 27 years. The goal of these observations includes the following: (a) having demonstrated during spring 2009 that IRAC could safely and accurately measure this bright star using a special method invented for the purpose, (b) we expect to derive precise photometric flux and color information about the relative contribution of the 550K disk and the 7500K F star to the light at these IRAC channels during a very unique orbital phase.

Spitzer Space Telescope - General Observer Proposal #70006

Taming the Invisible Monster: Infrared Monitoring of Epsilon Aurigae During Eclipse

Principal Investigator: Robert Stencel
Institution: University of Denver

Technical Contact: Donald Hoard, IPAC, California Institute of Technology

Co-Investigators:
Donald W. Hoard, Spitzer Science Center
Steve Howell, NOAO

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
We propose to continue a sequence of warm IRAC photometric measurements of the unusual binary star, Epsilon Aurigae, during the rest of its ongoing total eclipse throughout Cycle 7, in order to better constrain the degree of heating of the now interferometrically-imaged disk. As heated portions of the disk rotate into view, IRAC channels one and two provide a sensitive diagnostic of the infrared excess, which is expected to change as our view of the 550 K cold side of the disk is replaced by the portion heated to >1,000 K by the nearby F0 star, now rotating into view.

Spitzer Space Telescope - General Observer Proposal #10098

Warm Spitzer Imaging of NuSTAR Fields

Principal Investigator: Daniel Stern
Institution: Jet Propulsion Laboratory

Technical Contact: Daniel Stern, Jet Propulsion Laboratory

Co-Investigators:
David Alexander, Durham
George Lansbury, Durham
James Aird, Durham
Roberto Assef, JPL
David Ballantyne, Georgia Tech
Mislav Balokovic, Caltech
Franz Bauer, Catolica, Chile
Francesca Civano, Dartmouth
Agnese Del Moro, Durham
Martin Elvis, CfA
Poshak Gandhi, Durham
Brian Grefenstette, Caltech
Fiona Harrison, Caltech
Ryan Hickox, Dartmouth
Stephanie La Massa, Yale
Kristin Madsen, Caltech
James Mullaney, Durham
Simonetta Puccetti, INAF, ASI
Gianpiero Tagliaferri, INAF
Meg Urry, Yale
Dominic Walton, Caltech

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 134.4
Priority: 1

Abstract:
We propose to obtain complete 2-band Spitzer/IRAC maps over the entire NuSTAR field-of-view for all non-survey fields observed during the 2-year primary NuSTAR mission. Such data are important for identifying the low-energy counterparts to NuSTAR sources, which is a prerequisite for follow-up spectroscopy and fully characterizing the NuSTAR sources. The proposed 134.4 hr program will vastly improve our understanding of the sources responsible for the peak of the cosmic X-ray background, which is poorly understood currently -- only 1-2% of the X-ray background is resolved at 20-30 keV by missions prior to NUSTAR. The proposed data will also provide an important multi-mission NASA data base, including high-energy (3-79 keV) NuSTAR observations, low-energy (0.2-10 keV) Swift/XRT observations, and mid-infrared Spitzer/IRAC data. These data will be useful for stacking analyses, as well as provide a valuable legacy data set to the community.

Spitzer Space Telescope - Snapshot Proposal #70135

A Snapshot Survey of Galaxy Clusters around High-Redshift Quasars

Principal Investigator: Daniel Stern
Institution: JPL/Caltech

Technical Contact: Daniel Stern, JPL/Caltech

Co-Investigators:
Nicholas Seymour, MSSL
Carlos De Breuck, ESO
Mark Brodwin, CfA
Peter Eisenhardt, JPL/Caltech
James Falder, University of Hertfordshire
Audrey Galametz, ESO
Anthony Gonzalez, Univ. Florida
Nina Hatch, University of Nottingham
Matthew Jarvis, University of Hertfordshire
Conor Mancone, Univ. Florida
S. Adam Stanford, UC-Davis
Jason Stevens, University of Hertfordshire
Joel Vernet, ESO

Science Category: galaxy clusters and groups(high-z)
Hours Approved: 118.6

Abstract:
Extensive literature clearly demonstrates that powerful, radio-loud AGN are preferentially located in rich environments. We propose to take advantage of that tendency by obtaining a snapshot survey of rich galaxy clusters associated with radio-loud AGN at 1.3<z<2. Galaxy clusters are unique laboratories for studying the formation and evolution of massive galaxies. Previous results suggest that significant assembly of the red sequence occurs at z>1.3. Our proposed program will enhance the number of clusters known at these redshifts, and will be sufficiently deep to measure the luminosity function, including its faint end slope, to m*+2. We will study evolutionary trends, the relationship between radio power and environment, as well as probe AGN unification models by comparing the environments of radio galaxies to a matched sample of radio-loud quasars.

Data from this program was split into multiple PIDs. You can find the data in program IDs 70135, 70171

Spitzer Space Telescope - Snapshot Proposal #80154

A Snapshot Survey of Galaxy Clusters around High-Redshift Quasars

Principal Investigator: Daniel Stern
Institution: Jet Propulsion Laboratory

Technical Contact: Daniel Stern, Jet Propulsion Laboratory

Co-Investigators:
Audrey Galametz, JPL/Caltech
Nicholas Seymour, MSSL
Carlos De Breuck, ESO
Mark Brodwin, CfA
Peter Eisenhardt, JPL/Caltech
James Falder, University of Hertfordshire
Anthony Gonzalez, University of Florida
Nina Hatch, University of Nottingham
Matthew Jarvis, University of Hertfordshire
Conor Mancone, University of Florida
S. Adam Stanford, UC-Davis
Jason Stevens, University of Hertfordshire
Joel Vernet, ESO

Science Category: galaxy clusters and groups(high-z)
Hours Approved: 289.4

Abstract:
Extensive literature clearly demonstrates that powerful, radio?loud AGN are preferentially located in rich environments. We propose to take advantage of that tendency by obtaining a snapshot survey of rich galaxy clusters associated with radio?loud AGN at z>2. This proposal extends our successful Cycle 7 snapshot program identifying clusters around radio-loud AGN at 1.3<z<2. Galaxy clusters are unique laboratories for studying the formation and evolution of massive galaxies. Previous results suggest that significant assembly of the red sequence occurs at z>1.3. Our proposed program will enhance the number of clusters known at high redshift, and will be sufficiently deep to measure the luminosity function, including its faint end slope, to ~m*+2. We will study evolutionary trends, the relationship between radio power and environment, as well as probe AGN unification models by comparing the environments of radio galaxies to a matched sample of radio?loud quasars.

Data from this program was split into multiple PIDs. You can find the data in program IDs 80154, 80254

Spitzer Space Telescope - General Observer Proposal #14112

Probing M Dwarf Model-Data Discrepancies via Precise, Empirical Characterization of a Long-Period F+M Binary

Principal Investigator: Daniel Stevens
Institution: Ohio State University

Technical Contact: Daniel Stevens, Ohio State University

Co-Investigators:
Scott Gaudi, Ohio State University
Thomas Beatty, Pennsylvania State University
Robert Siverd, Las Cumbres Observatory

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 23.3
Priority: 1

Abstract:
Double-lined eclipsing binaries (EBs) have been the gold standard for direct, precise (less than a few percent), and accurate measurements of stellar masses and radii. However, with the availability of Gaia parallaxes and nearly complete spectral energy distributions (SEDs) of millions of stars, it will soon be possible to make such measurements for the much larger number of single-lined EBs such as high mass-ratio systems and transiting planets, both of which are routinely found by transit surveys. Combining high-precision eclipse photometry and radial velocity (RV) observations of the primary star enables measurements of the primary star's density, the ratio of stellar radii, and a combination of the stars' masses. Broad-band photometry from the ultraviolet to the infrared plus a Gaia parallax and an effective temperature of the primary from either the SED or high-resolution spectra, allow one to measure the radius (and mass via the density) of the primary. The radius and mass of the secondary can then be determined in the usual way with the radius ratio and RVs, and the companion's effective temperature can be determined from a secondary eclipse measurement and the primary star's effective temperature. For single-lined EBs, the precision of ingress/egress duration measurements dominates the error budget of the masses and companion radius. We propose to observe one primary and secondary eclipse of the F+M binary TYC 4223-1012-1, an M dwarf on a 16.5-day orbit around an F dwarf. Ground-based data poorly constrain TYC 4223-1012-1's masses due to the near-impossibility of observing the full ~10-hr eclipse from the ground. By combining extant RV and SED data with the Spitzer data, we expect to measure the mass, radius, and effective temperature of the M dwarf to a few percent. This is comparable to the precision of the best-characterized literature M dwarfs, but at an orbital period far beyond the majority of such systems, where tidal effects should be negligible.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10169

The Newest Hot Jupiter Archetype Through the Eyes of NASAs Great Observatories

Principal Investigator: Kevin Stevenson
Institution: University of Chicago

Technical Contact: Kevin Stevenson, University of Chicago

Co-Investigators:
Jacob Bean, University of Chicago
Jean-Michel Desert, University of Colorado
Jonathan Fortney, UC Santa Cruz
Adam Showman, LPL

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 26.2

Abstract:
Today, WASP-43b is an unfamiliar name within a pool of hundreds of confirmed transiting exoplanets. However, WASP-43b is on the verge of becoming one of the most intensely scrutinized exoplanets to date, joining the ranks of the exoplanet archetypes HD 209458b and HD 189733b. As part of a focused and in-depth investigation into this hot Jupiter's atmospheric composition and circulation, we dedicated 61 Hubble Space Telescope (HST) orbits to obtain a spectroscopic phase curve (the first of its kind with any telescope) between 1.1 and 1.7 microns. With two papers presenting our findings now on the verge of being accepted, WASP-43b will quickly become a rising star as it will be the subject of numerous theoretical and observational follow-up investigations. In this proposal, we aim to expand our investigation of WASP-43b to new pressure and temperature regions using the Spitzer Space Telescope. We propose an intensive program to sample the transmission, dayside emission, and phase-resolved emission spectra of WASP-43b in both the 3.6 and 4.5 micron channels at high precision. The Spitzer data will enable us to determine the oxygen and carbon abundances in the planet's atmosphere, search for the first signature of varying chemical composition as a function of longitude on a planet, measure the variation of hot spot offset as a function of altitude, and resolve competing hypotheses on the large day-night WFC3 flux variations. This final point is particularly important because, up until now, Spitzer has been our only window into these planets' day-night contrasts and HST is telling us a different story. With exoplanet phase curves sure to be one of the main enduring Spitzer legacies, we must connect what we have learned from Spitzer to current and future HST data so that, prior to its deactivation, we may learn if Spitzer has been telling us ``the truth'' for all of these years. Only the channel 2 observations were approved in this DDT.

Spitzer Space Telescope - General Observer Proposal #11001

The Newest Hot Jupiter Archetype Through the Eyes of NASA's Great Observatories, Part 2 of 2

Principal Investigator: Kevin Stevenson
Institution: University of Chicago

Technical Contact: Kevin Stevenson, University of Chicago

Co-Investigators:
Jacob Bean, University of Chicago
Jean-Michel Desert, Univeristy of Colorado
Jonathan Fortney, UC Santa Cruz
Michael Line, UC Santa Cruz
Laura Kreidberg, University of Chicago
Adam Showman, University of Arizona
Tiffany Kataria, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 26.2
Priority: 1

Abstract:
Until recently, WASP-43b was an unfamiliar name within a sea of confirmed transiting exoplanets. However, it is now one of the most intensely scrutinized exoplanets to date, joining the ranks of exoplanet archetypes HD 209458b and HD 189733b. In an in-depth investigation into this hot Jupiter's atmospheric composition and circulation, we dedicated 61 HST orbits to obtain a spectroscopic phase curve (the first of its kind with any telescope) from 1.1 to 1.7 microns. With the recent publication of our findings in Science and ApJL, WASP-43b is becoming the subject of numerous theoretical and observational follow-up investigations. Last cycle, we were awarded 26 hours of DDT to observe the transmission, dayside emission, and phase-resolved emission of WASP-43b at 4.5 microns. Here we propose to complete our IR spectrum by repeating our high-precision measurement at 3.6 microns. Data from just one Spitzer channel does not allow for a direct comparison with other Spitzer phase-curve targets and is insufficient to achieve our goals. This is because it is the flux variation between the two Spitzer channels (in conjunction with the HST data) that will enable us to determine the oxygen and carbon abundances in the planet's atmosphere, measure the variation of hot spot offset as a function of altitude, and resolve competing hypotheses on the large day-night WFC3 flux variations. This final point is particularly important because, up until now, Spitzer has been our only window into these planets' day-night contrasts and HST is telling us a different story. With exoplanet phase curves sure to be one of the main enduring Spitzer legacies, we must connect what we have learned from Spitzer to current and future HST data so that we can properly interpret these important measurements of benchmark exoplanets. This will allow us to connect all phase-curve measurements under one theory and predict future spectroscopic results with JWST.

Spitzer Space Telescope - General Observer Proposal #12028

The First Atmospheric Characterization of a Habitable-Zone Exoplanet

Principal Investigator: Kevin Stevenson
Institution: University of Chicago

Technical Contact: Kevin Stevenson, University of Chicago

Co-Investigators:
Jacob Bean, University of Chicago
David Charbonneau, Harvard University
Jean-Michel Desert, Univeristy of Colorado
Jonathan Fortney, UC Santa Cruz
Jonathan Irwin, Harvard University
Laura Kreidberg, University of Chicago
Michael Line, UC Santa Cruz
Ben Montet, Harvard University
Caroline Morley, UC Santa Cruz

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.3
Priority: 1

Abstract:
Exoplanet surveys have recently revealed nearby planets orbiting within stellar habitable zones. This highly-anticipated breakthrough brings us one step closer in our quest to identify cosmic biosignatures, the indicators of extrasolar life. To achieve our goal, we must first study the atmospheres of these temperate worlds to measure their compositions and determine the prevalence of obscuring clouds. Using observations from the K2 mission, Co-I Montet recently announced the discovery of a 2.2 Earth-radii planet within the habitable zone of its relatively bright, nearby M dwarf parent star, K2-18. This temperate world is currently the best habitable-zone target for atmospheric characterization. Congruent with currently planned HST observations, we propose a Spitzer program to measure the transmission spectrum of the first habitable-zone exoplanet. Both telescopes are essential to revealing K2-18b's chemical composition. In a cloud-free, hydrogen-dominated atmosphere, the precision achieved by these measurements will be sufficient to detect methane, ammonia, and water vapor, which are the dominant C, N, and O bearing species at these temperatures. In turn, elemental abundance constraints from a primordial atmosphere can tell us about the composition of a protoplanetary disk in which Earth-like planets could have formed. Conversely, if the atmosphere contains thick clouds then the multi-wavelength observations from K2, HST, and Spitzer will constrain the clouds' properties. Because temperature plays a key role in the formation of clouds, their detection within the atmosphere of this habitable-zone exoplanet would be an important signpost that serves as a guide to future investigations of smaller, rocky exoplanets. As K2 continues discovering more habitable-zone planets, it is imperative that we perform spectral reconnaissance with Spitzer to determine their physical characteristics and begin understanding the prevalence of potentially-obscuring clouds prior to the launch of JWST.

Spitzer Space Telescope - General Observer Proposal #12035

Rocky or Not, Here We Come: Revealing the Internal Structures of K2-21b+c Through Transit Timing

Principal Investigator: Kevin Stevenson
Institution: University of Chicago

Technical Contact: Kevin Stevenson, University of Chicago

Co-Investigators:
Jacob Bean, University of Chicago
Diana Dragomir, LCOGT
Daniel Fabrycky, University of Chicago
Laura Kreidberg, University of Chicago
Sean Mills, University of Chicago
Erik Petigura, CalTech

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.1
Priority: 1

Abstract:
The provenance of planets 1.5 -- 2 times the size of the Earth is one of the biggest unresolved mysteries from the Kepler mission. Determining the nature and origins of these exoplanets relies not only on measuring their radii, but also requires knowledge about their masses, atmospheric compositions, and interior structures. With this information, we can more confidently estimate planet mass distributions from measured radii, distinguish between rocky and non-rocky compositions, and better constrain the occurrence rate of Earth-like planets. Co-I Petigura recently announced the discovery of a two-transiting-planet system, K2-21, with bodies of 1.6 and 1.9 Earth-radii. The latter is expected to have a volatile-rich atmosphere, but the former lies squarely on the rocky/non-rocky composition boundary. These exoplanets orbit their relatively bright, nearby M dwarf parent star in a near 5:3 resonance and likely exhibit transit timing variations (TTVs) that can be resolved by Spitzer. Knowledge about their TTVs, in turn, will reveal constraints on the planets' masses, which is important because significant stellar activity makes RV mass measurements impractical. We propose to measure precise transit times of K2-21b and K2-21c with Spitzer and combine that information with existing K2 timing constraints to determine their masses. Understanding the planets' masses is a critical, first step to ultimately determining their atmospheric compositions and internal structures. These planets will provide an excellent test to current statistical arguments that suggest there is a turning point in composition from rocky, true-to-name super-Earths to volatile-rich sub-Neptunes in the range of 1.5 -- 2 Earth-radii.

Spitzer Space Telescope - Exploration Science Proposal #13038

The Ultimate Spitzer Phase Curve Survey

Principal Investigator: Kevin Stevenson
Institution: University of Chicago

Technical Contact: Kevin Stevenson, University of Chicago

Co-Investigators:
Jacob Bean, University of Chicago
Drake Deming, University of Maryland
Jean-Michel Desert, Univeristy of Amsterdam
Y. Katherina Feng, UC Santa Cruz
Jonathan Fortney, UC Santa Cruz
Tiffany Kataria, JPL
Eliza Kempton, Grinnell College
Nikole Lewis, STScI
Michael Line, NASA Ames
Caroline Morley, UC Santa Cruz
Emily Rauscher, University of Michigan
Adam Showman, University of Arizona

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 660.0
Priority: 1

Abstract:
Exoplanet phase curves are sure to be one of the main enduring legacies of Spitzer. They provide a wealth of information about exoplanet atmospheres, including longitudinal constraints on atmospheric composition, thermal structure, and energy transport, that will continue to open new doors of scientific inquiry and propel future investigations for years to come. The measured heat redistribution efficiency (or ability to transport energy from a planet's highly-irradiated dayside to its eternally-dark nightside) shows considerable variation between exoplanets. Theoretical models predict a correlation between heat redistribution efficiency and planet temperature; however, the latest results are inconsistent with current predictions. Instead, a new potential trend is emerging, one that connects heat redistribution efficiency with planet rotation rate. We will test this hypothesis by performing Spitzer phase curve observations of seven exoplanets with physical properties that span the parameter space. We have identified high-contrast targets with short orbital periods around bright host stars to ensure the observations reveal robust phase curve results. Spitzer is uniquely suited for this program because we can achieve our primary goals using broadband photometry. Part of the phase curve legacy will be to combine our archived Spitzer data with transmission and dayside emission spectra from HST and JWST. Adding energy transport and cloud coverage constraints to the measured dayside abundances and thermal profiles will yield a fundamental understanding of these exoplanets' atmospheres that can be leveraged into new avenues of investigation.

Spitzer Space Telescope - General Observer Proposal #13045

Rocky or Not, Here We Come: Further Revealing the Internal Structures of K2-21b+c Through Transit Timing

Principal Investigator: Kevin Stevenson
Institution: University of Chicago

Technical Contact: Kevin Stevenson, University of Chicago

Co-Investigators:
Jacob Bean, University of Chicago
Diana Dragomir, University of Chicago
Daniel Fabrycky, University of Chicago
Laura Kreidberg, University of Chicago
Sean Mills, University of Chicago
Erik Petigura, CalTech

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 36.5
Priority: 1

Abstract:
The provenance of planets 1.5 - 2 times the size of the Earth is one of the biggest unresolved mysteries from the Kepler mission. Determining the nature and origins of these exoplanets relies not only on measuring their radii, but also requires knowledge about their masses, atmospheric compositions, and interior structures. With this information, we can more confidently estimate planet mass distributions from measured radii, distinguish between rocky and non-rocky compositions, and better constrain the occurrence rate of Earth-like planets. Last year, Co-I Petigura announced the discovery of a two-transiting-planet system, K2-21, with bodies of 1.6 and 1.9 Earth-radii. The latter is expected to have a volatile-rich atmosphere, but the former lies squarely on the rocky/non-rocky composition boundary. These exoplanets orbit their relatively bright, nearby M dwarf parent star in a near 5:3 resonance and, based on our successful Spitzer observations, exhibit measurable transit timing variations (TTVs). Complete knowledge about their interactions will reveal constraints on the planets' masses, which is important because significant stellar activity makes RV mass measurements impractical. We propose to continue measuring precise transit times of K2-21b and K2-21c with Spitzer and combine that information with existing K2 timing constraints to determine their masses. Understanding the planets' masses is a critical, first step to ultimately determining their atmospheric compositions and internal structures. These planets will provide an excellent test to current statistical arguments that suggest there is a turning point in composition from rocky, true-to-name super-Earths to volatile-rich sub-Neptunes in the range of 1.5 - 2 Earth-radii.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14244

Rocky or Not, Here We Come: Bridging the Fulton Gap With K2-21b+c

Principal Investigator: Kevin Stevenson
Institution: STScI

Technical Contact: Kevin Stevenson, STScI

Co-Investigators:
Jacob Bean, UChicago
Diana Dragomir, MIT
Dan Fabrycky, UChicago
Laura Kreidberg, Harvard CfA
Nikole Lewis, Cornell
Sean Mills, CalTech
Erik Petigura, CalTech
Kristin Showalter, JHU

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 16.1
Priority: 1

Abstract:
The provenance of planets 1.5 - 2 times the size of the Earth is one of the biggest unresolved mysteries from the Kepler mission. Determining the nature and origins of these exoplanets relies not only on measuring their radii, but also requires knowledge about their masses, atmospheric compositions, and interior structures. With this information, we can more confidently estimate planet mass distributions from measured radii, distinguish between rocky and non-rocky compositions, and better constrain the occurrence rate of Earth-like planets. K2-21 is a two-transiting-planet system with bodies of 1.6 and 1.9 Earth-radii. These worlds reside on opposing sides of the Fulton Gap (a minimum in the planet occurrence rate near 1.75 Earth radii), thus one is predicted to have a volatile-rich atmosphere while the other is predicted to be rocky. These exoplanets orbit their relatively bright, nearby M dwarf parent star in a near 5:3 resonance and, based on past successful Spitzer observations, exhibit ~60-minute transit timing variations (TTVs). Complete knowledge about their interactions will reveal constraints on the planets' masses, which is important because stellar activity makes RV mass measurements impractical. We propose to continue measuring precise transit times of K2-21b and K2-21c with Spitzer and, when combined with existing K2 timing constraints, improve their mass constraints by a factor of two. Understanding the planets' masses is a critical, first step to ultimately determining their atmospheric compositions and internal structures using JWST. Preliminary mass constraints suggest these temperate super-Earth planets are favorable for atmospheric characterization, with predicted one-scale-height signal sizes of 30 - 50 ppm. These planets will provide an excellent test to current statistical arguments that suggest there is a turning point in composition from rocky, true-to-name super-Earths to volatile-rich sub-Neptunes in the range of 1.5 - 2 Earth-radii.

Spitzer Space Telescope - Snapshot Proposal #80070

A New Technique for Identifying Very Highly-Obscured Quasar Sightlines

Principal Investigator: John Stocke
Institution: University of Colorado

Technical Contact: John Stocke, University of Colorado

Co-Investigators:
Jeremy Darling, University of Colorado
Ting Yan, University of Colorado
Kyle Willett, University of Colorado
Nissim Kanekar, National Centre for Radio Astrophysics, India

Science Category: AGN/quasars/radio galaxies
Hours Approved: 15.6

Abstract:
We propose to obtain two-color IRAC snapshot images of radio-loud quasars to pre-select prime candidates for observing high-redshift molecular absorption. Obscured quasars are extremely rare objects, with only five currently known despite over 1000 sources observed. Such targets offer unique opportunities to determine the physical conditions in star-forming clouds, measure the molecular gas fraction as a function of cosmic time, and explore whether fundamental constants (such as the fine-structure constant) have changed over the history of the Universe. "Blind searches" for obscured quasars in the radio, however, are highly inefficient due to absorption of the optical/UV continuum, radio-frequency interference close to redshifted lines, and lack of abundance of molecular gas. A steep near-IR index identified by IRAC colors can pre-select highly obscured objects and establish a new technique for efficiently identifying candidate absorbers. Our sample consists of radio-loud AGN associated with spiral and irregular galaxies, as well as targets without optical counterparts that have been detected in the near-IR. We will use IRAC colors in conjunction with ground-based K-band images (already obtained) to immediately begin deep optical and radio observations of the most highly-obscured targets. We propose to take "snapshots" of 91 strong (> 300 mJy) radio sources, requiring a total Spitzer observing time of 15.6 hours.

Spitzer Space Telescope - General Observer Proposal #12030

Deep IRAC imaging of a complete sample of SPT-selected clusters at z~1.5: the restframe-NIR view of galaxies in the most massive very distant structures

Principal Investigator: Veronica Strazzullo
Institution: Universitaetssternwarte der LMU Muenchen

Technical Contact: Veronica Strazzullo, Universitaetssternwarte der LMU Muenchen

Co-Investigators:
Joseph Mohr, LMU USM
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Spencer A. Stanford, UC Davis
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Michael McDonald, MIT
I-Non Chiu, LMU USM
Joerg Dietrich, LMU USM
Sebastian Bocquet, LMU USM
Raffaella Capasso, LMU USM
Bodo Ziegler, U. Vienna
Ulrike Kuchner, U. Vienna

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.5
Priority: 1

Abstract:
We propose deep IRAC mapping at 3.6um and 4.5um of a complete sample of the five most distant clusters discovered in the SPT-SZ survey, to get a detailed (at least M*+3) restframe NIR (thus stellar mass) picture of galaxy populations in the densest environments at z~1.5. This redshift is a crucial transition time for massive galaxies in cluster environments, bridging the major star formation events at z~2 that built most of the stars in massive cluster early-types, and the z~1 regime that is largely characterized by passive evolution in cluster cores. All five targeted clusters have scheduled HST observations in the ACS/F814W and WFC3/F140W bands probing stellar populations and morphologies. The observations proposed here will crucially complement these data, probing the restframe NIR luminosity function (and galaxy stellar mass function), the galaxy number density and stellar mass profiles, stellar mass fractions and halo occupation distribution. The depth of these observations and the clear selection function of the cluster sample will be critical in addressing the still controversial results of the first very few studies of stellar mass assembly in early cluster environments. A real synergy of HST and Spitzer observations, in combination with a unique cluster sample, will allow an important step forward in our understanding of crucial aspects of galaxy evolution in the first massive clusters.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14242

Star formation in transitional environments

Principal Investigator: Andra Stroe
Institution: Harvard & Smithsonian CfA

Technical Contact: Joseph Hora, Harvard & Smithsonian CfA

Co-Investigators:
Matthew Ashby, Harvard & Smithsonian CfA
Howard Smith, Harvard & Smithsonian CfA

Science Category: Galaxy clusters
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30.2
Priority: 2

Abstract:
Cluster mergers are the most energetic events since the Big Bang, releasing ~10e64 erg over 1-2 Gyr. This creates extremely violent environments permeated by Mpc-wide shock waves and cluster-wide turbulence. The merger phase is an formative event in the evolution of all clusters and provides a unique window into the complex physics of structure formation. However, little is known about the effect of disturbed clusters on galaxy evolution. We recently completed the largest narrow-band survey of Halpha-selected star-forming galaxies in a sample of low-redshift clusters (Stroe et al. 2017). With our extensive optical, radio, and X-ray imaging and spectroscopy, we have already measured most of the fundamental properties of the star-forming galaxies (e.g. star-formation rate, powering source, metallicity etc) and placed them in the context of the parent cluster properties (mass, merger state). Our results are striking: relaxed environments have 25 times fewer star-forming galaxies compared to merging clusters. As an example, star-forming galaxies in one of our massive merging clusters showed strong evidence for higher than expected metallicities, low-electron densities and high supernova rates compared to field counterparts. What drives this reversal of typical environmental trends? It potentially could be explained by a number of scenarios such as shock-induce star-formation or triggering by ram pressure stripping. To discriminate among them, here we propose two-band Spitzer/IRAC imaging of our sample of merging and relaxed clusters. The proposed imaging will fill a gap in our existing data, and reveal the AGN rates in and outside the clusters, and measure masses for their star-forming galaxies. The data will also unveil the effect shocks and turbulence may have on star formation in cluster galaxies. Finally, given the similarities between low-z disturbed clusters and high-z protoclusters, our study may provide important clues to the evolution of galaxies in high-z overdensities.

Spitzer Space Telescope - General Observer Proposal #11093

Debris Disk Variability: Observational Test Bed for Probing Terrestrial Planet Formation

Principal Investigator: Kate Su
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
George Rieke, University of Arizona
Alan Jackson, Arizona State University
Andras Gaspar, University of Arizona
Huan Meng, University of Arizona

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 130.0
Priority: 1

Abstract:
The newly discovered variable emission by extreme debris disks provides a unique opportunity to learn about asteroid-sized bodies in young exoplanetary systems and to explore planetesimal collisions and their aftermaths during the era of terrestrial planet building. However, the baseline of existing observations is too short to characterize this behavior well. We propose to monitor variations in seven systems where they have already been identified, and to look for them in seven more systems that are likely to behave similarly, selected because their high levels of warm dust point to elevated rates of planetesimal collisions. This program requires 130 hours of observing time and will establish the time-domain study of debris disks as an important heritage of the Spitzer warm mission.

Spitzer Space Telescope - General Observer Proposal #13014

Probing Terrestrial Planet Formation with Extreme Disk Variability

Principal Investigator: Kate Su
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
George Rieke, University of Arizona
Andras Gaspar, University of Arizona
Alan Jackson, Arizona State University

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 120.0
Priority: 1

Abstract:
Spitzer has advanced our knowledge about the critical stages of terrestrial planet formation (and in some cases destruction) by discovering young stars orbited by 1.) silica dust emission close to their terrestrial zones indicative of the violent collisions, and 2.) variable disk emission arising from the aftermath of asteroid-size impacts. The variable emission provides a unique opportunity to learn about asteroid-sized bodies in young exoplanetary systems and to explore planetesimal collisions and their aftermaths during the era of terrestrial-planet-building. We propose continued study of debris disk variability, focused in two areas: (1) to provide continuous monitoring of systems where our existing program has discovered substantial variations indicative of major ongoing episodes of planetesimal impacts; and (2) to investigate intensively possible variations in the dust content of systems that show prominent crystalline emission features to establish a link between the two indicators of planet building. Together these objectives will prepare us for the JWST era, when we will again obtain mid-infrared spectra of these systems, and of both higher spectral resolution and signal to noise than has been possible previously. This program will extend the time-domain study of extreme debris disks as an important heritage of the Spitzer warm mission.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14238

Testing the Impact Hypothesis in the NGC 2457-ID8 System

Principal Investigator: Kate Su
Institution: University of Arizona

Technical Contact: Kate Su, University of Arizona

Co-Investigators:
George Rieke, University of Arizona
Alan Jackson, University of Toronto
Andras Gaspar, University of Arizona

Science Category: Debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 16.7
Priority: 2

Abstract:
Terrestrial plant formation is a violent and messy process with roughly half of the impact-body mass contributing to net growth, leading to diverse compositions in the solar system's terrestrial bodies. Through time-domain monitoring young exoplanetary systems, we have demonstrated that variable disk emission by the dust produced in the aftermaths of planetesimal impacts provides very diagnostic information about these violent events.Through our dedicated Spitzer monitoring campaign, we have identified multiple violent impacts in the 35-Myr-old NGC 2547-ID8 system, involving large (>100 km) asteroid-sized bodies. Our high-quality infrared light curves detail the amount of freshly generated dust during the post-impact evolution. The extraordinary photometry precision, high cadence and long baseline observations provided by Spitzer enable detailed documenting these violent events, and provide unique observational insights into the processes of terrestrial planet formation. We propose to continue monitoring this iconic variable debris system to fully test the impact hypothesis. The knowledge we learn from this system provides the template for studies of other variable systems, leaving a long-term legacy value.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14266

Constraining Planetesimal Collisions in the Terrestrial Planet Zone of HD 166191

Principal Investigator: Kate Su
Institution: University of Arizona

Technical Contact: Kate Su, University of Arizona

Co-Investigators:
George Rieke, University of Arizona

Science Category: Debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.4
Priority: 1

Abstract:
Variable disk emission by the dust produced in the aftermath of large planetesimal collisions provides very diagnostic information about the violent collisions that are needed to build terrestrial planets. Our multi-year Spitzer monitoring shows that the debris production in the terrestrial zone of HD 166191 has become very active since 2018, exhibiting a large-scale, year-long flux increase similar to that observed in the prototype of variable system ID8. This behavior is consistent with the collisional evolution within an impact-produced cloud whose main constituents are unaltered, escaping sand and boulders. Occultations in this system place a unique constraint on the orbit of the debris, so models will be highly constrained. We propose to continue monitoring the HD 166191 system to document its disk variability and further improve our understanding of terrestrial-planet-building impacts

Spitzer Space Telescope - General Observer Proposal #70076

A Complete Census of Warm Debris Disks

Principal Investigator: Kate Su
Institution: The University of Arizona

Technical Contact: Kate Su, The University of Arizona

Co-Investigators:
George Rieke, University of Arizona
Karl Stapelfeldt, Caltech/JPL
Karl Gordon, STScI
Jennifer Sierchio, University of Arizona
Andras Gaspar, University of Ariozna
Micaela Bagley, University of Arizona
Zoltan Balog, Max Planck Institute for Astronomy

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 109.0

Abstract:
Debris disks are our best means to observe planetary system evolution after the protoplanetary phase. Warm debris disks are especially interesting because they trace material in the terrestrial planet zones analogous to our inner solar system. Their short dynamical time scales make them proxies for high levels of gravitational stirring by massive planets or even collisions between large planetesimals. Nearly 3000 field stars were measured by Spitzer at 24 microns to search for debris disks. We have been funded under the NASA ADP to reduce these measurements uniformly and to photometric accuracies of better than 1% rms. We are committed to providing this unique Spitzer legacy for open community access, in support of programs with Herschel and eventually with JWST, SPICA, and far-future missions. However, as a result of the high accuracy we have achieved at 24 microns, identifying weak excesses and warm systems is limited by the quality of the near infrared measurements used to extrapolate the photospheric levels. Completing the Spitzer legacy requires IRAC 3.6 micron observations, which are capable of measuring the photospheric level to 1% or better, allowing identification of 24-micron excesses at the 5% level (3-sigma). Measurements at this level are required for a complete census of warm disks, making full use of the capabilities of Spitzer and Herschel at 70 microns. We will use the full population of warm disks to test the most widely accepted paradigm for disk evolution, that it is dominated by monotonic evolution from the protoplanetary stage. The deep and complete sampling of warm systems will help identify suitable targets for exoplanet searches. Our program also prepares for JWST, which will be capable of obtaining spectra of these warm disks to study mineralogical features. The warm-mission IRAC measurements are therefore a critical part of taking full advantage of the huge investment in Spitzer cold-mission time to use debris disks to study planetary system evolution.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12129

Light Echoes and the Progenitor of SN 2016adj in Cen A

Principal Investigator: Ben Sugerman
Institution: Goucher College

Technical Contact: Ben Sugerman, Goucher College

Co-Investigators:
Stephen Lawrence, Hofstra University

Science Category: Evolved stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.6

Abstract:
The Type Ib/IIb supernova (SN) 2016adj is the fifth closest SN to be discovered during the lifetime of HST. This event offers us a rich variety of rare and unique opportunities, including: (1) identifying the progenitor; (2) mapping the three-dimensional structure and chemical composition of the progenitor's circumstellar and the host galaxy's interstellar environments; and (3) testing models of stellar mass loss and high-mass stellar evolution. The progenitor field of the SN has been observed from the near-UV to the mid-IR with HST and Spitzer, which will immediately allow us to accomplish the first science goal by identifying the progenitor (or establishing its upper limits) once new image with the SN present are taken with both observatories. Preliminary analyses of early-time spectra of SN 2016adj indicate its light is being extinguished by at least A(V)=2-4 magnitudes, meaning it is buried deep within the dust lane of Cen A. Echoes of the SN light off of this dust will allow us to produce high- resolution, three-dimensional maps of the structure and composition of the dust in and around the line-of-sight to the SN, which we will use to accomplish science goals (2)-(3) listed above. In particular, we will directly test the hypothesis that Type Ib/IIb SNe come not from very-high mass stars but from only moderately-massive stars that lost their envelopes to close binary companions. Please note that since echoes pass through a given point in space only once, data are permanently lost for each epoch that is not observed. While we will propose for continued observations in the Cycle 13 call for proposals, most of the science we propose cannot be achieved if the observations in this proposal are not taken before Cycle 13 begins.

Spitzer Space Telescope - General Observer Proposal #13151

Light Echoes and the Environments of SNe 2014J and 2016adj

Principal Investigator: Ben Sugerman
Institution: Goucher College

Technical Contact: Ben Sugerman, Goucher College

Co-Investigators:
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G. Bryan, Columbia University in the City of New York
M. Joung, Columbia University in the City of New York
S. Lawrence, Hofstra University
M. Mac Low, American Museum of Natural History
J. Ostriker, Columbia University in the City of New York
J. Peek, Space Telescope Science Institute

Science Category: evolved stars/pn/sne
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.4
Priority: 1

Abstract:
Light echoes are one of the most powerful and efficient probes of the structure and composition of dust in circumstellar and interstellar environments. Observations of light echoes provide exact three-dimensional (3-D) positions of dust while constraining its density, grain-size and chemical make-up. These can be used to study the evolutionary history of supernova (SN) progenitors, produce high-resolution maps of the structure and composition of interstellar media (ISM), and geometrically measure extragalactic distances. However, echoes pass through a given point only once, and only illuminate a thin slice of a complete structure at any given time, thus accomplishing meaningful science requires carefully-planned, repeated observations. The Type Ia SN 2014J in M82, and the core-collapse SN 2016adj in Cen A are both nearby (~3.5 Mpc), highly reddened (A_V=2-4 mags), and were reported within the last year to have produced resolved light echoes. With 12 orbits of HST and 2.4 hours of Spitzer follow-up observations proposed here, we will map out much more of the 3-D geometry and measure the dust properties of numerous independent structures within the ISM of the host galaxies, and map out or constrain the presence of circumstellar material around each SN. These results can be further used to investigate why the extinction toward SN 2014J (R_V=1.4) differs from Galactic values; measure the geometric distances to both host galaxies; constrain the progenitor properties; test competing models of Type Ib/IIb SNe; and benchmark whether echoes can help us understand galactic feedback, by comparing the actual structures they reveal to ISM simulations.

Spitzer Space Telescope - General Observer Proposal #60180

Deep IRAC Imaging of 24-micron Only Sources: Constraining the SEDs

Principal Investigator: Jason Surace
Institution: Spitzer Science Center

Technical Contact: Jason Surace, Spitzer Science Center

Co-Investigators:
David Shupe, Herschel Science Center
Mari Polletta, INAF-IASF
Jessica Krick, Spitzer Science Center

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 16.8

Abstract:
We request 17 hours for deep 3.6 micron IRAC observations of three extraordinary objects that are very bright at 24 microns, but are undetected at all other Spitzer, optical, or near-infrared wavelengths. Found in the widest of the extragalactic areal surveys (SWIRE; 45 square degrees) these are the only such objects found by Spitzer. Followup infrared spectroscopy centered on the 24-micron band indicates that at least two of the objects are extragalactic in nature and lie near a redshift of 2.5. However, the photometric non-detections are not compatible with the spectral energy distribution (SED) of any known class of objects. The new Spitzer data will lower the detection limits by an order of magnitude relative to the existing data, providing much stronger limits on the rest-frame near-IR luminosity.

Spitzer Space Telescope - General Observer Proposal #70039

Deep IRAC Imaging of 24-micron Only Sources: Constraining the SEDs and Testing Variability

Principal Investigator: Jason Surace
Institution: Spitzer Science Center

Technical Contact: Jason Surace, Spitzer Science Center

Co-Investigators:
David Shupe, Herschel Science Center
Mari Polletta, INAF-IASF
Jessica Krick, Spitzer Science Center

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 10.6

Abstract:
We request 10.6 hours to complete deep imaging at 3.6 and 4.5 microns with IRAC of a sample of fourteen extraordinary objects that are very bright at 24 microns, but were undetected at all other Spitzer, optical, or near-infrared survey wavelengths. Found in the widest of the extragalactic areal surveys (SWIRE; 45 square degrees) these are the only such objects found by Spitzer. Followup infrared spectroscopy centered on the 24-micron band indicates that at least two of the objects are extragalactic in nature and lie near a redshift of 2.5. However, the photometric non-detections are not compatible with the spectral energy distribution (SED) of any known class of objects. Ultradeep IRAC observations of a handful of these objects in the last Spitzer cycle provided the first detections at 3.6 microns; interestingly, some are significantly brighter than they were five years ago, suggesting a role for variability in these objects. Based on this pilot deep imaging, we believe all the objects will be detected in the imaging requested here, or will have detection limits more than a magnitude fainter than the current ones. The new photometric points will be crucial for constraining the spectral shapes, the rest-frame near-IR luminosity, and for determining the extent of variability in the sample.

Spitzer Space Telescope - General Observer Proposal #70100

The origin of variability in a hot-Jupiter

Principal Investigator: Mark Swain
Institution: JPL

Technical Contact: Mark Swain, JPL

Co-Investigators:
Jeroen Bouwman, Max Planck Institute for Astronomy, Heidelberg, Ge
Gautam Vasisht, Jet Propulsion Laboratory
Pieter Deroo, Jet Propulsion Laboratory
Giovanna Tinetti, University College London
Jean-Philippe Beaulieu, Institut d'astrophysique de Paris
Sean Carey, Spitzer Science Center
Adam Showman, Department of Planetary Sciences and Lunar and Pla
Jonathan Fortney, Department of Astronomy and Astrophysics, UCO/Lick
Caitlin Griffith, Department of Planetary Sciences and Lunar and Pla
Eric Agol, Department of Astronomy, University of Washington
Gregory Henry, Tennessee State University

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 49.4

Abstract:
We will determine (1) if the variability, detected by Spitzer/IRS in the dayside emission spectrum of the hot-Jupiter HD 189733b via the secondary eclipse method, is accompanied by correlated variability in the primary eclipse and (2) place further constraints on the global energy budget. The primary eclipse (a transmission measurement) primarily probes composition while the secondary eclipse (an emission measurement) probes a combination of composition and temperature. By testing for correlated variations in the primary and secondary eclipse depth, we will establish whether variability present in HD 189733b is primarily due to changes in temperature, changes in composition (such as inter-conversion of carbon monoxide into methane), or some combination of the two. We will compare our multi-epoch measurements of the primary/secondary eclipse depth ratio at 3.6 microns to the existing multi-epoch measurements of the primary/secondary eclipse depth ratio at 8 microns (Agol et al. 2010); our proposed measurements will place additional constraints on the global energy budget of the planet. We will also use ground-based 3.1-4.1 micron spectroscopy, of both the primary and secondary eclipse events, to provide additional modeling constraints for interpreting the IRAC 3.6 micron photometry measurements.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14322

A dust storm surrounding a white dwarf

Principal Investigator: Andrew Swan
Institution: UCL

Technical Contact: Jay Farihi, UCL

Co-Investigators:
Boris Gaensicke, University of Warwick

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 3.2
Priority: 1

Abstract:
On 2019 Oct 11, Wang et al. announced on the arXiv that a hitherto unremarkable white dwarf had brightened by 250% in the infrared. A day later, our colleague detected photospheric Ca in the star, corroborating that this event is related to the destruction of a planetesimal that is now accreting onto the white dwarf. No such event has ever been witnessed, and the one and only window of opportunity for Spitzer to observe it opens on 2019 Nov 18, hence this urgent DDT proposal.

Spitzer Space Telescope - General Observer Proposal #11115

An Absolute Calibration of Stellar Mass for IRAC 3.6 Micron Data

Principal Investigator: Robert Swaters
Institution: NOAO

Technical Contact: Robert Swaters, NOAO

Co-Investigators:
Matthew Bershady, University of Wisconsin
David Andersen, NRC Herzberg Programs in Astronomy and Astrophysic
Thomas Martinsson, Leiden Observatory
Marc Verheijen, Kapteyn Astronomical Institute
Kyle Westfall, Institute of Cosmology and Gravitation

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.7
Priority: 1

Abstract:
The 3.6 micron band of Spitzer is an ideal tracer of the stellar mass distribution because at this wavelength emission is dominated by stars and affected little by dust. In order to use IRAC images to estimate stellar mass the stellar mass-to-light ratio (M/L_3.6) is needed. Previous calibrations of M/L_3.6 rely on assumptions about the initial stellar mass function, as well as the star formation histories; with different assumptions, different values of M/L_3.6 are found. These calibrations therefore lack an absolute zeropoint. The goal of this proposal is to provide an independent, absolute calibration of M/L_3.6, using dynamically inferred masses from our DiskMass survey. We request 7 hours of observing time to obtain 3.6 micron data for all galaxies in our sample. We will combine these with our existing 4.5 micron data to correct the 3.6 micron data for nonstellar emission. The ratio of our existing dynamical mass measurements over the 3.6 micron stellar light will give an absolute calibration of M/L_3.6. With our calibration, IRAC 3.6 micron data can be used accurately to measure stellar mass in galaxies.

Spitzer Space Telescope - Directors Discretionary Time Proposal #70205

The mysterious cosmological transient GRB 110328A/J164449.3+573451

Principal Investigator: Nial Tanvir
Institution: University of Leicester

Technical Contact: Nial Tanvir, University of Leicester

Co-Investigators:
Andrew Levan, University of Warwick
Joshua Bloom, UC Berkeley
Daniel Perley, UC Berkeley
Andrew Fruchter, STScI
Brad Cenko, UC Berkeley
Nat Butler, UC Berkeley

Science Category: GRBs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.2

Abstract:
The behaviour of GRB 110328A is completely unlike any previously detected gamma-ray burst, showing a long series of X-ray flares lasting over several days (indeed it is ongoing at the time of writing). Given this it was first identified as a likely Galactic transient, despite its high Galactic latitude, and given the alternative designation J164449.3+573451. However, we have found that the only optical source in the Swift X-ray error circle is a galaxy at redshift z=0.35. Variability has now been detected at nIR and radio wavelengths but not in the optical, confirming its cosmological nature, and suggesting the transient is an intrinsically red or dust enshrouded source. We therefore propose Spitzer ToO observations of the field as part of a campaign to monitor its spectral energy distribution, which will provide a key constraint on models of this remarkable event.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13157

What is the host of FRB 121102?

Principal Investigator: Shriharsh Tendulkar
Institution: McGill University

Technical Contact: Shriharsh Tendulkar, McGill University

Co-Investigators:
Aard Keimpema, JIVE
Andrew Seymour, SOFIA-USRA
Benito Marcote, JIVE
Bryan Butler, Associated Universities
Casey Law, UC Berkeley
Cees Bassa, ASTRON
Geoffrey Bower, ASIAA
Huib Jan van Langevelde, JIVE
James Cordes, Cornell U.
Jason Hessels, ASTRON
Joseph Lazio, JPL
Laura Spitler, MPIfR
Matthew Abruzzo, Haverford College
Maura McLaughlin, WVU
Michael Rupen, Associated Universities
Paul Demorest, Associated Universities
Paul Scholz, DRAO
Robert Wharton, Cornell U.
Ryan Lynch, Associated Universities
Sarah Burke-Spolaor, Associated Universities
Scott Ransom, Associated Universities
Shami Chatterjee, Cornell U.
Slavko Bogdanov, Columbia U
Victoria Kaspi, McGill U.
Zsolt Paragi, JIVE

Science Category: AGN/QSO/RG
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.3

Abstract:
FRB 121102 is the only known repeating source in the class of mysterious phenomena known as Fast Radio Bursts (FRBs). Through our very recent VLA campaign, we have a direct sub-arcsecond localization of FRB 121102, the first for any FRB. At the location of the burst, VLA and EVN observations show a potentially variable radio point source and archival Keck imaging shows a faint (R = 24.5 mag), possibly extended object. This is an unprecedented opportunity to learn about the yet unknown origins of FRBs, their distance scales, and host properties. The known characteristics of the source point to it being a low-luminosity AGN, possibly obscured by dust. We are requesting a 23-ks Spitzer/IRAC observation to characterize the emission properties in 3.6 um and 4.5 um bands. This observation, feasible only with Spitzer, will fill a crucial gap between our radio (VLA, VLBA, EVN, ALMA) to X-ray (Chandra, XMM-Newton) campaign to characterize this source.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14276

The First Young Warm Jupiter Transit with Spitzer

Principal Investigator: Kamen Todorov
Institution: University of Amsterdam

Technical Contact: Kamen Todorov, University of Amsterdam

Co-Investigators:
Jean-Michel Desert, University of Amsterdam
Lorenzo Pino, University of Amsterdam
Claire Baxter, University of Amsterdam

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 13.5
Priority: 1

Abstract:
We propose to observe a transit of recently discovered young warm Jupiter V 1298 Tau b using the Spitzer/IRAC 3.6 microns channel. This is an opportunity for Spitzer to begin the characterization of transiting young warm gas giant planets. We will also be able to place constraints on the atmospheric properties of this likely inflated gas giant (its age is ~23Myr, radius of 0.9 Jupiter radii). This observation represents an opportunity for Spitzer, in its final weeks of operation, to open a new chapter of exoplanet characterization of a completely unexplored class of planets. It is critical to observe this object with Spitzer in the mid-infrared in order to enable further spectroscopic transit and eclipse studies with HST, JWST, and even ARIEL.

Spitzer Space Telescope - General Observer Proposal #90186

WASP-12b and HD 209458b: An Enigma and an Archetype

Principal Investigator: Kamen Todorov
Institution: Pennsylvania State University

Technical Contact: Kamen Todorov, Pennsylvania State University

Co-Investigators:
Drake Deming, University of Maryland, College Park
Heather Knutson, Caltech
Jonathan Fortney, UC Santa Cruz

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 84.9

Abstract:
Spitzer observations have revealed several important results on transiting hot Jupiters based on secondary eclipse time-series photometry. These results include the day-night contrast, atmospheric temperature inversion, and proposed unusual compositions. However, they may be less robust than we think. The determinations of energy redistribution efficiency from day side to night side and temperature inversion may be subject to uncertainty due to variable planetary flux. Planetary variability for planets with inverted atmospheres has never been tested observationally. In some cases, planets have been claimed to have unusually high C/O ratio in their atmospheres, and this has caused controversy. Therefore, we choose to focus on two transiting hot Jupiters: HD 209458b and WASP-12b. The former is the archetypal planet with an inverted atmosphere, while the latter was the first planet reported to have a C/O ratio larger than 1. We will follow up on previous observations of its secondary eclipses and will test its variability and re-examine the conclusion that it has a temperature inversion. Most of the time we request is dedicated to follow-up phase curve observations of WASP-12b. Previous secondary eclipse depth and phase curve studies of this planet have reached contradictory conclusions about the planet's shape, and the temperature-pressure profile and composition of its atmosphere. Follow-up measurements benefiting from the PCRS Peak-Up and improved photometry and data analysis techniques should help resolve many of these questions.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14243

Precision Measurements of Stellar Radii in Young, Low-Mass Eclipsing Binaries

Principal Investigator: Benjamin Tofflemire
Institution: UT-Austin

Technical Contact: Benjamin Tofflemire, UT-Austin

Co-Investigators:
Andrew Mann, UNC Chapel Hill
Elisabeth Newton, Dartmouth College
Aaron Rizzuto, UT-Austin
Andrew Vandenburg, UT-Austin
Adam Kraus, UT-Austin

Science Category: YSOs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 93.4
Priority: 1

Abstract:
Eclipsing binaries provide benchmark measurements of stellar masses and radii that are the foundation of theoretical stellar astrophysics. Large areas of parameter space remain poorly constrained by data, however, particularly at low masses and young ages. The few sources that have been studied in this regime reveal substantial deviations from existing stellar models. Numerous young eclipsing binaries were recently discovered by K2 in the Upper Sco star-forming region (~10 Myr), offering an exciting opportunity to explore physical processes that are unique to young low-mass stars (e.g. magnetic fields and star spots). However, radius measurements for young eclipsing binaries are impacted by large amplitude and complex variability that star-spots induce on light curves, inhibiting robust radius measurements. The effects of stellar variability are much less extreme in the infrared wavelengths where Spitzer observes. We therefore propose to monitor the primary and secondary eclipses of 4 young eclipsing binaries with Spitzer/IRAC at 3.6 micron. With a range in stellar mass spanning nearly two orders of magnitude (1.4-0.02 Solar Masses), these data will allow for a detailed test of pre-main sequence stellar evolution models across the stellar-substellar boundary.

Spitzer Space Telescope - General Observer Proposal #80104

A Tidal Tale: The Origin of Intra-Cluster Light in an Assembling Galaxy Cluster at z=0.37

Principal Investigator: Kim-Vy Tran
Institution: Texas A&M

Technical Contact: Kim-Vy Tran, Texas A&M

Co-Investigators:
Emily Freeland, Texas A&M
Anthony Gonzalez, University of Florida
Amelie Saintonge, Max Planck Institute for Extraterrestrial Physics

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.8

Abstract:
We propose to obtain IRAC mosaics at 3.6 and 4.5 microns of a super galaxy group at z=0.37 to trace the origins of Intra-Cluster Light (ICL) and quantify the ICL's role as a stellar reservoir. Our target SG1120 is composed of four X-ray luminous galaxy groups at z=0.37 that are gravitationally bound to each other and will merge to form a cluster comparable in mass to Coma. SG1120 is an optimal system for studying how the ICL forms because the ICL dominates the total stellar budget on group scales and SG1120 contains multiple (massive) merging members. Three of the four Brightest Group Galaxies are growing via major merging, and the BGGs have asymmetric stellar plumes visible in our r' imaging. At least 5 additional SG1120 members have extended tidal features. Only by combining IRAC imaging with our multi-wavelength dataset (optical/X-ray/radio imaging, 174 spectroscopically confirmed SG1120 members) can we trace the physical extent of these diffuse stellar structures and measure their total flux (mass) and colors (ages, metallicities). We can then trace how the ICL forms, e.g. by tidally stripped stars from L* galaxies or disrupted dwarfs, and thus better understand how the total baryon distribution (galaxies, ICL, X-ray gas) evolves in these massive halos.

Spitzer Space Telescope - General Observer Proposal #60145

Massive Galaxy Formation: Testing the AGN Feedback Hypothesis

Principal Investigator: Christy Tremonti
Institution: University of Wisconsin, Madison

Technical Contact: Christy Tremonti, University of Wisconsin, Madison

Co-Investigators:
John Moustakas, New York University
Aleks Diamond-Stanic, University of Arizona
Gregory Rudnick, University of Kansas

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 18.4

Abstract:
Ad hoc prescriptions of feedback from an active galactic nucleus (AGN) are widely adopted in theoretical models of massive galaxy formation in order to efficiently quench the merger-induced starburst and growth of the supermassive black hole. Remarkably, however, observational evidence that AGN feedback is necessary for quenching star formation is conspicuously lacking. To address this fundamental problem, we propose to measure the stellar masses and burst mass fractions of an extraordinary sample of massive galaxies at z=0.4-0.8 that show evidence for large-scale outflows of cold gas, and whose last recent star formation episode was abruptly truncated. These measurements will establish whether the mechanical energy provided by supernovae and young stars in the last starburst is sufficient for driving the supergalactic wind, and therefore whether AGN feedback played an energetically important role for the formation of massive galaxies at intermediate redshift.

Spitzer Space Telescope - General Observer Proposal #90159

Full-orbit atmospheric characterisation of a gas giant transiting an M dwarf

Principal Investigator: Amaury Triaud
Institution: Universite de Geneve

Technical Contact: Amaury Triaud, Universite de Geneve

Co-Investigators:
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Didier Queloz, Departement d'Astronomie, Universite de Geneve
Andrew Collier Cameron, University of St Andrews
Coel Hellier, University of Keele
Don Pollacco, University of Warwick

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30

Abstract:
The WASP (Wide Angle Search for Planets) consortium has identified a rare gas giant transiting a red dwarf. The combination of the size ratio and brightness contrast, along with the luminosity of the host star means that WASP-80b is one of the most practical target on which we can carry out an atmospheric characterisation. In addition, it gives us an opportunity to study a Jovian planet whose atmosphere is much less irradiated than the usual hot Jupiters. In order to confront theoretical predictions that have been made about heat redistribution and flux penetration in a temperature regime where they have not been tested yet, we aim to use the Spitzer Space telescope to observe and detect a full orbital phase curve. While its very deep transit is favourable to carry out transmission spectroscopy, the contrast between the planet and the star means we will have no issue detecting its emission spectrum. Our Spitzer observations mark the starting point of our campaign to characterise the atmosphere of a warm Jupiter which will lead to the construction of a full spectrum and a measure of its chemical abundances. This data will also be used to seek an additional transiting companion down to an inner Mars-sized planet.

Spitzer Space Telescope - General Observer Proposal #10132

Constraining the size, density, and mass of ARRM mission target 2011 MD

Principal Investigator: David Trilling
Institution: Northern Arizona University

Technical Contact: David Trilling, Northern Arizona University

Co-Investigators:
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Giovanni Fazio, SAO
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Michael Mueller, SRON (NL)
Joseph Hora, SAO
Howard Smith, SAO

Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 19.9
Priority: 1

Abstract:
NASA is actively working to develop the Asteroid Robotic Retrieval Mission (ARRM) concept. This is a high profile mission concept that is receiving considerable attention at the highest levels. The project involves the capture of an asteroid about 7-10 meters in size that will be diverted onto a new trajectory in which it will be captured in the Earth-Moon system. The current baseline candidate body for this mission is the near-Earth asteroid 2009 BD; the current backup candidate is the NEA 2011 MD. We have an approved Cycle 9 DDT proposal to observe 2009 BD; observations will take place in October, 2013, the last opportunity for Spitzer to observe that target for nearly a decade. However, 2011 MD is no less important a candidate than 2009 BD, as a mission to 2011 MD has a slightly later (and therefore more likely) launch schedule, and provides a somewhat larger margin on the amount of mass that can be retrieved. We propose here to observe the primary ARRM backup target 2011 MD to determine its diameter, which is the primary unknown for mission planning. We will also determine its mass and its density, which will be an interesting scientific result. A non-detection will yield a significant result that will also be useful for mission planning. The physical properties that we will derive are essential to optimal planning for and execution of a NASA mission to that asteroid.

Spitzer Space Telescope - General Observer Proposal #11002

An Exploration Science Survey of Near Earth Object Properties

Principal Investigator: David Trilling
Institution: Northern Arizona University

Technical Contact: David Trilling, Northern Arizona University

Co-Investigators:
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Joseph Hora, Smithsonian Astrophysical Observatory
Steve Chesley, NASA/JPL
Joshua Emery, University of Tennessee, Knoxville
Giovanni Fazio, Smithsonian Astrophysical Observatory
Alan Harris, German Aerospace Center
Migo Mueller, Netherlands Institute for Space Research
Howard Smith, Smithsonian Astrophysical Observatory

Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 710.1
Priority: 1

Abstract:
Near Earth Objects (NEOs) are small Solar System bodies whose orbits bring them close to the Earth's orbit. NEOs lie at the intersection of science, space exploration, and civil defense. We propose here a fast and efficient flux-limited survey of 597 known NEOs to derive their diameters and albedos. We include only targets that are too faint to be detected by NEOWISE. This catalog is therefore highly complementary to existing and forthcoming samples, and will complete a database of diameters and albedos for nearly 2000 NEOs. Our primary goal, in line with the planetary science priorities for Spitzer Cycle 11, is to create a large and uniform catalog of NEO properties. From this catalog we will derive the size distribution of NEOs down to 100 meters to unprecedented accuracy, resolving a current controversy. We will also derive, through our albedo measurements, the compositional distribution of NEOs as a function of size. This catalog will enable many other science investigations to be pursued by us and other researchers. Our team has unmatched experience observing NEOs with Spitzer.

Spitzer Space Telescope - Frontier Legacy Proposal #13006

NEOLegacy: The ultimate Spitzer survey of Near Earth Objects

Principal Investigator: David Trilling
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Steve Chesley, Jet Propulsion Laboratory
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Giovanni Fazio, Smithsonian Astrophysical Observatory
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Michael Mueller, SRON (NL)
Howard Smith, Smithsonian Astrophysical Observatory

Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1750.0
Priority: 1

Abstract:
Near Earth Objects (NEOs) are bodies whose orbits bring them close to the Earth's orbit. NEOs are valuable tracers of the evolution of our Solar System, and are also key components of current and future space exploration. Finally, the study of NEOs is relevant for civil defense through understanding the impact threat. We propose here an efficient and comprehensive survey to measure the diameters, albedos, and lightcurves of 1154 NEOs. We include only targets that are too faint to be detected by NEOWISE. This catalog will complete a database of diameters and albedos for nearly 3000 NEOs -- more than 20% of all known objects. Our primary goal, in line with the planetary science priorities for Spitzer Cycle 13, is to create a large and uniform catalog of NEO properties. From this catalog we will calculate an independent estimate of the NEO size distribution, addressing a current controversy, and measure the compositional distribution of NEOs as a function of size. We will increase by up to a factor of five the number of NEO lightcurves with relatively well known periods and amplitudes. The legacy value of this project is most evident in the fact that there will not ever in the foreseeable future be another opportunity to measure thousands of NEO diameters and carry out the type of science described above. Our online database will be the single most valuable resource of NEO diameters and albedos for years to come. Only Spitzer is sensitive and efficient enough to create such an important catalog of this scale. Our team has unmatched experience observing NEOs with Spitzer.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13249

Spitzer DDT observations of the interstellar comet A/2017 U1

Principal Investigator: David Trilling
Institution: Northern Arizona University

Technical Contact: David Trilling, Northern Arizona University

Co-Investigators:
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Carey Lisse, APL/JHU
Mike Werner, JPL
Steve Chesley, JPL
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Massimo Marengo, Iowa State
Migo Mueller, SRON/NL
Alissa Roegge, NAU
Howard Smith, SAO
Nathan Smith, NAU
Hal Weaver, APL/JHU

Science Category: comets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 32.6

Abstract:
We propose to observe the newly discovered interstellar comet A/2017 U1 to measure its diameter and albedo. Little is known about this object, which presumably formed in another planetary system. This is the only opportunity *ever* to determine the albedo of this object, which will help us understand how planetary system formation in other systems compares to what occurred in our Solar System. The proposed observations - requiring 32.6 hours in late November - are the last telescopic observations that will ever be made of this object. The return from these proposed observations would be tremendous - characterizing the first ever known object from beyond our Solar System. Because the object is faint and fading, these observations must be made as soon as possible.

Spitzer Space Telescope - General Observer Proposal #14003

ToO observations of a newly discovered interstellar ('Oumuamua-like) object

Principal Investigator: David Trilling
Institution: Northern Arizona University

Technical Contact: David Trilling, Northern Arizona University

Co-Investigators:
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Michael Mommert, Lowell Observatory
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Joshua Emery, U. Tennessee, Knoxville
Giovanni Fazio, Harvard-Smithsonian CfA
Alan Harris, DLR (Germany)
Migo Mueller, SRON (NL)
Howard Smith, Harvard-Smithsonian CfA

Science Category: asteroids
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 32.6
Priority: 1

Abstract:
We propose a Target of Opportunity (ToO) program to observe a newly discovered interstellar asteroid. This program is modeled on our DDT observations of 'Oumuamua. We will only trigger this ToO observation if an object is discovered with sufficient lead time to be scheduled for Spitzer observations; if the object will be within the Spitzer observability cone; and if the object is likely to be bright enough to be detected. From the proposed observations we will measure the diameter and albedo of the object -- likely the only way that either of those properties will be determined. The result will provide a critical second data point for studies of planetary system formation as traced by these interstellar interlopers.

Spitzer Space Telescope - General Observer Proposal #14004

Physical characterization of Near Earth Objects with Spitzer

Principal Investigator: David Trilling
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Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 82.8
Priority: 1

Abstract:
We propose here an efficient, flux-limited survey of 426 optically discovered NEOs in order to measure their diameters and albedos. We include only targets not previously detected by Spitzer or NEOWISE and includes all NEOs available to Spitzer in Cycle 14. This program will maintain the fraction of all known NEOs with measured diameters and albedos at around 20% even in the face of increasingly successful NEO discovery surveys. By the conclusion of this program nearly 3500 NEOs will have measured diameters and albedos, with nearly 3000 of those observations being made by Spitzer and our team. We will determine an independent size distribution of NEOs at 100 meters that is free from albedo assumptions, addressing a current controversy. We will also derive, through our albedo measurements, the compositional distribution of NEOs as a function of size. We will measure or constrain lightcurves for more than 400 NEOs, thus constraining their shapes in addition to sizes and compositions. This catalog will enable a number of other science cases to be pursued by us and other researchers. Our team has unmatched experience observing NEOs with Spitzer.

Spitzer Space Telescope - General Observer Proposal #60012

The Warm Spitzer NEO Survey: Exploring the history of the inner Solar System and near Earth space

Principal Investigator: David E. Trilling
Institution: Northern Arizona University

Technical Contact: David E. Trilling, Northern Arizona University

Co-Investigators:
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William Bottke, SWRI
Steve Chesley, JPL
Marco Delbo, Observatoire de la Cote d'Azur
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Giovanni Fazio, Harvard-Smithsonian
Alan Harris, DLR, Germany
Joseph Hora, Harvard-Smithsonian
Amy Mainzer, JPL
Michael Mueller, University of Arizona
Bryan Penprase, Pomona College
Howard Smith, Harvard-Smithsonian
Timothy Spahr, Harvard-Smithsonian
John Stansberry, University of Arizona

Science Category: near-Earth objects
Observing Modes: IracPostCryoMap
Hours Approved: 500.0

Abstract:
The majority of Near Earth Objects (NEOs) originated in collisions between bodies in the main asteroid belt and have found their way into near-Earth space via complex and little understood dynamical interactions. This transport of material from the main belt into the inner Solar System has shaped the histories of the terrestrial planets. However, despite their scientific importance, key characteristics of the NEO population --- such as the size distribution, mix of albedos and mineralogies, and contributions from so-called dead or dormant comets --- remain largely unexplored; some 99% of all presently known NEOs are essentially uncharacterized. Recent evidence suggests that the size distribution of NEOs may undergo a transition at 1 km, and that the smaller bodies may record fundamental physical processes that are presently occurring in the Solar System but not understood. We propose to use the unique capability of Warm Spitzer to observe 750 NEOs. We will measure the size distribution of this population to understand fundamental physical processes that occur among the small bodies of our Solar System. We will measure the fraction of NEOs likely to be dead comets, with implications for the flux of organic material onto the Earth. We will measure the albedo distribution of NEOs, which indicates the compositional diversity among these small bodies. We will study properties of individual NEOs, including their surface properties and potentially their densities, and detailed properties of a subset of well-characterized objects. Our expert team and our previous experience in this field allow us to complete a comprehensive study of the origin and evolution of the NEO population. Our work is nothing less than an exploration of the history of near-Earth space.

Data from this program was split into multiple PIDs.
You can find the data in program IDs 60012, 61010, 61012, 61011, 61013

Spitzer Space Telescope - General Observer Proposal #90147

The Pilot Warm Spitzer Near Earth Object Survey: Probing the size distribution of the most abundant Near Earth Objects

Principal Investigator: David Trilling
Institution: Northern Arizona University

Technical Contact: David Trilling, Northern Arizona University

Co-Investigators:
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Joshua Emery, University of Tennessee
Giovanni Fazio, SAO
Cesar Fuentes, Northern Arizona University
Alan Harris, DLR (Germany)
Joseph Hora, SAO
Michael Mommert, DLR (Germany)
Michael Mueller, SRON (NL)
Howard Smith, SAO

Science Category: near-Earth objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 83.2

Abstract:
We propose a Warm Spitzer search for Near Earth Objects (NEOs), bodies whose orbits bring them close to the Earth's orbit. Previous work has measured the properties of larger NEOs, but the physical properties of the smallest and most numerous NEOs are poorly constrained. We will capitalize on Spitzer's unparalleled sensitivity and unique geometry to measure the size distribution of NEOs down to 100 meters, where completeness from previous surveys is poor. This allows us to probe the dynamical history of near-Earth space and meet the Congressional mandate to determine the impact threat from objects >140 m. This project will also serve as a scientific and technical pathfinder for a future large Spitzer proposal that will increase our knowledge of the small NEO size distribution by another order of magnitude. Both projects will also be sensitive to previously unseen NEO populations. This proposed work significantly surpasses recent results from both our ExploreNEOS program and NEOWISE. Future ground- and space-based missions have been proposed to carry out similar work at costs of $500M or more, but this fundamental work can be done now, with Spitzer, for far less money. Our team has unmatched scientific and technical expertise in observations and modeling of Spitzer-observed NEOs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #90256

DDT observations of 2009 BD, the primary target of the Asteroid Retrieval Mission

Principal Investigator: David Trilling
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Science Category: NEOs
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 30.0

Abstract:
JPL and NASA are actively working to develop the Asteroid Retrieval Mission concept. This is a high profile mission concept that is receiving considerable attention at the highest levels. The project involves the capture of an asteroid about 7 meters in size that will be diverted onto a new trajectory in which it will be captured in the Earth-Moon system. The prime target body for this mission is the near-Earth asteroid 2009 BD. We request Director's Discretionary time to measure the diameter and albedo of this very faint mission target. We will determine the asteroid's diameter, yielding its mass and density. The physical properties that we will derive are essential to optimal planning for and execution of this mission to that asteroid. The physical properties of this body can only be measured by Spitzer, and only with Director's Discretionary time in 2013, before the start of Cycle 10.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80235

Absolute Measurement of the Cosmic Infrared Background Using Ganymede as an Occulter

Principal Investigator: Kohji Tsumura
Institution: Japan Aerospace Exploration Agency

Technical Contact: Jason Surace, SSC

Co-Investigators:
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Fumihiko Usui, ISAS/JAXA
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Science Category: CIB
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.5

Abstract:
The Cosmic Infrared Background (CIB) as an integrated history of the early universe is important for the study of the Dark Ages, and it may include the light from the first stars at z~10. However, previous CIB measurements suffer from residual contamination from the strong foreground emission (e.g. the zodiacal light). We propose to observe Ganymede eclipsed in the shadow of Jupiter at 3.6 microns to detect the absolute CIB intensity without any zodiacal light subtraction error. The zodiacal light originates inside the orbit of Jupiter; since Ganymede in eclipse shields all light beyond the Jovian orbit, it should be detected as a "dark spot" if the strong CIB implied by previous observations exists. The intensity deficit of this dark spot relative to the surrounding sky directly measures the strength of the CIB, free from any assumptions about the zodiacal light. We have carefully considered the intensity of Jupiter and the issue of scattered light. The estimated point source "negative flux" is 0.67uJy at 3.6um, which can be detected with IRAC in two hours at 5-sigma with the estimated background.

Spitzer Space Telescope - General Observer Proposal #90143

Absolute Measurement of the Cosmic Infrared Background Using Ganymede as an Occulter

Principal Investigator: Kohji Tsumura
Institution: Japan Aerospace Exploration Agency(JAXA)

Technical Contact: Jason Surace, Spitzer Science Center

Co-Investigators:
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Shuji Matsuura, ISAS, Japan
Mai Shirahata, ISAS, Japan
Fumihiko Usui, ISAS, Japan
Takehiko Wada, ISAS, Japan

Science Category: cosmic infrared background
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 23.0

Abstract:
The Cosmic Infrared Background (CIB) as an integrated history of the early universe is important for the study of the Dark Ages, and it may include the light from the first stars at z~10. However, previous CIB measurements suffer from residual contamination from the strong foreground emission (e.g. the zodiacal light). We propose to observe Ganymede eclipsed in the shadow of Jupiter at 3.6 microns to detect the absolute CIB intensity without any zodiacal light subtraction error. The zodiacal light originates inside the orbit of Jupiter; since Ganymede in eclipse shields all light beyond the Jovian orbit, it should be detected as a "dark spot" if the strong CIB implied by previous observations exists. The intensity deficit of this dark spot relative to the surrounding sky directly measures the strength of the CIB, free from any assumptions about the zodiacal light. A previous DDT program demonstrated the efficacy of the major observational components of this program, including the severity of the Jovian straylight. The new observations are required to further refine the measurements to reach the required S/N.

Spitzer Space Telescope - General Observer Proposal #80072

Cosmic Flows

Principal Investigator: Brent Tully
Institution: Institute for Astronomy, University of Hawaii

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Co-Investigators:
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Tom Jarrett, IPAC, California Institute of Technology
Barry Madore, Carnegie Institute of Washington
Eric Persson, Carnegie Institute of Washington
Mark Seibert, Carnegie Institute of Washington
Ed Shaya, University of Maryland

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 200.0

Abstract:
It is astonishing that only 30% of the motion of our Galaxy is understood, a fact that highlights a fundamental deficiency in our understanding of the composition of the Universe. Spitzer Cosmic Flows is the photometric component of a program to map the peculiar motions and large-scale flows of galaxies out to 200 Mpc in order to constrain the distribution of mass. This task requires measuring the peculiar velocity of galaxies, a response to the distribution of both baryonic and dark matter, densely sampled over the full sky. With an independent distance measurement, an observed galaxy redshift can be separated into cosmic expansion and peculiar velocity components. Spitzer Cosmic Flows will use IRAC 3.6 micron imaging to obtain independent distances using the correlation between galaxy luminosity and rotation rate (the mid-IR Tully-Fisher relation). The rotational velocity data is being acquired through the Cosmic Flows Large Program on the NRAO Green Bank Telescope and a complementary program of southern targets with the Parkes Telescope. Spitzer Cosmic Flows consists of five distinct samples totaling 4642 galaxies. New observations are required for 3531 galaxies and archival data exists for 1111 galaxies. Each of the samples serves a distinct purpose and/or domain while overlapping to assure a connectivity over a wide range of distances. The photometry of galaxies directly drives the peculiar velocity accuracy of this program. Spitzer IRAC 3.6 micron imaging provides the ability of a single instrument to perform the required imaging over the full sky with exquisite quality. The mid-IR traces the dominant stellar population with negligible extinction. Most importantly, the backgrounds are low from space enabling surface photometry to be extended to many exponential scale-lengths, capturing essentially all the light from the target.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14314

Confirming TESS's first Habitable-Zone Earth

Principal Investigator: Andrew Vanderburg
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Chelsea Huang, MIT
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Elisabeth Newton, Dartmouth
Andrew Mann, University of North Carolina, Chapel Hill
Maximilian Guenther, MIT
Alton Spencer, Danbury High School

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 20.0
Priority: 1

Abstract:
We propose observations of the first small habitable-zone transiting planet candidate from the TESS mission. The newly-discovered planet candidate, TOI 700.02, is only 25% larger than Earth, small enough that its composition is likely rocky. TOI 700.02 is located just 31 parsecs from Earth. The M-dwarf host star, TOI 700, hosts two other transiting planet candidates, and is the brightest star (in V-band) to host a small transiting habitable-zone planet known today. The bright host star will enable follow-up studies to measure the planet's mass. We request Spitzer observations to confirm the transit signal detected (with fairly low signal-to-noise) by TESS and improve the transit parameters/ephemeris. When confirmed by Spitzer, TOI 700.02 will be the third-closest potentially terrestrial, habitable-zone planet known, and will cement Spitzer's legacy pioneering the study of habitable worlds.

Spitzer Space Telescope - General Observer Proposal #80136

The stellar mass and galaxy population in distant, massive, X-ray selected clusters of galaxies

Principal Investigator: Miguel Verdugo
Institution: Max-Planck-Institut fuer extraterrestrische Physik

Technical Contact: Miguel Verdugo, Max-Planck-Institut fuer extraterrestrische Physik

Co-Investigators:
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Hernan Quintana, P. Universidad Catolica de Chile
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Alessandro Nastasi, MPE
Michael Lerchster, MPE
Gabriel Pratt, CEA/Saclay

Science Category: galaxy clusters and groups(high-z)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.3

Abstract:
We propose warm Spitzer IRAC photometry (channels 1 and 2) on a sample of 24 distant ($0.8<z<1.6$), massive, X-ray selected clusters. We want to 1) Determine cluster memberships based on precise photometric redshifts for galaxies fainter than our s pectroscopic limit. 2) Study the rest frame NIR luminosity function at least down to Lstar+2, which will allow to derive more accurately the total stellar mass of those systems and compare it with the total mass derived from X-ray analysis. 3) Investigate the galaxy populations in a representative sample of distant clusters. This study on this unique sample of clusters will allow to produce meaningful comparisons with studies at lower redshifts.

Spitzer Space Telescope - General Observer Proposal #10094

High-Redshift Starburst Galaxies Under the Cosmic Microscope: Unveiling the stellar histories of strongly lensed starburst galaxies with ALMA and Spitzer

Principal Investigator: Joaquin Vieira
Institution: Caltech

Technical Contact: Joaquin Vieira, Caltech

Co-Investigators:
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Manuel Aravena, ESO
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Matthew Bothwell, Cambridge
Mark Brodwin, UMKC
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Maria Strandet, MPIfR
Axel Weiss, MPIfR
Niraj Welikala, APC

Science Category: starburst galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 37.0
Priority: 1

Abstract:
We propose to study the stellar populations in a sample of strong gravitationally lensed starburst galaxies discovered by the South Pole Telescope (SPT) in a 2500 square degree survey of the southern sky. In the first extragalactic spectroscopic redshift survey with ALMA, we have obtained robust and unambiguous redshifts for these sources directly from their star forming gas, as traced by carbon monoxide. High-resolution ALMA imaging conclusively demonstrates that these sources are strong gravitationally lensed by foreground galaxies and allows us to make state-of-the-art lens models with a custom pipeline. The central aim of this proposal is to use Spitzer/IRAC to determine stellar masses for 14 of these sources to connect the rapid star formation observed with ALMA to the generations of stars that came before them. The combination of our unique ALMA dataset with the proposed Spitzer observations will allow a full characterization of the stars, gas, and dust in this cosmologically important class of primordial starburst galaxies which mark the epoch of stellar mass assembly in the Universe. We ask for 37 hours of Spitzer/IRAC and 6 orbits of HST/ACS+WFC3 to observe 14 high redshift starburst galaxies spanning $2.5<z<5.7$.

Spitzer Space Telescope - General Observer Proposal #14061

The SPT+Herschel+ALMA+Spitzer Legacy Survey: The stellar content of high redshift strongly lensed systems

Principal Investigator: Joaquin Vieira
Institution: University of Illinois, Urbana-Champaign

Technical Contact: Joaquin Vieira, University of Illinois, Urbana-Champaign

Co-Investigators:
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Dan Marrone, U. Arizona
Matt Malkan, UCLA
Cassie Reuter, U. Illinois
Kaja Rotermund, Dalhousie University
Justin Spilker, U. Texas, Austin
Axel Weiss, MPIfR

Science Category: starburst galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 115.4
Priority: 1

Abstract:
The South Pole Telescope (SPT) has systematically identified 90 high-redshift strongly gravitationally lensed submillimeter galaxies (SMGs) in a 2500 square-degree cosmological survey of the millimeter (mm) sky. These sources are selected by their extreme mm flux, which is largely independent of redshift and lensing configuration. We are undertaking a comprehensive and systematic followup campaign to use these ‘‘cosmic magnifying glasses’’ to study the infrared background in unprecedented detail, inform the condition of the interstellar medium in starburst galaxies at high redshift, and place limits on dark matter substructure. Here we ask for 115.4 hours of deep Spitzer/IRAC imaging to complete our survey of 90 systems to a uniform depth of 30min integrations at 3.6um and 60min at 4.5um. In our sample of 90 systems, 16 have already been fully observed, 30 have been partially observed, and 44 have not been observed at all. Our immediate goals are to: 1) constrain the specific star formation rates of the background high-redshift submillimeter galaxies by combining these Spitzer observations with our APEX, Herschel, and ALMA data, 2) robustly determine the stellar masses and mass-to-light ratios of all the foreground lensing galaxies in the sample by combining these observations with our VLT and Gemini data, the Dark Energy Survey, and ALMA; and 3) provide complete, deep, and uniform NIR coverage of our entire sample of lensed systems to characterize the environments of high redshift SMGs, maximize the discovery potential for additional spectacular and rare sources, and prepare for JWST. This program will provide the cornerstone data set for two PhD theses: Kedar Phadke at Illinois will lead the analysis of stellar masses for the background SMGs, and Kaja Rotermund at Dalhousie will lead the analysis of stellar masses for the foreground lenses.

Spitzer Space Telescope - General Observer Proposal #60194

High-Redshift Sub-Millimeter Galaxies

Principal Investigator: Joaquin Vieira
Institution: University of Chicago

Technical Contact: Joaquin Vieira, University of Chicago

Co-Investigators:
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Anthony Gonzalez, University of Florida
Adam Stanford, UC Davis
Thomas Crawford, University of Chicago
Joe Mohr, University of Illinois at Urbana-Champaign
William Holzapfel, UC Berkeley
Adrian Lee, UC Berkeley

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 55.4

Abstract:
We propose to obtain IRAC imaging of 40 rare millimeter sources discovered by the South Pole Telescope (SPT). These sources are the observably brightest, rarest members of the population commonly referred to as sub-millimeter galaxies (SMGs) and will provide a new window on galaxy formation in the early universe. Because our targets are selected at longer wavelengths than typical SMG surveys, and are an order of magnitude brighter than the typical SMGs, they are expected to have a higher median redshift than objects currently in the literature. Simulations suggest that we are detecting a significant number of lensed sources, some of which should lie at z>6. The proposed observations, when combined with precise positions from ATCA 3 mm interferometric images, will enable photometric redshifts and measurements of total luminosity, star formation rates, and stellar masses for this unique sample of galaxies.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80240

Measuring the stellar mass of a z=6.3 submillimeter galaxy

Principal Investigator: Joaquin Vieira
Institution: Caltech

Technical Contact: Joaquin Vieira, Caltech

Co-Investigators:
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Carrie Bridge, Caltech
Alex Conley, U. Colorado
Asantha Cooray, UC Irvine
Dave Clements, Imperial
Darren Dowell, JPL
Julie Wardlow, UC Irvine
Ismael Perez-Fournon
Seb Oliver, Sussex
Dominik Riechers, Caltech
Marco Viero, Caltech

Science Category: cosmology
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.4

Abstract:
HerMES, the Herschel/SPIRE extragalactic GTO program, is detecting high redshift sources which were once the domain of high redshift QSOs. Our most spectacular object discovered to date, from over 50 square degrees of survey area with rich ancillary data, is an extraordinarily bright submillimeter galaxy with a confirmed redshift of z=6.337, which we call First Look Survey #3 (FLS3). This source is at a redshift close to the epoch of reionization, and it is most likely a signpost of the extreme evolution which fueled the transition from a neutral universe (the dark ages) to a completely ionized universe which we live in today. The epoch of reionization is the new frontier in structure formation, and the ability to select massive star formation-dominated galaxies in this era will lead to great advances in our understanding of the end of the dark ages. We have already measured the FIR luminosity, dust mass, dust temperature, rest-frame UV continuum, CO, H2O, and C+ line luminosities for FLS3. The last remaining physical characteristic to measure in order to understand the source is its stellar mass. Here we propose for two hour-long integrations of this source with IRAC CH1 and CH2 to robustly detect the source, measure its stellar mass, and constrain the UV extinction. These observations will enable us to determine stellar, dust, and gas mass ratios, and specific star formation rate. This single source will have major implications for our understanding of galaxy formation, the epoch of reionization, and the cosmic infrared background. These near infrared observations cannot be made with any other instrument. The high redshift value for this source was confirmed only after the last Spitzer call for proposals, and due to the overall uncertainty in the future Spitzer cycles and the paper reporting the discovery of this source now under preparation for publication in a high-profile journal, we request a rapid DDT observation.

Spitzer Space Telescope - General Observer Proposal #70088

Variable Massive YSOs in the Magellanic Clouds

Principal Investigator: Uma Vijh
Institution: University of Toledo

Technical Contact: Uma Vijh, University of Toledo

Co-Investigators:
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Rosie Chen, University of Virginia
Joseph Hora, Havard/CfA
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Tom Megeath, University of Toledo
Margaret Meixner, STScI
Joana Oliveira, Keele University
Marta Sewilo, STScI
John Stauffer, IPAC/SSC
Jacco van Loon, Keele University
Barbara Whitney, Space Science Institute

Science Category: young stellar objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 47.0

Abstract:
We propose to obtain well-sampled, IRAC light curves for massive YSOs in the LMC and SMC using the IRAC 3.6 and 4.5 micron channels in select star forming regions with a range of metallicity, morphology, environment and spatial scale of star formation to determine the characteristic timescales and amplitude of the infrared variability. Variability at optical and near-infrared wavelength is mostly related to the central star itself. Mid-infrared flux changes, on the other hand, are in most cases due to varying emission of the circumstellar material. Using 2-epoch SAGE-LMC data we have discovered a number of infrared-variable massive YSOs. We propose these follow-up observations in carefully selected regions, with a cadence suited to variability of YSOs in order to establish the fraction of massive YSOs that exhibit flux variations, to determine whether they are periodic or stochastic and to search for dependencies on the physical properties of the YSOs and their environments. Spitzer/IRAC is uniqely suited to carry out these accurate photometric monitoring and is the only means to do so for these targets. We will target the massive star forming regions: 30 Dor, N11, N44 in the LMC and NGC 602, NGC 346 and N83-84 in the SMC. These regions have been well studied at many other wavelengths and a number of YSOs in a wide range of evolutionary stages have been identified by various techniques.

Spitzer Space Telescope - General Observer Proposal #14019

Weather and Rotation on Young Brown Dwarfs

Principal Investigator: Johanna Vos
Institution: University of Edinburgh

Technical Contact: Johanna Vos, University of Edinburgh

Co-Investigators:
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Katelyn Allers, Bucknell University
Elena Manjavacas, University of Arizona
Michael Liu, University of Hawaii
William Best, University of Hawaii
Stanimir Metchev, Western University
Esther Buenzli, ETH Zurich
Mariangela Bonavita, University of Edinburgh
Simon Eriksson, University of Stockholm
Trent Dupuy, Gemini Observatory
Taisiya Kopytova, Arizona State University
Wolfgang Brandner, MPIA
Thomas Henning, MPIA
Mickael Bonnefoy, Universite Grenoble Alpes
Ian Crossfield, Massachusetts Institute of Technology
Joshua Schlieder, NASA Goddard
Derek Homeier, Zentrum fur Astronomie der Universitat Heidelberg
Markus Janson, University of Stockholm
Jacqueline Radigan, Utah Valley University

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 68.5
Priority: 2

Abstract:
As part of a large, ground-based survey for weather patterns on exoplanet analogues, we have detected J-band variability in 5 young exoplanet analogues. We have already carried out followup Spitzer monitoring of two objects and here we propose Spitzer 3.6um and 4.5um monitoring of three early-mid-L detections in our survey. The proposed observations will enable us to assess the role of gravity in the variability properties of these young objects by providing a full measure of mid-IR amplitude across the full L spectral sequence for low-gravity objects. The proposed observations will also allow us to measure the rotational periods of our three targets. This will provide vital information on the angular momentum of young brown dwarfs, while enabling us to correct for geometric effects when considering the variability properties of our targets. This study will act as a necessary pathfinder for future variability studies of free-floating and companion exoplanets with JWST.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14234

Spatial Cloud Map of a Planetary-Mass Companion

Principal Investigator: Johanna Vos
Institution: American Museum of Natural History Astrophysics

Technical Contact: Johanna Vos, American Museum of Natural History Astrophysics

Co-Investigators:
Trent Dupuy, Gemini
Katelyn Allers, Bucknell University
Beth Biller, University of Edinburgh
Michael Liu, University of Hawaii
Theodora Karalidi, University of Central Florida

Science Category: Exoplanets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 33.1
Priority: 1

Abstract:
We propose to obtain Spitzer variability monitoring observations of a recently discovered, wide-separation planetary-mass companion. Mid-IR variability monitoring directly probes the presence of condensate clouds in the atmosphere, allowing us to trace their dynamics. The proposed observations will enable us to: 1) Fully characterize the spin properties of this newly discovered companion, by measuring its rotational period, inclination and equatorial velocity, and 2) Produce a spatial cloud map of a planetary-mass companion for the first time. We have already obtained all the feasible ground-based photometry and spectroscopy needed to characterize this object. The addition of the proposed Spitzer observations will provide a unique opportunity to characterize the atmospheric and spin properties of a planetary-mass companion in unprecedented detail.

Spitzer Space Telescope - General Observer Proposal #60108

First Multi-Orbit Time Series Observations of Jets in Ultracompact X-ray Binaries

Principal Investigator: Stefanie Wachter
Institution: California Institute of Technology

Technical Contact: Donald Hoard, IPAC, California Institute of Technology

Co-Investigators:
D. W. Hoard, Spitzer Science Center
Steve B. Howell, NOAO

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 22.0

Abstract:
Jets are a ubiquitous feature in many different astrophysical objects. They are found in extragalactic sources such as quasars and active galactic nuclei, in Galactic X-ray binary systems, and in newly forming young stellar objects. While the occurrence of jets is clearly connected to accretion processes in all of these objects, the exact mechanism for initiating the outflow and the roles specific parameters play in these wildly different sources are poorly understood. We propose to explore jet properties in the physically smallest systems among the XRBs, the ultracompact XRBs. The known ultracompact XRBs harbor a neutron star accretor and have orbital periods of less than an hour, requiring non-main sequence donor stars (typically a C/O white dwarf). The formation rate of ultracompact XRBs could be higher than that of hydrogen-rich (i.e., main sequence donor) XRBs, making them a significant - if currently poorly sampled - part of the Galactic population of interacting binary stars. Ultracompact XRBs are important to jet studies, because they expand the parameter space in physical size and chemical composition compared to XRBs with main sequence donors. The main focus of our observing program is to, for the first time, study the behavior of an XRB jet across several orbital cycles, by obtaining mid-infrared light curves of the ultracompact XRBs 4U 0614+091 and 4U 1626-67. Our observations are designed to characterize both orbital variations and long-term secular variations. No similar studies of jets in normal XRBs have been carried out because of lack of persistent jets, need to observe in the mid-IR, and prohibitively long orbital periods (several hours to tens of days). Because of their short periods, ultracompact XRBs are the only XRBs that allow continuous study over several orbital cycles. Currently, we only know what XRB jets look like in instantaneous snapshots; we do not have any information about their orbitally-resolved behavior. This Spitzer program will remedy that unfortunate situation.

Spitzer Space Telescope - General Observer Proposal #80177

How Common are Pulsar Debris Disks?

Principal Investigator: Stefanie Wachter
Institution: California Institute of Technology

Technical Contact: Stefanie Wachter, California Institute of Technology

Co-Investigators:
Chryssa Kouveliotou, NASA MSFC
Donald Hoard, Spitzer Science Center / Caltech

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 36.1

Abstract:
We propose a uniform survey of 37 nearby pulsars in order to determine the overall frequency of debris disks around neutron stars. Debris disks around neutron stars are invoked in the formation mechanism of the planets around the pulsar PSR 1257+12 and to explain the intermittent cessation of pulsations for a substantial number of radio pulsars. Furthermore, simulations of supernova explosions predict the existence of so-called fallback disks of material that is not ejected during the supernova. However, the direct detection of such disks has proven elusive. We currently only know of two examples, both discovered with Spitzer around isolated X-ray pulsars. This lack of disk detections might simply be a consequence of the limited size and depth of the observed sample. The presence of such disks has important implications for the general properties of the neutron star population, affecting the spin-down evolution and distribution of magnetic field strength and ages. Additional observations are needed to evaluate whether debris disks are a common feature in the evolution of neutron stars.

Spitzer Space Telescope - General Observer Proposal #60197

Detecting the remnant of a hot disk that is gone

Principal Investigator: Zhongxiang Wang
Institution: McGill University

Technical Contact: Zhongxiang Wang, McGill University

Co-Investigators:
Anne Archibald, McGill
Victoria Kaspi, McGill
Ingrid Stairs, UBC

Science Category: compact objects
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.7

Abstract:
An hot disk surrounding a millisecond radio pulsar in a binary system is identified in optical spectroscopic observations. The disk existed in a year and then disappeared before 2003 January. The disappearance of the disk was likely caused by its interaction with the radio pulsar. Different scenarios have been suggested for the interaction between pulsars and their disks. This binary system thus serves as a rare case that we would like to study in detail, helping our understanding of the interaction. Here we propose Spitzer/IRAC imaging of the binary system. We seek to detect excess emission from the remnant of the disk. A detection would suggest that the disk was pushed away and the remnant would exist as a circumbinary disk. For a non-detection, we would set a constraint on the existence of any dust material in the system, helping our near-future studies of this rare system at optical and infrared wavelengths.

Spitzer Space Telescope - General Observer Proposal #11079

The stellar populations in the earliest dusty starburst galaxies

Principal Investigator: Julie Wardlow
Institution: Niels Bohr Institute, U. of Copenhagen

Technical Contact: Julie Wardlow, Niels Bohr Institute, U. of Copenhagen

Co-Investigators:
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Asantha Cooray, University of California, Irvine
Dominik Riechers, Cornell University
Helmut Dannerbauer, University of Vienna, Austria
Duncan Farrah, Virginia Tech
Alain Omont, IAP, France

Science Category: high-z galaxies (z>0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.7
Priority: 1

Abstract:
We propose Spitzer IRAC imaging of the two brightest spectroscopically confirmed dusty starburst galaxies at z>4 that do not yet have mid-IR observations. The targeted galaxies are members of a rare class of Herschel sources that provide some of the most stringent constraints on galaxy formation theories. The two targets already have complementary optical and far-IR observations, and the proposed short IRAC data are all that is missing to ~double the number of confirmed z>4 dusty starbursts with well-sampled stellar SEDs. The IRAC data are critical for deriving accurate measurements of physical conditions such as dust extinction and stellar mass to ~30% accuracy (~10x better than otherwise). The proposed data complete the IRAC coverage of the four most luminous confirmed z>4 dusty starburst galaxies, which will be observed with HST in cycle 22. The targets already have CO observations and their [CII] 158 micron emission is being mapped with ALMA in cycle 2; with the addition of the proposed IRAC data we will be able to probe the dust-to-gas and stellar-to-gas mass ratios at the highest redshifts and in the most active galaxies. The IRAC data are also key to determining whether these highest redshift dusty starbursts are markers of overdensities in the early Universe via photometric dropout searches. By probing the details of star-formation in the most extreme sources in the first 1.5 Gyr of the Universe the proposed observations will critically test theories of galaxy formation and evolution.

Spitzer Space Telescope - General Observer Proposal #80114

Photometry of the z=7.08 quasar ULAS J1120+0641

Principal Investigator: Steve Warren
Institution: Imperial College London

Technical Contact: Steve Warren, Imperial College London

Co-Investigators:
Daniel Mortlock, Imperial College London
Bram Venemans, European Southern Observatory
Chris Simpson, Liverpool John Moores University
Paul Hewett, University of Cambridge
Richard McMahon, University of Cambridge

Science Category: cosmology
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.8

Abstract:
Numerous surveys are underway, or planned, to discover quasars of redshift z>6.5 in order to explore the epoch of cosmic reionisation. In UKIDSS we recently discovered the bright quasar ULAS J1120+0641, of redshift z=7.08, the highest redshift quasar known by a large margin. We propose photometry of this source in Channels 1 and 2 at S/N=30. The Spitzer observations form part of a campaign to measure the multiwavelength SED of the source which will be used to seek evidence for evolution at this very early time. The SED will also provide a benchmark for future surveys for high-redshift quasars to explore the epoch of reionisation at even higher redshifts. Additionally these deep confusion-limited observations will complement any future deep optical and near-ir observations of the field to detect companion galaxies and faint AGN.

Spitzer Space Telescope - General Observer Proposal #10067

SpiKeS: Spitzer Kepler Survey

Principal Investigator: Michael Werner
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
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David Ciardi, NExScI
Grant Kennedy, Cambridge University
John Livingston, JPL
Patrick Lowrance, Spitzer Science Center
Peter Plavchan, NExScI
Christopher Stark, Carnegie Institution of Washington
Mark Wyatt, Cambridge University
Varoujan Gorjian, Jet Propulsion Laboratory

Science Category: stellar populations
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 449.4
Priority: 1

Abstract:
We propose a Warm Spitzer survey of the entire Kepler field to provide precision 3.6 and 4.5 micron photometry of the more than 180,000 Kepler Observed Objects (KOBs) for which light curves have been obtained by Kepler. We base the proposal on a successful Cycle 9 pilot project which studied one 2.4x2.4 degree Kepler tile. These data from the pilot project have been expeditiously and thoroughly analyzed and show that our observing strategy will allow us to achieve a photometric precision of 2% or better for half the KOBs and 3% or better for more than 90% of the KOBs. The principal science thrusts of this survey are to: 1. Facilitate searches for infrared excesses above the stellar photosphere attributable either to warm circumstellar dust or to cool companions. Either could be of great significance in understanding the properties of planets or planetary systems detected around those stars. 2. Provide fundamental data on the KOBs, already the best characterized group of stars in the sky, which can be used to test stellar models and to support the all-important determination of stellar effective temperatures and radii, and thus exoplanet radii and densities. 3. Augment the Kepler archive with precision infrared photometry which will be a vital ingredient in research using this archive to study both exoplanetary and astrophysical questions over the coming decades The Spitzer data will thus greatly enhance both the exoplanet and the astrophysical power of the Kepler data. The survey proposed here will become a very important part of the scientific legacy of both Spitzer and Kepler.

Spitzer Space Telescope - General Observer Proposal #11026

Spitzer vs. K2

Principal Investigator: Michael Werner
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
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Dave Ciardi, NExSci
Jessie Christiansen, NExSci
Ian Crossfield, LPL
Erik Petigura, US Berkeley
Jessica Krick, SSC

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 455.0
Priority: 1

Abstract:
We propose a program of Spitzer photometry of candidate transiting planets orbiting M dwarf stars, to be identified in the K2 fields. K2 is the repurposed Kepler, observing a sequence of fields in the Ecliptic Plane for about 80 days each. Of the 1763 exoplanet listed on the Exoplanet Archive on 10/24/2014, only 86 orbited M stars, although M stars are by far the most abundant type in the Galaxy. Whereas the Kepler prime mission eschewed M stars, they have become a major focus of the community-driven target selection for K2. Our team has the capability and resources to carry out this program end to end, starting with finding M stars in the K2 data stream, validating them using both proven Kepler techniques and ground-based observations, executing the Spitzer observations, and analyzing the Spitzer data in conjunction with the K2 data. We will observe M stars in K2 fields 0 through 6 and foresee a yield of about 6 well-studied M star exoplanetary systems in each field, for a total of ~40, which is close to 50% of the presently known number. In the end, we expect to have greatly improved characterization of the exoplanet and its orbit than would be possible from the Kepler data alone. As a result of this program, we will gain a fuller understanding of the formation of planets around the lowest mass stars and provide a target list of M star candidates for higher sensitivity and resolution follow up with JWST. This is a Generic Target proposal: The fields to be studied and their visibility windows are known, but until the K2 data is analyzed and the targets vetted, we cannot specify exact AORs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #11184

Observations of transits of K2 exoplanet discoveries EPIC 203371098b&c

Principal Investigator: Michael Werner
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
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Dave Ciardi, NExSci
Jessie Christiansen, NExSci
Ian Crossfield, LPL
Erik Petigura, US Berkeley
Jessica Krick, SSC

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 35.0

Abstract:
We request DDT time to observe transits of two super-Neptune planets orbiting a bright G star, EPIC 203371098. Erik Petigura has brought to our attention a particularly interesting K2 discovery that consists of two sub-Saturn-sized planets (5.9 RE and 7.8 RE) orbiting EPIC-203371098, a bright G star (K = 9.2). The orbital periods of the planets are 20.9 d and 42.4 d, respectively. The planets have sizes between that of Neptune and Saturn; sizes not represented among the Solar System planets. Due to the brightness of the host star, this system is an ideal laboratory to study this new class of planets. Over the past two months, our team has conducted radial velocity (RV) follow up of EPIC-203371098 with Keck/HIRES. Our preliminary measurements suggest these planets have low densities, ~0.6 g/cc and ~0.4 g/cc, respectively. Low planet masses translate into larger atmospheric scale heights, which sets the amplitude of the features in planet transmission spectra. The apparent commensurability of their orbits suggest that this is a resonant system where transit timing variations may be particularly large. Our Spitzer observations, compared with the previous K2 first epoch observations, can provide initial evidence for TTVs and set the stage for future campaigns from Spitzer and other telescopes which will independently determine the planetary masses; they will also pin down the ephemerides of these interesting planets - including the hard to capture orbital eccentricity - for possible JWST study. It is important to carry out these observations in the upcoming apparition of this star in the October-December time frame because multiple observations are required for accurate studies of TTVs, and to prevent secular errors in timing from building up to a point where the system is hard to recover. The size of these planets and the brightness of the star shows us that we will achieve S/N>20 per transit on each planet. We will propose to observe one transit of each planet. We expect to spend of order 15 hours observing each of the two transits and request a total of 35 hours of DDT time to provide some headroom; a more precise estimate will be submitted with the forthcoming AORs. The observation strategy and data reduction will be drawn from our approved cycle 11 program to study transiting planets around M stars identified by K2.

Spitzer Space Telescope - Exploration Science Proposal #13052

Spitzer v. K2: Part II

Principal Investigator: Michael Werner
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
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Katherine Deck, Caltech
Courtney Dressing, Caltech
Andrew Howard, U. of Hawaii Manoa, IfA
Steve Howell, NASA/Ames
Heather Knutson, Caltech
Jessica Krick, IPAC/Caltech
John Livingston, U. of Tokyo
Farisa Morales, JPL/Caltech
Erik Petigura, Caltech
Joshua Schlieder, NASA/Ames
Varoujan Gorjian, Jet Propulsion Laboratory

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 360.0
Priority: 1

Abstract:
We propose to build on our Cycles 11-12 program of Spitzer photometry of planets from the K2 survey by enlarging our sample to interesting exoplanets from the continuing K2 mission. Our team has shown that we can carry out this program end to end, starting with finding interesting candidate stars/planets in the K2 data stream, validating them using both proven Kepler techniques and ground-based observations, selecting and executing the Spitzer observations, and analyzing the Spitzer data in conjunction with the K2 data. To date we have observed or scheduled 38 transits/eclipses of 27 exoplanets. We will observe stars in K2 fields 0 through 15 and foresee executing over 60 AOR's on over 40 exoplanets. In the end, we expect to have a greatly improved characterization of exoplanets and their orbits than would be possible from the K2 data alone. This will be vital for JWST follow-up. In addition to improvements in ephemerides, these Spitzer observations will look for transit timing variations, analyze exoplanet atmospheres, study young exoplanets, and provde early TESS follow-up. This work will add substantially to the extensive exoplanet legacy of the Spitzer mission. This is a Generic Target proposal: The fields to be studied and their visibility windows are known, but until the K2 data is analyzed and the targets vetted, we cannot specify exact AORs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14328

Spitzer's Last Observation

Principal Investigator: Michael Werner
Institution: Jet Propulsion Laboratory

Technical Contact: Patrick Lowrance
Institution: SSC/Caltech

Science Category: Other
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.0

Abstract:
This is a proposal requesting that time be reserved for the execution of a final observation with Spitzer.

Spitzer Space Telescope - General Observer Proposal #60175

Spitzer Studies of X-ray Detected Radio Hotspots

Principal Investigator: Michael Werner
Institution: JPL

Technical Contact: Varoujan Gorjian, JPL

Co-Investigators:
Dayton Jones, JPL
Charles Lawrence, JPL
David Meier, JPL
David Murphy, JPL
Anthony Readhead, Caltech

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.2

Abstract:
We propose new observations at 3.6um of 27 hotspots in the extended lobes of radio galaxies which have also been detected in x-rays, which will be combined with archival Spitzer data on 14 additional hotspots. The hotspots arise at the interface where a jet accelerated by a black hole at the center of the galaxy plows into the local intergalactic medium. Shocks created at this interface accelerate electrons to relativistic energies, and synchrotron radiation from the electrons produces both the radio hotspot and, as the electrons diffuse away from the hotspot, the extended emission from the lobe. These hotspots play a critical role in the transport of energy from the nuclei of galaxies back into the intergalactic medium. However, our understanding of the complex and highly non-linear interactions between relativistic jets and the IGM occurring in hotspots is limited by the paucity of data in the critical region where the interplay between the ageing of electron energy distributions and the beginning of inverse Compton photons occurs. Spitzer's 3.6um band is right in the middle of this critical region, with the required sensitivity. The new observations are planned to distinguish between several models put forward for hotspots based on radio and x-ray data alone. Spitzer observations are essential for understanding these cosmic train wrecks where relativistic jets hit the IGM. No other existing facility can come close to achieving the sub-uJy sensitivity needed to detect the hotspots at 3.6um. Although our observing time request is modest, our intention to produce a catalog of multispectral data on upwards of 40 hotspots is consistent with Warm Spitzer's thrust towards comprehensive studies of important astrophysical questions.

Spitzer Space Telescope - Directors Discretionary Time Proposal #80095

Spitzer and DIRBE Studies of the Infrared Background

Principal Investigator: Michael Werner
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
Varoujan Gorjian, JPL
Michael Hauser, STSci
Edward Wright, UCLA
Rick Arendt, GSFC
Ranga-Ram Chary, Spitzer Science Center
Louis Levenson, Caltech

Science Category: cosmology
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 120.6

Abstract:
The extragalactic background light (EBL), defined as the sky surface brightness of all radiation arising from outside the Milky Way, carries in the 1-5um region the imprint of the nearby Universe, of red-shifted light from the first galaxies, and of any possible pre-galactic contributions. The DIRBE instrument on the COBE satellite has measured the total sky brightness, the Cosmic Infrared Background (CIRB), over the entire sky at 3.6um. The CIRB is the sum of the zodiacal light, galactic starlight, radiation from the ISM, and the EBL. Although the determinations of the EBL are presently limited by uncertainties in the zodiacal light model, experiments now under way can reduce those uncertainties. This Spitzer proposal prepares for that reduction by eliminating other uncertainties. We will use Spitzer to determine the point source components of CIRB at 3.6um, the wavelength of the minimum in the bright foreground from interplanetary dust. We will measure essentially all of the stellar contribution, and more than 80% of the integrated light from resolved galaxies; this can be extrapolated using other Spitzer data to determine IGL. The ultimate objective of this type of study is to search for a currently unknown diffuse component of EBL, DEBL. Symbolically, DEBL = EBL-IGL. In this program, we will execute the following steps aimed at reducing the uncertainties in DEBL once the zodiacal uncertainty in CIRB is minimized and a correction for ISM emission is applied: 1. Cross calibrating DIRBE and Spitzer so that EBL and IGL are on the same flux scale; 2. Reducing the uncertainties in EBL by measuring stars as faint as 19th mag at 3.6um. 3. Determining EBL and IGL at six widely separated positions so that the isotropy - and hence the cosmological significance - of any detection of DEBL can be assessed. We emphasize that this important investigation can be carried out only with Spitzer, and this scientific opportunity is perishable due to Spitzer's finite lifetime.

Spitzer Space Telescope - General Observer Proposal #90100

Small SpiKeS: Small Spitzer Kepler Survey

Principal Investigator: Michael Werner
Institution: Jet Propulsion Laboratory

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
Varoujan Gorjian, Jet Propulsion Laboratory
Charles Beichman, NExScI
David Ciardi, NExScI
Grant Kennedy, Cambridge University
John Livingston, JPL
Patrick Lowrance, Spitzer Science Center
Peter Plavchan, NExScI
Christopher Stark, Carnegie Institution of Washington
Mark Wyatt, Cambridge University

Science Category: stellar populations
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 21.4

Abstract:
We propose a pilot Spitzer survey of the field being studied by Kepler by observing one of the 21 tiles that comprises the full Kepler field. We have selected the tile with the most current Kepler Objects of Interest (KOI) and we will obtain photometry of essentially all of the KOBs (Kepler Observed Objects) in that field of which the KOIs form a small but important and growing subset - with SNR better than 100 in both IRAC bands. The tile we have selected to observe contains 167 KOIs and 12,500 KOBs. The main specific scientific thrust of our program is to search for infrared excesses indicative of circumstellar matter and/or cool companions, which would be of particular interest if identified in association with the KOIs. We will reach limiting [5-sigma, Vega] magnitudes of 18.4 at 3.6 microns and 17.6 at 4.5 microns, about two magnitudes fainter than achieved by WISE in this field and with 10x better areal resolution than WISE. Based on the results of this pilot study we will propose a larger Spitzer study of the entire Kepler field in Cycle 10 using the proven methods of this proposal. We emphasize that this pilot study is a vital step towards a full survey of the Kepler field which will form an important part of Spitzer's scientific legacy, because the ~190,000 KOBs will, for the foreseeable future, be the best-studied large group of field stars available to stellar astronomers for a variety of studies. For the combined legacy of both Kepler and Spitzer, it will be important to have the best possible data for these stars and their surroundings at the highest possible sensitivity and angular resolution. The Kepler field is being targeted by many new and existing surveys. The value and applicability of this multi-spectral dataset will be greatly enhanced by the addition of sensitive mid-infrared photometry.

Spitzer Space Telescope - General Observer Proposal #80164

Testing the effects of metallicity on the atmospheric chemistry of exoplanets

Principal Investigator: Peter Wheatley
Institution: University of Warwick

Technical Contact: Peter Wheatley, University of Warwick

Co-Investigators:
Joseph Harrington, University of Central Florida
Jonathan Fortney, University of California Santa Cruz
Andrew Collier Cameron, University of St Andrews
Alexis Smith, University of Keele
David Anderson, University of Keele
Don Pollacco, Queen's University Belfast

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 48.6

Abstract:
The infrared emission spectra of highly-irradiated exoplanets are usually modified by atmospheric temperature inversions. Evidence is growing that parmaeters other than irradiation determine whether or not an inversion will form, with at least one highly-irradiated planet not exhibiting an inversion. One possibility, raised by our recent discovery of a planet with an extreme C/O abundance ratio, is that composition plays a key role in dictating the temperature profile of a planetary atmosphere. We propose Spitzer secondary eclipse observations of three exoplanets that we have recently discovered in the WASP project. The host stars of these planets have been found to have the lowest metallicities of all known transiting planets, and our observations will test a prediction that temperature inversions are suppressed in low metallicity atmospheres.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14250

Resolving QUIEscent Magnified (REQUIEM) Galaxies: The Missing (Spitzer/IRAC) Piece of the Puzzle

Principal Investigator: Katherine Whitaker
Institution: University of Connecticut

Technical Contact: Peter Capak, California Institute of Technology

Co-Investigators:
Iary Davidzon, California Institute of Technology
Harald Ebeling, Institue for Astronomy, Hawaii
Sune Toft, Niels Bohr Institute
Mohammad Akhshik, University of Connecticut

Science Category: High-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.3
Priority: 2

Abstract:
An unexpected discovery in the last decade is the remarkable compactness of the quiescent progenitors of today's most massive elliptical galaxies. Although there is some consensus about how these early galaxies grow through merging to become present day ellipticals, the formation of such dense objects is widely debated. Formation models predict unique observational signatures that are imprinted on the stellar populations and structures, however often these galaxies are barely resolved, even with HST. Moreover, it is challenging to sample their rest-NIR properties, a critical wavelength regime to constrain stellar population parameters. Strong gravitational can provide an unmatched improvement in spatial resolution and SNR and, despite their low space density, we have identified a unique sample of eight strongly lensed high redshift ($1.6<z<2.9$), massive ($10.5<\log M^*<11.7$) quiescent galaxies at this pivotal epoch. This is the most comprehensive sample of strongly-lensed massive quiescent galaxies to date, including some of the deepest HST/grism observations in existence through our new REQUIEM survey, and (almost) comprehensive Spitzer/IRAC coverage. Here, we propose to add the critically missing rest-NIR IRAC coverage for the last target, eMACS1341-1, to the existing/approved 7-band HST imaging, ultra deep (15-orbits) HST/G141 spectroscopy, ALMA band 6 continuum, and XSHOOTER spectroscopy. This particular quintessential target is magnified by a remarkable factor of 30, enabling us to resolve the past (formation) and present (quenching) at a critical time for the formation of massive quiescent galaxies.

Spitzer Space Telescope - General Observer Proposal #60020

GLIMPSE360: Completing the Spitzer Galactic Plane Survey

Principal Investigator: Barbara A. Whitney
Institution: Space Science Institute

Technical Contact: Barbara A. Whitney, Space Science Institute

Co-Investigators:
Richard Arendt, CRESST/UMBC/GSFC
Brian Babler, University of Wisconsin
Robert Benjamin, University of Wisconsin - Whitewater
Henrick Beuther, MPIA-Heidelberg
Bidushi Bhattacharya, Spitzer Science Center
Robert Blum, CTIO
Steve Bracker, University of Wisconsin
Chris Brunt, University of Exeter
Sean Carey, Spitzer Science Center
Ed Churchwell, University of Wisconsin
Dan Clemens, Boston University
Martin Cohen, University of California - Berkeley
Bruce Elmegreen, IBM Research Division
Peter Frinchaboy, University of Wisconsin
Fabian Heitsch, University of Michigan
Melvin Hoare, University of Leeds
Joseph Hora, Harvard-Smithsonian CfA
Remy Indebetouw, University of Virginia
James Jackson, Boston University
Thomas Jarrett, IPAC
Charles Kerton, Iowa State University
Henry Kobulnicky, University of Wyoming
Kathleen Kraemer, Air Force Research Laboratory
Phil Lucas, University of Hertfordshire
Steve Majewski, University of Virginia
Massimo Marengo, Harvard-Smithsonian CfA
Marilyn Meade, University of Wisconsin
Margaret Meixner, Space Telescope Science Institute
Don Mizuno, Boston College
Sergio Molinari, Instituto Fisica Spazio Interplanetario
Matt Povich, University of Wisconsin
Steve Price, Air Force Research Laboratory
Jill Rathborne, Harvard-Smithsonian CfA
William Reach, IPAC
Neill Reid, Space Telescope Science Institute
Jeonghee Rho, Spitzer Science Center
Thomas Robitaille, University of St. Andrews
Marta Sewilo, Space Telescope Science Institute
Sachindev Shenoy, Spitzer Science Center
Howard Smith, Harvard-Smithsonian CfA
Nathan Smith, University of California - Berkeley
John Stauffer, Spitzer Science Center
Susan Stolovy, Spitzer Science Center
Leonardo Ubeda, Universite Laval
Schuyler Van Dyk, IPAC
Jacco van Loon, University of Keele
Kevin Volk, Gemini Observatory
Christer Watson, Manchester College
Michael Wolff, Space Science Institute
Farhad Yusef-Zadeh, Northwestern University
Gail Zasowski, University of Virginia

Science Category: galactic structure
Observing Modes: IracPostCryoMap
Hours Approved: 1980.3

Abstract:
We propose to map the remaining 187 degrees of the Galactic Plane that have not

been observed with the Spitzer Space Telescope. The survey will cover longitude l=65-265 degrees excluding l ~102-109 and l~76-82. The latitude range will be 3.1 degrees, wider than the previous GLIMPSE surveys (2 degrees) because the disk flares more in the Outer Galaxy. The latitude center will follow the Galactic warp. Three visits on each sky position with 0.6&12s HDR frames will provide a high dynamic range of sensitivity that exceeds both GLIMPSE and the planned WISE mission surveys at both ends. This will allow us to determine the edge of the Galactic stellar disk, study low and high mass star formation in the nearby Perseus arm as well as in the Far Outer Galaxy, and study evolved stars throughout the Galaxy. The combination of GLIMPSE360 and the previous GLIMPSE (abs(l)<65 deg.) and smaller surveys will provide us with a lasting global dataset, encompassing most of the stars and star formation in our Galaxy. This database will allow us to determine the star-formation rate in the Galaxy, how the stellar disk scale heights and lengths vary across the Galaxy, and how the dust extinction law varies with location in the disk. In addition, we will catalog stars, star clusters, PAH bubbles, supernova remnants, infrared dark clouds, outflows from massive protostars, planetary nebulae, external galaxies in the Zone of Avoidance, and many other types of objects. Following the tradition of the previous GLIMPSE Legacy programs, we will deliver enhanced data products for the survey-source lists and cleaned mosaics-to the community.

Data from this program was split into multiple PIDs.
You can find the data in program IDs 60020, 61070, 61071, 61072, 61073

Spitzer Space Telescope - Directors Discretionary Time Proposal #61073

GLIMPSE360: Completing the Spitzer Galactic Plane Survey

Principal Investigator: Barbara A. Whitney
Institution: Space Science Institute

Technical Contact: Barbara A. Whitney, Space Science Institute

Co-Investigators:
Richard Arendt, CRESST/UMBC/GSFC
Brian Babler, University of Wisconsin
Robert Benjamin, University of Wisconsin - Whitewater
Henrick Beuther, MPIA-Heidelberg
Bidushi Bhattacharya, Spitzer Science Center
Robert Blum, CTIO
Steve Bracker, University of Wisconsin
Chris Brunt, University of Exeter
Sean Carey, Spitzer Science Center
Ed Churchwell, University of Wisconsin
Dan Clemens, Boston University
Martin Cohen, University of California - Berkeley
Bruce Elmegreen, IBM Research Division
Peter Frinchaboy, University of Wisconsin
Fabian Heitsch, University of Michigan
Melvin Hoare, University of Leeds
Joseph Hora, Harvard-Smithsonian CfA
Remy Indebetouw, University of Virginia
James Jackson, Boston University
Thomas Jarrett, IPAC
Charles Kerton, Iowa State University
Henry Kobulnicky, University of Wyoming
Kathleen Kraemer, Air Force Research Laboratory
Phil Lucas, University of Hertfordshire
Steve Majewski, University of Virginia
Massimo Marengo, Harvard-Smithsonian CfA
Marilyn Meade, University of Wisconsin
Margaret Meixner, Space Telescope Science Institute
Don Mizuno, Boston College
Sergio Molinari, Instituto Fisica Spazio Interplanetario
Matt Povich, University of Wisconsin
Steve Price, Air Force Research Laboratory
Jill Rathborne, Harvard-Smithsonian CfA
William Reach, IPAC
Neill Reid, Space Telescope Science Institute
Jeonghee Rho, Spitzer Science Center
Thomas Robitaille, University of St. Andrews
Marta Sewilo, Space Telescope Science Institute
Sachindev Shenoy, Spitzer Science Center
Howard Smith, Harvard-Smithsonian CfA
Nathan Smith, University of California - Berkeley
John Stauffer, Spitzer Science Center
Susan Stolovy, Spitzer Science Center
Leonardo Ubeda, Universite Laval
Schuyler Van Dyk, IPAC
Jacco van Loon, University of Keele
Kevin Volk, Gemini Observatory
Christer Watson, Manchester College
Michael Wolff, Space Science Institute
Farhad Yusef-Zadeh, Northwestern University
Gail Zasowski, University of Virginia

Science Category: galactic structure
Observing Modes: IracPostCryoMap
Hours Approved: 108.2

Abstract:
We propose to map the remaining 187 degrees of the Galactic Plane that have not

been observed with the Spitzer Space Telescope. The survey will cover longitude l=65-265 degrees excluding l ~102-109 and l~76-82. The latitude range will be 3.1 degrees, wider than the previous GLIMPSE surveys (2 degrees) because the disk flares more in the Outer Galaxy. The latitude center will follow the Galactic warp. Three visits on each sky position with 0.6&12s HDR frames will provide a high dynamic range of sensitivity that exceeds both GLIMPSE and the planned WISE mission surveys at both ends. This will allow us to determine the edge of the Galactic stellar disk, study low and high mass star formation in the nearby Perseus arm as well as in the Far Outer Galaxy, and study evolved stars throughout the Galaxy. The combination of GLIMPSE360 and the previous GLIMPSE (abs(l)<65 deg.) and smaller surveys will provide us with a lasting global dataset, encompassing most of the stars and star formation in our Galaxy. This database will allow us to determine the star-formation rate in the Galaxy, how the stellar disk scale heights and lengths vary across the Galaxy, and how the dust extinction law varies with location in the disk. In addition, we will catalog stars, star clusters, PAH bubbles, supernova remnants, infrared dark clouds, outflows from massive protostars, planetary nebulae, external galaxies in the Zone of Avoidance, and many other types of objects. Following the tradition of the previous GLIMPSE Legacy programs, we will deliver enhanced data products for the survey-source lists and cleaned mosaics-to the community.

Please note that this DDT is part of GLIMPSE360 (programs 60020,61070,61071, 61072,61073)

Spitzer Space Telescope - General Observer Proposal #70072

Filling the Gaps in the GLIMPSE360 Survey

Principal Investigator: Barbara Whitney
Institution: Space Science Institute

Technical Contact: Christer Watson, Manchester College

Co-Investigators:
Christer Watson, Manchester College
Edward Churchwell, University of Wisconsin
Robert Benjamin, University of Wisconsin-Whitewater
Marilyn Meade, University of Wisconsin-Madison
Brian Babler, University of Wisconsin-Madison
Matthew Povich, The Pennsylvania State University
Thomas Robitaille, Harvard-Smithsonian Center for Astrophysics

Science Category: galactic structure
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 46.4

Abstract:
Regarding the GLIMPSE360 Exploration Science project that is mapping the outer Galaxy, we have some good news and bad news to report. The good news is that the data are proving to be spectacular. Due to the higher dynamic range and the lower confusion compared to the GLIMPSE survey (of the inner Galaxy), we can detect stars out to the edge of the Galaxy, PAH bubbles at 3.6 microns; and YSO outflows, H II regions, and supernova remnants at 4.5 microns; and we can separate IR-excess sources in color-magnitude space. The bad news is that due to a variety of conditions we did not fully anticipate, a substantial portion of the survey observed so far (about 1/6 of the entire survey) has narrow gaps in coverage, in between AORs. We have corrected the problem and our recent data show no gaps. The complete coverage of this survey is meaningful for several science goals that are based on global studies, such as mapping Galactic structure and measuring star formation rate as a function of Galacto-centric radius. We request additional time to fill in these gaps and to realize the full potential of the survey.

Spitzer Space Telescope - General Observer Proposal #80074

Deep GLIMPSE: Exploring the Far Side of the Galaxy

Principal Investigator: Barbara Whitney
Institution: University of Wisconsin, Madison

Technical Contact: Brian Babler, University of Wisconsin, Madison

Co-Investigators:
Robert Benjamin, University of Wisconsin-Whitewater
Ed Churchwell, University of Wisconsin-Madison
Marilyn Meade, University of Wisconsin-Madison
Brian Babler, University of Wisconsin-Madison
Lori Allen, NOAO
Loren Anderson, Laboratoire d'Astrophysique de Marseille
Dana Balser, NRAO
Thomas Bania, Boston University
Leo Blitz, UC-Berkeley
Martha Boyer, STScI
Chris Brunt, University of Exeter
Sukanya Chakrabarti, Florida Atlantic University
Ed Chambers, Northwestern University
Dan Clemens, Boston University
Martin Cohen, UC-Berkeley
Angela Cotera, SETI
Claudia Cyganowski, Harvard-Smithsonian Center for Astrophysics
Chris Davis, Joint Astronomy Center, Hawaii
Bruce Elmegreen, IBM Research
Peter Frinchaboy, Texas Christian University
Dirk Froebrich, University of Kent
Joseph Hora, Harvard-Smithsonian Center for Astrophysics
Remy Indebetouw, University of Virginia
Georgios Ioannidis, University of Kent
Thomas Jarrett, IPAC-Caltech
Charles Kerton, Iowa State University
Henry Kolbulnicky, University of Wyoming
Kathleen Kraemer, Air Force Research Laboratory
Nanda Kumar, University of Porto
Sheng-Yuan Liu, ASIAA, Taiwan
Philip Lucas, University of Hertfordshire
Steve Majewski, University of Virginia
Jon Mauerhan, IPAC-Caltech
Massimo Marengo, Iowa State University
Tom Megeath, University of Toledo
Dante Minniti, Universidad Catolica de Chile
Joseph Mottram, University of Exeter
Matthew Povich, Penn State University
Thomas Robitaille, Harvard-Smithsonian Center for Astrophysics
Robert Rood, University of Virginia
Marta Sewilo, Johns Hopkins University
Howard Smith, Harvard-Smithsonian Center for Astrophysics
Michael Smith, University of Kent
Thomas Stanke, ESO
John Stauffer, IPAC, Caltech
Schuyler Van Dyk, IPAC-Caltech
Jacco van Loon, Keele University
Kevin Volk, STScI
Christer Watson, Manchester College
Grace Wolf-Chase, Adler Planetarium
Gail Zasowski, University of Virginia

Science Category: galactic structure
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 600.0

Abstract:
We propose to re-observe and enhance the original GLIMPSE survey region by

following the Galactic warp at a Galactocentric distance of 13 kpc to survey the far outer Galaxy. The new survey will cover longitudes of 15 < l < 65, -15 > l > -95, with a latitude width of 2.5 degrees; 55% of the survey will overlap with GLIMPSE, and 45% will cover new territory. The survey strategy of 3 HDR visits on each sky position will increase the dynamic range over GLIMPSE by a factor of 13 on the faint end and 3 on the bright end. The survey will be enhanced by several complementary surveys at near-IR, mid-IR, far-IR, submm, and radio wavelengths. Deep GLIMPSE will allow us to map stellar Galactic structure out to the edge of the stellar disk; map star formation and H II regions in the far outer Galaxy; improve our estimate of the star formation rate (SFR) of the Galaxy and study the SFR as a function of Galactocentric distance; study low-mass as well as high-mass star formation in the Galactic plane and determine stellar mass functions and evolutionary timescales of YSOs as a function of stellar mass and environment; continue to catalog PAH bubbles, IRDCs, YSO outflows, stellar clusters, external galaxies, brown dwarfs, and more; and search for dwarf galaxies hidden by the Galactic midplane.

Data from this program was split into multiple PIDs. You can find the data in program IDs 80074, 80253

Spitzer Space Telescope - Directors Discretionary Time Proposal #10162

Mapping a Luminous Seyfert 1 Dust Torus

Principal Investigator: Steven Willner
Institution: Smithsonian Astrophysical Observatory

Technical Contact: Steven Willner, SAO

Co-Investigators:
Matthew Ashby, SAO
Martin Haas, Ruhr-University Bochum
Francisco Pozo Nunez, Ruhr-University Bochum

Science Category: AGN
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.2

Abstract:
Ground-based reverberation mapping of the well-studied Seyfert 1 galaxy WPVS 48 has revealed that the near infrared J+K band variations lag those in the visible B band by ~72 days. The extremely sharp echo suggests a nearly face-on view of the ~1500 K hot dust torus and a surprisingly small apparent dust covering angle <20 deg. Additional ground-based monitoring is scheduled for 2013 November through 2014 May. Measurements will include photometry in visible (UBVRI) and NIR bands (JHK) at 2-day cadence along with spectroscopic monitoring with the 10-m South African Large Telescope. Adding Spitzer/IRAC 3.6 and 4.5 micron monitoring will reveal the echo of cooler (~800 K) dust and of deeply embedded hot dust expected in the optically thick case. The results will confirm or reject AGN models proposing 1) a concave dust torus geometry (by Kawaguchi & Mori); 2) a convex dust torus geometry optically thick at 2 micron (suggested by us), potentially with puffed-up inner rim to explain the 3 micron bump seen in the SEDs of type-1 AGN; and 3) a dust-related origin of the broad line region (by Elitzur & Shlosman and Czerny et al.). We therefore ask for 18 Spitzer visits during the 51-day visibility window in early 2014. Spitzer is needed because 1% photometric repeatability cannot be achieved from the ground in the L+M bands. We apply for DDT because our initial detections of the NIR echoes were made after the regular proposal deadline. Observations of WPVS 48 will complement the sole comparable Spitzer AGN dust reverberation mapping program by observing an object 25 times more luminous.

Spitzer Space Telescope - General Observer Proposal #90126

Astrometry and Stellar Masses of the 3C 220.3 Lensed Galaxy System

Principal Investigator: Steven Willner
Institution: Center for Astrophysics

Technical Contact: Steven Willner, Center for Astrophysics

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.3

Abstract:
The optical structure associated with radio source 3C 220.3 is very likely a superposition of a high-redshift submillimeter galaxy seen in the far infrared by Herschel being lensed by the radio source host galaxy at z=0.68. The source is important because the lensing magnification of order 10 offers a detailed view of the submillimeter galaxy. A quarter-hour IRAC observation will locate the lens, allowing detailed modeling of the source. The observation will also reveal the stellar mass of the foreground object and of the background object if it’s massive enough.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14274

Dust Recycling over the 2 hour Period of a White Dwarf Planetesimal

Principal Investigator: Thomas Wilson
Institution: University College London

Technical Contact: Jay Farihi, University College London

Co-Investigators:
Christopher Manser, University of Warwick
Andrew Swan, University College London
Jay Farihi, University College London

Science Category: Debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.9
Priority: 1

Abstract:
It is now known that 30-50% of white dwarfs are accreting planetary material from circumstellar debris disks. Spitzer has played a key role in the discovery of circumstellar dust at 40 of these systems via detection of infrared excess emission. Circumstellar gas that is co-spatial with the dust has also been detected around eight white dwarfs, however the origin of such gas is still unknown. WD 1226+110 is the prototype disk with gaseous emission and has recently been observed to have gas velocity variation with a period of 123.4 min. We propose this is due to gas production via collisions between a co-orbiting planetesimal and dust disk. Gas should rapidly re-condense into dust, providing a recycling channel for further collisions. We expect that this scenario of dust production and destruction results in stochastic infrared flux variations on orbital timescales. We propose a 4.9 h, high-cadence staring mode observation of WD 1226+110 that covers two orbital periods of the planetesimal to discover and characterize flux variations indicative of dust recycling. Currently, Spitzer is the only facility that can probe the dust in this compelling system, and the proposed observations will pave the way for studies with future facilities.

Spitzer Space Telescope - General Observer Proposal #14030

WASP-12b: Orbital Decay or Apsidal Precession?

Principal Investigator: Joshua Winn
Institution: Princeton University

Technical Contact: Joshua Winn, Princeton University

Co-Investigators:
Heather Knutson, California Institute of Technology

Science Category: extrasolar planets
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 28.0
Priority: 2

Abstract:
Over the last decade, the interval between the transits of the hot Jupiter WASP-12b has been steadily shrinking by 29 milliseconds per year. This may represent the first direct detection of tidal orbital decay, a phenomenon that has long been predicted to occur for hot Jupiters and that features in many theories to explain their properties. Another viable explanation for the apparent period decrease is that the orbit is slightly eccentric and apsidally precessing, in which case the data could be used to measure the planet’s Love number. This would be a rare and precious constraint on its interior density distribution. The best way to tell the difference is to combine new Spitzer observations of secondary eclipses with ongoing ground-based transit observations. Orbital decay predicts that the transit and eclipse timing residuals will have the same sign, while apsidal precession would produce anti-correlated residuals. We propose to observe 4 eclipses with Spitzer during Cycle 14, which will allow the two hypotheses to be distinguished with high confidence.

Spitzer Space Telescope - General Observer Proposal #80049

Dynamic Decretion Disks in the Magellanic Clouds

Principal Investigator: John Wisniewski
Institution: University of Washington

Technical Contact: John Wisniewski, University of Washington

Co-Investigators:
Karen Bjorkman, University of Toledo
Alex Carciofi, University of Sao Paulo
Zack Draper, University of Washington
Xavier Haubois, University of Sao Paulo
Uma Vijh, University of Toledo

Science Category: local group galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 49.0

Abstract:
We propose to use the exquisite sensitivity of Spitzer to revolutionize our understanding of viscous decretion disks which surround rapidly rotating massive stars. Using 8 epochs (1 every 30-45 days) of deep 3.6 and 4.5 micron IRAC imagery, we propose to monitor >650 B-type stars in 4 young clusters in the SMC/LMC to a) perform the first statistical test of the prevalence and duration of large-scale disk-loss/disk-renewal events in classical Be stars in low metallicity environments; and b) begin to constrain the time-dependence of the stellar mass-loss rate in these systems. Our investigation would triple the number of B stars that have been systematically monitored to statistically investigate this phenomenon. Major disk dispersal/regeneration events represent an ideal time to investigate the fundamental mechanism(s) driving disk formation around Be stars; hence, our proposed Spitzer systematic study has the potential to revolutionize our understanding of viscous decretion disks.

Spitzer Space Telescope - General Observer Proposal #60078

Triggered Star Formation and the Power within PacMan

Principal Investigator: Scott Wolk
Institution: Harvard Smithsonian Center for Astrophysics

Technical Contact: Scott Wolk, Harvard Smithsonian Center for Astrophysics

Co-Investigators:
S. Thomas Megeath, University of Toledo
Robert Gutermuth, Smith College
Damian Christian, Eureka Scientific

Science Category: star formation
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 6.1

Abstract:
NGC 281 (a.k.a. the Pac Man Nebula) is a complex region of star formation. At a distance of about 3 kpc is lies a remarkable 300 pc above the galactic plane. Apparently triggered by a supernova that occurred 6 Myr ago, it includes at least 3 separate but related sites of star formation within 4 pc. The oldest regions includes a trapezium-like set of several 3.5 Myr O stars while the youngest regions are still active. In addition to hundreds of young stars, our recent Chandra observation, revealed copious plasma surrounding the O stars and impacting on at least one of the active regions. We will determine whether the clusters are part of a single, continuous cluster, or whether they are separate clusters created by distinct episodes of star formation - and distinquish between predictions made by "collect & collapse" or radiation driven implosion models (RDI). The face-on aspect of the region allows us to study the diffuse plasma in the region to understand the role of X-ray ionization along the HII region/molecular cloud interface. We propose to map the region using IRAC in order to study: 1.) The mechanism of the triggered star formation within the embedded clouds. 2.) The relationship between hot plasma and molecular clouds and to look for dust in and around the hot plasma 3.) The disk frequency of massive stars (1-2 Msun) in molecular cloud, in cluster surrounding OB stars, and in the hot plasma.

Spitzer Space Telescope - Directors Discretionary Time Proposal #10175

Witnessing Extrasolar Asteroid Destruction?

Principal Investigator: Siyi Xu
Institution: European Southern Observatory

Technical Contact: Siyi Xu

Co-Investigators:
Michael Jura, UCLA
Kate Su, University of Arizona
Huan Meng, University of Arizona

Science Category: Debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.4

Abstract:
40 white dwarfs with excess infrared radiation due to a circumstellar dust disk from tidally disrupted asteroids have been identified. Recently, we identified one dusty white dwarf whose infrared fluxes have been increasing since May 2014. Very likely, it is caused by a recent tidal disruption event of extrasolar asteroid. We propose DDT to follow it up in a timely manner because the flare could dissipate very soon. This proposal provides a unique opportunity to study the destruction of an extrasolar asteroid.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12128

Simultaneous Spitzer, HST and VLT Observations of a White Dwarf with an Actively Disintegrating Asteroid

Principal Investigator: Siyi Xu
Institution: European Southern Observatory

Technical Contact: Siyi Xu, European Southern Observatorys

Co-Investigators:
Andrew Vanderburg, CFA
Michael Jura, UCLA
Bryce Croll, Boston University
Saul Rappaport, MIT
Ben Zuckerman, UCLA

Science Category: Circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 8.7

Abstract:
We have recently discovered a white dwarf where an asteroid is actively disintegrating. Using data from K2, transits with periods less than 5 hours have been detected from at least 6 fragments. Evidence for circumstellar dust was found by comparing UKIDSS and WISE data. High-resolution optical spectroscopic data from Keck show that the host star is heavily polluted with 11 heavy elements and circumstellar gas. We were granted observing time with the Hubble Space Telescope and the Very Large Telescope to obtain a light curve in the ultraviolet and time-resolved ultraviolet and optical spectroscopy. Here, we propose simultaneous observation with Spitzer/IRAC to monitor the short-term variability of the dust disk. We aim to have a complete picture of this rapidly evolving system.

Spitzer Space Telescope - General Observer Proposal #13065

The Real Time Disintegration of an Asteroid Transiting a White Dwarf

Principal Investigator: Siyi Xu
Institution: European Southern Observatory

Technical Contact: Siyi Xu, European Southern Observatory

Co-Investigators:
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John DeVore, Visidyne Inc
Valentin Ivanov, European Southern Observatory
John Debes, Space Telescope Institute
Judith Provencal, University of Delaware
Andrew Vanderburg, Harvard University
Bryce Croll, Boston University
Patrick Dufour, University of Montreal
Ben Zuckerman, University of California, Los Angeles

Science Category: circumstellar/debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 21.4
Priority: 1

Abstract:
There is strong evidence that an actively disintegrating asteroid is orbiting the white dwarf WD 1145+017. This scenario is supported by several observations, including: (i) transits from multiple objects within the white dwarf's tidal radius; (ii) infrared excess from a circumstellar dust disk; (iii) ubiquitous high-velocity absorption lines from circumstellar gas; (iv) a heavily polluted atmosphere from the accretion of the circumstellar material. We were awarded Spitzer DDT time to perform photometric observation simultaneously with a few other telescopes on March 29, 2016. Our preliminary analysis has returned the first detection of a color-dependent transit. Here, we propose to monitor this system over the next two years to understand the change of the transiting material as well as the possible change of the dust disk. This system provides a unique window to study the real time disintegration of an asteroid around a white dwarf.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14220

The Gaia View of Dust Disks around White Dwarfs

Principal Investigator: Siyi Xu
Institution: Gemini Observatory

Technical Contact: Siyi Xu, Gemini Observatory

Co-Investigators:
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Simon Hodgkin, Cambridge
Scot Kleinman, Gemini
Samuel Lai, UCL
Sandy Leggett, Gemini
Atsuko Nitta, Gemini
Alberto Rebassa, UPC
Laura Rogers, Cambridge

Science Category: Debris disks
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 59.2
Priority: 1

Abstract:
The recent Gaia Data Release 2 has significantly increased the known white dwarf population. By cross-correlating the bright Gaia white dwarfs with different catalogs, we have identified 189 high confidence candidates with infrared excesses from dust disks. We propose to observe these candidates with Spitzer/IRAC to confirm the origin of the infrared excess. Combined with our on-going Gemini near-infrared imaging program, we will be able to determine the nature of the infrared excess and constrain the disk properties. It is now widely accepted that dust disks around white dwarfs come from disintegrated asteroids. This is the largest dusty white dwarf sample from an unbiased study and likely it will more than double the current population of dusty white dwarfs. This will be a long-term legacy for both the white dwarf and debris disk community.

Spitzer Space Telescope - General Observer Proposal #13024

Deep IRAC Imaging Lensing Galaxy Clusters for JWST "First Light" Search

Principal Investigator: Haojing Yan
Institution: Missouri

Technical Contact: Haojing Yan, Missouri

Co-Investigators:
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Rogier Windhorst, Arizona State University
Seth Cohen, Arizona State University
Mehmet Alpaslan, NASA Ames Research Center
Adi Zitrin, California Institute of Technology
Tom Broadhurst, University of the Basque Country
Brenda Frye, University of Arizona
Simon Driver, University of Western Australia, Australia
Aaron Robotham, University of Western Australia, Australia
Andrew Hopkins, AAO, Australia
Staurt Wyithe, University of Melbourne, Australia
Rolf Jansen, Arizona State University
Nimish Hathi, Laboratory of Astrophysics of Marseille
Matthew Mechtley, Max Planck Institute for Astronomy
Russell Ryan, STScI
Michael Rutkowski, University of Minnesota
Steven Finkelstein, University of Texas-Austin
Anton Koekemoer, STScI

Science Category: intermediate-z galaxies (0.05<z<0.5)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 52.5
Priority: 1

Abstract:
JWST has a key goal to search for First Light objects beyond z>10. Our 110-hr JWST GTO program, "Webb Medium-Deep Fields" (WMDF), will target both blank and lensed fields to probe both the bright and the faint ends of the galaxy luminosity function at z > 10. While a number of well studied lensing clusters exist, not all of them are optimal for the JWST search of First Light objects, either because of their low Ecliptic latitudes (and hence high Zodiacal background) or because of their strong intra-cluster light (ICL) at the critical curve regions corresponding to the redshifts of interest. For this reason, our WMDF candidate lensing targets will include some recently discovered, high-mass (log[M/Msun] ~ 15) galaxy clusters, which we choose either because of their high Ecliptic latitude (beta > 40 deg) or because of their extreme compactness that minimizes the impact of the ICL. As part of our effort to collect ancillary data for these new systems to finalize the target list, we propose IRAC observations for 13 of them that are lacking sufficient data. These 3.6/4.5um data will be critical for our guaranteed JWST program: (1) they will greatly facilitate the modeling of the straylight that JWST will suffer in 1--5 um (the key range to search for z>10--20 objects), a problem that has recently been identified. If left untreated, such straylight components would severely hamper the detection of faint sources in a lensing field. The JWST observations alone would be difficult to separate the ICL from the straylight at the level needed. (2) the new 3.6/4.5um data will best match our deep optical imaging and spectroscopy at HST, Gemini, LBT and MMT. We will derive accurate photometric redshifts for any lensed background galaxies (at z<6) and most member galaxies in the outskirts, which will be critical in refining the mass profile through strong/weak lensing analysis. Finally, we note that these data will be highly valuable for the study of these clusters themselves before the JWST mission.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13168

Confirm the Nature of a TDE Candidate in ULIRG F01004-2237 Using Spitzer mid-IR Light Curves

Principal Investigator: Lin Yan
Institution: Caltech/IPAC

Technical Contact: Lin Yan, Caltech/IPAC

Science Category: extragalactic stellar studies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.5

Abstract:
ULIRG F01004-2237 had a strong optical flare, peaked in 2010, and the follow-up optical spectra classified thisevent as a TDE candidate (Tadhunter et al. 2017, Nature Astronomy). In early 2017, using archival WISE data, we discovered that its 3.4 and 4.6um fluxes have been steadily rising since 2013, increased by a factor of 3.5 and 2.6 respectively. The last epoch data from WISE on 2016-12-12 shows that F01004-2237 has reached 7.5 and 14mJy at 3.4 and 4.6um. We interpret the mid-IR LCs as infrared echoes from the earlier optical flare. We infer a convex, dust ring with a radius of ~1 pc from the central heating source. Our model predicts that if this event is indeed a TDE, its mid-IR LCs should start to fade in next 5-12 months because it has already reprocessed most of the UV/optical energy from the tidal disruption. However, if this event is due to activities from an AGN, its mid-IR LCs could last over a much longer time scale. We request a total of 3.2 hours of Spitzer time to monitor the mid-IR variations in next 12 months. This will provide the critical data to confirm the nature of this transient event.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13251

Systematic Mid-Infrared Survey of A Sample of Tidal Disruption Events Discovered by ZTF

Principal Investigator: Lin Yan
Institution: Caltech

Technical Contact: Lin Yan, Caltech

Co-Investigators:
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Shri Kulkarni, Caltech
Mansi Kasliwal, Caltech
Suvi Gezari, Univ. of Maryland
Brad Cenko, GSFC
Nadia Blagorodnova, Caltech
Tiara Hung, Univ. of Maryland

Science Category: Intermediate-z galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 24.1

Abstract:
Zwicky Transient Facility (ZTF) saw its first light (press release on Nov 14, 2017) and is currently in the commissioning phase. The science operation is scheduled to start on Feb 1, 2018. Based on the data from Palomar Transient Factory (PTF), ZTF is expected to discover 30 new tidal disruption events (TDE) in the centers of galaxies containing supermassive blackholes. TDEs are rare transient events, and have only been discovered in recent years by large area transient surveys. Observations of optically discovered TDEs appear to show common characteristics, including blackbody temperatures of a few 10,000K, derived bolometric peak luminosities of several 10^43 - 10^44 erg/s, and photospheric radius of 10^15 - 10^16 cm. These properties are in conflict with the classic TDE model predictions, which suggest an order of magnitude higher temperature and peak luminosity. One proposed explanation is the possible existence of a reprocessing gas layer which absorbs X-ray, UV/optical photons and produces a cooler spectral energy distribution (SED). So far, there are only two published mid-IR light curves of TDEs, each with two epochal data. To solve this mystery, we require higher cadence Spitzer observations of a sample of uniformly selected TDEs. Next year is the only opportunity to obtain the critical observations because Spitzer is expected to operate only to March 2019. We request 24.1 hours of Spitzer time to observe 7 ZTF TDEs. This will produce a unique legacy dataset for many future studies of physics of TDEs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14321

IRAC Imaging of Planck "550 micron Peakers" Selected Based on PCCS2

Principal Investigator: Haojing Yan
Institution: University of Missouri

Technical Contact: Haojing Yan, University of Missouri

Co-Investigators:
Jiasheng Huang, Center for Astrophysics, Harvard & Smithsonian
Valentino Gonzalez, University of Chile
Lulu Fan, University of Science and Technology, China
Marat Musin, National Astronomical Observatories, Chinese Academy of Sciences
Cheng Cheng, National Astronomical Observatories, Chinese Academy of Sciences

Science Category: high-z galaxies (z>0.5)
Hours Approved: 26.4
Priority: 1

Abstract:
The Planck CMB mission has also provided the first all-sky survey of astrophysical sources in the sub-mm/mm regime. Of particular interest among these sources are those of red sub-mm colors that resemble dusty starbursts at high redshifts. These sources are very bright (> 200 mJy), implying extremely high luminosities (> 1e14 L_sun) if they are indeed at high-z. The natural explanation to their extreme brightness would then be that they are either galaxy clusters or gravitationally lensed individual galaxies. In either case, these sources are important because they form a complete sample of the most extreme sources in the universe from an all-sky survey. There have been a few programs to find and to study such sources based on the early and the first release of Planck compact sources. Using the Second Planck Catalog of Compact Sources (PCCS2) that utilizes the full Planck mission data, we have selected a sample of five "550 micron peakers" whose SED peaks are at 550 micron, and thus could be at z>4. As the Planck data are plagued by the coarse spatial resolutions (5'--5.5' in sub-mm), we have requested higher resolution far-IR sub-mm observations (some have already been approved) to better locate the sources and to judge if they are lensed objects or clusters. We have also requested optical/near-IR observations to study the host galaxies of these dusty starbursts. Here we propose to observe them in IRAC. These 3.6 and 4.5 micron data are critical in deriving the stellar masses of the host galaxies, in improving their photometric redshift estimates at the presence of dust, in obtaining the properties of the foreground lens (in case of lensing) and in studying the environment of the SMGs (in case of clusters). This is the final chance to obtain such data for these extreme sources selected over the entire sky.

Spitzer Space Telescope - Directors Discretionary Time Proposal #14312

Rotational modulations of a highly variable planetary-mass companion

Principal Investigator: Yifan Zhou
Institution: University of Arizona

Technical Contact: Yifan Zhou, University of Arizona

Co-Investigators:
Brendan Bowler, University of Texas
Daniel Apai, University of Arizona
Bjorn Benneke, University of Montreal
Marta Bryan, University of California, Berkeley
Tiffany Kataria, JPL

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 37.0
Priority: 1

Abstract:
Our recent 8.5 hr Hubble Space Telescope/Wide Field Camera 3 (HST/WFC3) observations have revealed that VHS1256b, a planetary-mass companion is highly variable with an unconstrained period. This discovery offers an unprecedented opportunity to use time-series observations to characterize the condensate clouds and constrain the rotation of a planetary-mass companion. We propose 37 hr Spitzer/IRAC Channel 2 observation to measure the 4.5 micron variability amplitude and the rotation period of VHS1256b. The 4.5 micron variability amplitude, together with the HST/WFC3 variability amplitude, will allow us to derive the cloud base altitude and vertical cloud structures of a planetary-mass companion. The rotation period measurement combined with our published v sin i value will place a tight constraint on VHS1256b's angular momentum vector orientation, which helps us trace the formation pathway of this planetary-mass companion. The Spitzer 2019 Fall visibility window of VHS1256b is likely the last opportunity of space-based mid-infrared uninterrupted monitoring of this JWST ERS target in the coming decade. The proposed observation will add critical astrophysical context for the JWST observations of VHS1256b.

Spitzer Space Telescope - General Observer Proposal #12020

Hunting the Coolest Substellar Dwarfs

Principal Investigator: Ben Zuckerman
Institution: University of California, Los Angeles

Technical Contact: Ben Zuckerman, University of California, Los Angeles

Co-Investigators:
David Rodriguez, Universidad de Chile
Carl Melis, University of California, San Diego
Inseok Song, University of Georgia
Laura Vican, University of California, Los Angeles

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 4.6
Priority: 1

Abstract:
Brown dwarfs with effective surface temperatures of 500 K or cooler have recently been identified as a new spectral class: Y-dwarfs. Some Y-dwarfs have now been discovered, most with the WISE all sky survey. Additional Y-dwarfs may be found by searching for widely separated companions to old stars given that the lowest mass substellar objects discovered in previous imaging surveys tend to have large semi?major axes, typically hundreds of AU. To expand the sample of the coolest brown dwarfs, we propose to re?observe some of our Spitzer Cycle 7 fields that targeted nearby old (ages >2 Gyr) white dwarfs. We have identified a number of 3.6-micron dropouts that could represent cold Y-dwarf companions. These second epoch observations are crucial to confirm these as co-moving substellar companions. As companions to white dwarfs, we will be able to determine the ages of any cool brown dwarfs we find and thus constrain their masses.

Spitzer Space Telescope - General Observer Proposal #70102

Hunting the Coolest Substellar Dwarfs

Principal Investigator: Ben Zuckerman
Institution: University of California, Los Angeles

Technical Contact: David Rodriguez, University of California, Los Angeles

Co-Investigators:
David Rodriguez, University of California, Los Angeles
Inseok Song, University of Georgia
Carl Melis, University of California, San Diego

Science Category: brown dwarfs/very low mass stars
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 19.7

Abstract:
The few lowest mass substellar objects discovered in previous imaging surveys are found to have large semi-major axes, typically hundreds of AU. We show that at such large separations and toward old stars one has the best chance to detect the coolest brown dwarf companions, with effective temperatures of <500 K (the so-called "Y dwarfs''). Effective temperatures of 500 K represent a region of temperature space that is only recently being probed for free floating brown dwarfs. The discovery of such cool objects will illuminate their physics and chemistry and will provide observational data to test planetary models. To discover one or more Y dwarfs, we are conducting a survey of white dwarfs with ages >2 Gyr that lie within 35 pc of Earth. As companions to white dwarfs, we will be able to determine the ages of any cool brown dwarfs we find and thus constrain their masses.

Spitzer Space Telescope - General Observer Proposal #12046

Dust Reprocessing of Stellar Tidal Disruption Flares

Principal Investigator: Sjoert van Velzen
Institution: Johns Hopkins University

Technical Contact: Varoujan Gorjian, Jet Propulsion Laboratory

Co-Investigators:
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Julian Krolik, Johns Hopkins University
Alexander Mendez, Johns Hopkins University

Science Category: AGN/quasars/radio galaxies
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 0.7
Priority: 2

Abstract:
A stellar tidal disruption flare (TDF) occurs when a star gets too close to a supermassive black hole and is shredded into streams that are accreted. Traditionally, TDFs are observed at optical to soft X-ray wavelengths. We have recently made a discovery that opens a new (and unexpected) wavelength regime for the study of these flares: transient emission at 3.4 micron in WISE multi-epoch imaging. This dust reprocessing signal was not previously predicted, but will likely be of great importance to further our (limited) understanding the TDF emission mechanism. Since the radius of the IR-emitting shell is determined by the dust sublimation temperature, the break in the IR light curve can be used to measure the bolometric luminosity of the tidal flare. With the low-cadence WISE observations as a proof-of-concept, the time is ripe to use warm Spitzer observations to make a major breakthrough: we wish to obtain the first well-sampled light curve of dust reverberation by a stellar tidal flare. If successful, these observations will have lasting impact; near-future synoptic surveys (ZTF, LSST) will find thousands of TDFs per year, which can be followed-up by IR missions (JWST, WFIRST) to obtain a census of dust within the sphere of influence of quiescent supermassive black holes.

Spitzer Space Telescope - Directors Discretionary Time Proposal #12131

Detecting early IR emission from dust heated by a tidal disruption flare.

Principal Investigator: Sjoert van Velzen
Institution: JHU

Technical Contact: Varoujan Gorjian, JPL

Co-Investigators:
Suvi Gezari, UMD
Tiara Hung, UMD
Bradley Cenko, GSFC
Varoujan Gorjian, JPL

Science Category: AGN/QSO/RG
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 2.9

Abstract:
A stellar tidal disruption flare (TDF) occurs when a star gets too close to a supermassive black hole and is shredded into streams that are accreted. New TDFs can be discovered by their transient optical or X-ray emission. We have recently made a discovery that opens a new wavelength regime for the study of these flares: transient emission at 3 micron in WISE multi-epoch imaging. This emission is best understood as originating from dust that has been heated by the intense UV and X-ray emission of the flare. However, the 6-month cadence of the WISE observations is too low to critically test this dust reprocessing model. Using optical observations of the iPTF survey, we recently discovered a very strong TDF candidate that is currenlty only a few weeks past maximum light. Since TDFs are rare, this new source provides an unique oppurtunity for Spitzer to make a very important contribution to this field. We proposed 7 Spitzer follow-up observations of this flare, which would yield the first early-time light curve of IR emission from a tidal flare. This data will be crucial to estabilish (or rule-out) dust reprocessing as the origin of IR emission from TDFs.

Spitzer Space Telescope - Directors Discretionary Time Proposal #13154

A rare opportunity to characterize dust emission from a stellar tidal disruption event

Principal Investigator: Sjoert van Velen
Institution: JHU

Technical Contact: Varoujan Gorjian, JPL

Co-Investigators:
Varoujan Gorjian, JPL
Ori Fox, STScI
Suvi Gezari, UMD

Science Category: AGN/QSO/RG
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1.5

Abstract:
A stellar tidal disruption flare (TDF) occurs when a star gets too close to a supermassive black hole and is shredded into streams that are accreted. We have recently discovered transient emission from TDFs in WISE multi-epoch imaging data. This emission is best understood as originating from dust that has been heated by the intense optical to X-ray emission of the flare. Besides providing valuable information about the total energy emitted during a stellar disruption, this dust echo also provides a unique tool to study dust within the nucleus of inactive galaxies. However, the 6-month cadence of the WISE observations is too low to fully constrain all parameters of TDF dust reprocessing models. The temperature of the dust during the peak of the flare is poorly constrained, but expected to be T~1800. For this temperature, both K-band and warm Spitzer observations are needed to sample the peak of the dust SED. Previous attempts to measure the dust temperature near the peak have failed; these observations were not sensitive enough or were obtained too late after the peak of the TDF light curve. The recently discovered transient iPTF-16fnl is the lowest redshift TDF found to date and thus provides a unique opportunity to obtain both rapid and very sensitive observations of a TDF dust echo. We propose 6 epochs of Spitzer observations to measure, for the first time, the evolution of the dust temperature as it gets heated by the radiation of a stellar tidal disruption flare.

Spitzer Space Telescope - General Observer Proposal #60094

Faint Stellar Distributions in Extended HI Disks

Principal Investigator: Liese van Zee
Institution: Indiana University

Technical Contact: Daniel Dale, University of Wyoming

Co-Investigators:
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Daniela Calzetti, University of Massachusetts
Julianne J. Dalcanton, University of Washington
James S. Bullock, University of California Irvine
Rupali Chandar, University of Toledo
Joannah L. Hinz, University of Arizona

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 69.6

Abstract:
In Lambda-CDM models, galactic disks are built through the accretion of small satellites and through in situ star formation activity. We propose to obtain deep observations with IRAC bands 1 and 2 to trace the faint extended stellar component of nearby gas-rich galaxies in order to investigate models of galactic disk formation and growth. While little is currently known about the full spatial extent of the stellar component within a dark matter halo, we have identified a sample of 5 gas-rich galaxies with extremely large HI disks (D_HI/D_opt > 5) as being the most likely candidates to harbor extended faint stellar populations. The proposed deep IR observations will allow us to trace their stellar distributions to unprecedented levels at wavelengths that are insensitive to both dust extinction and the galaxy's star formation history. Because our observations are exploratory in nature, we also propose observations of a control sample of 4 gas-rich galaxies with normal HI distributions (D_HI/D_opt ~ 2) in order to investigate the extent and nature of faint stellar populations in the outer disks of galaxies. Comparison of the observed IR surface brightness profiles with multiwavelength data (from UV to radio) will reveal the characteristics of the extended disk and provide insight into disk growth and evolution of gas-rich galaxies.

Spitzer Space Telescope - General Observer Proposal #80025

Stellar Distributions in Dark Matter Halos: Looking Over the Edge

Principal Investigator: Liese van Zee
Institution: Indiana University

Technical Contact: Daniel Dale, University of Wyoming

Co-Investigators:
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Kate L. Barnes, Indiana University
Shawn Staudaher, University of Wyoming
Daniela Calzetti, University of Massachusetts
Julianne J. Dalcanton, University of Washington
James S. Bullock, University of California, Irvine
Rupali Chandar, University of Toledo

Science Category: nearby galaxies (z<0.05, v_sys<15,000 km/s)
Observing Modes: IRAC Post-Cryo Mapping
Hours Approved: 1005.3

Abstract:
We propose to obtain deep observations with IRAC bands 1 and 2 to trace the faint extended stellar component of nearby galaxies. Little is known about the full extent of the stellar distribution in normal galaxies; deep IR observations of the area around galaxies will allow us to trace the stellar distribution to unprecedented levels. Our sample will include galaxies with a range of morphology, inclination angle, luminosity, and environment in order to explore fully the diverse range of galaxy properties and to enhance the legacy value of this data set. These observations will enable a wide variety of projects, including investigation of thick disks and halo formation, identification of old and young star clusters, and identification of stars well beyond the bright stellar disk. The proposed observations will provide not only a census, but also the first quantitative measurements of the physical properties of low surface brightness features identified around nearby galaxies (e.g., stellar mass surface density, distribution, and fraction of total stellar mass). With sensitivity to substructures featuring stellar mass surface densities of only a few x 0.01 M_sun/pc^2, this project will provide the first look at the stellar edge for a large sample of galaxies and will be instrumental in providing observational constraints for galaxy formation models.