Eric Becklin –
Pioneer of Infrared Astronomy

Karl Menten
MPIfR

Before Eric: Prehistoric IR astronomy

PUBLICATIONS
OF THE
Astronomical Society of the Pacific.

VOL. XXVI SAN FRANCISCO, CALIFORNIA, OCTOBER, 1914 No. 155

NOTE ON THE RADIATION FROM STARS.

BY W. W. COBLENTZ.

The termination of the present investigation marks a new epoch in radiometry, especially as applied to the measurement of weak radiations. It makes available to the astronomer one more instrument for the investigation of celestial objects. This, of course is not the first attempt to measure the radiation ("heat") from stars. The previous ones wer... stones which gave positive indications of heat fr...

We "see" the stars with our eyes, and it goe... that when we can produce instruments which ... ately sensitive to the eye, we shall be able to ... "light," the radiations, emitted by stars.

The present instrument (a thermo-element) is perhaps a hundred times as sensitive as some of the radiometers used in previous attempts at the measurement of stellar radiation. With it quantitative measurements were made on stars down to the fifth magnitude and highly qualitative measurements were made on stars down to the seventh magnitude.

W. W. Coblentz
1873 –1962

CLIMATIC CONDITIONS ON MARS.*

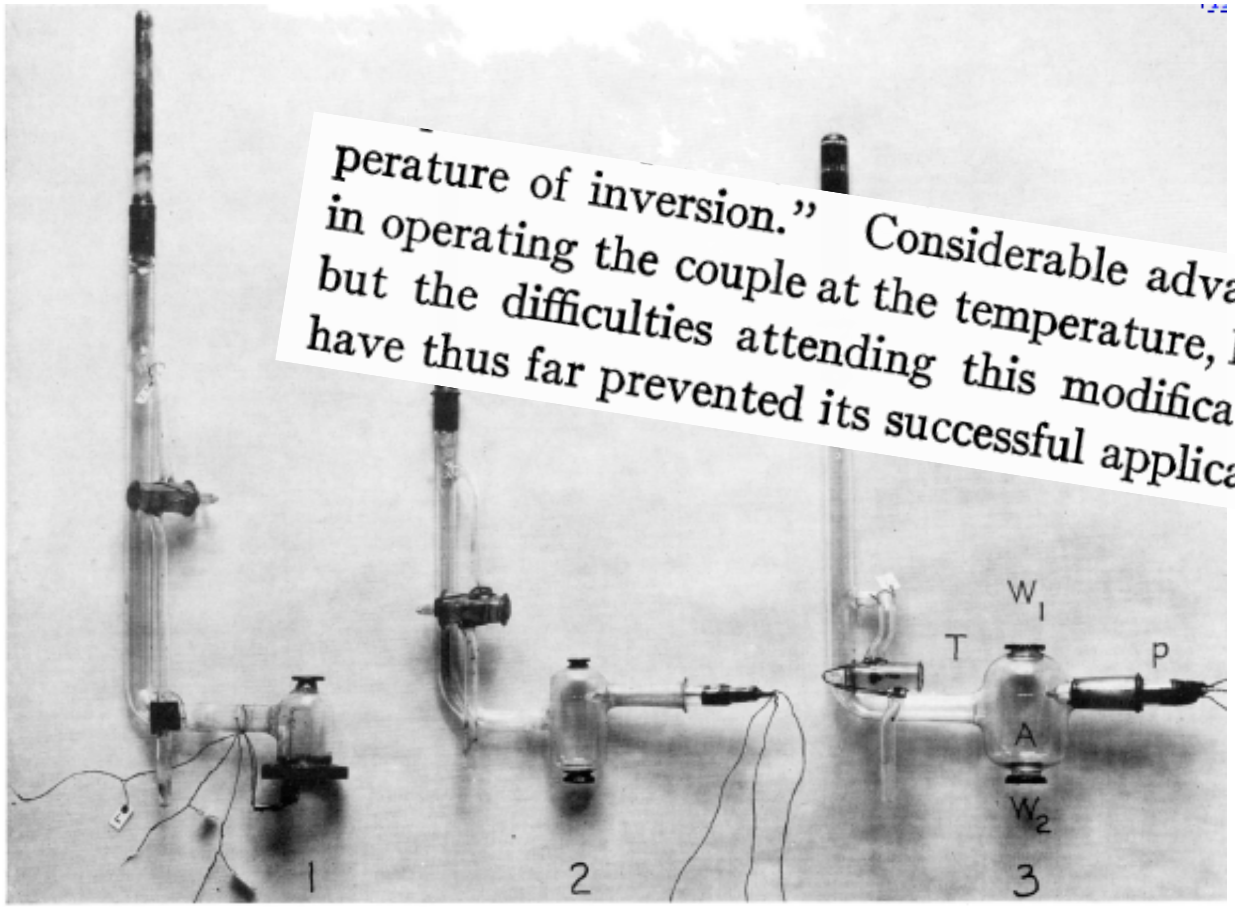
By W. W. COBLENTZ

THE APPLICATION OF VACUUM THERMOCOUPLES TO PROBLEMS IN ASTROPHYSICS[1]

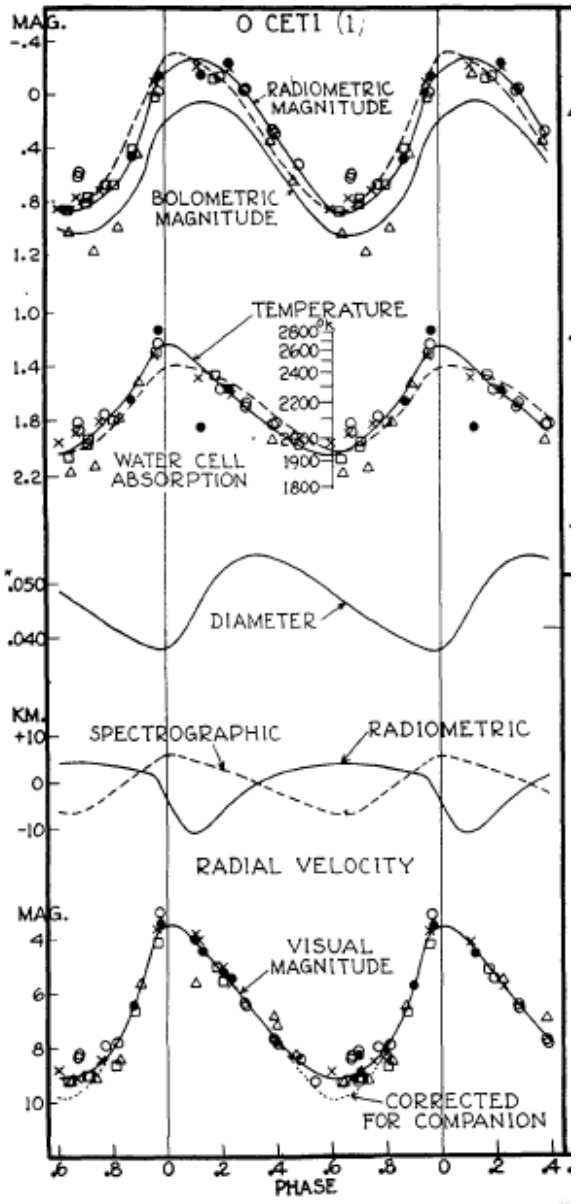
By EDISON PETTIT and SETH B. NICHOLSON

ApJ **56**, 295 (1922)

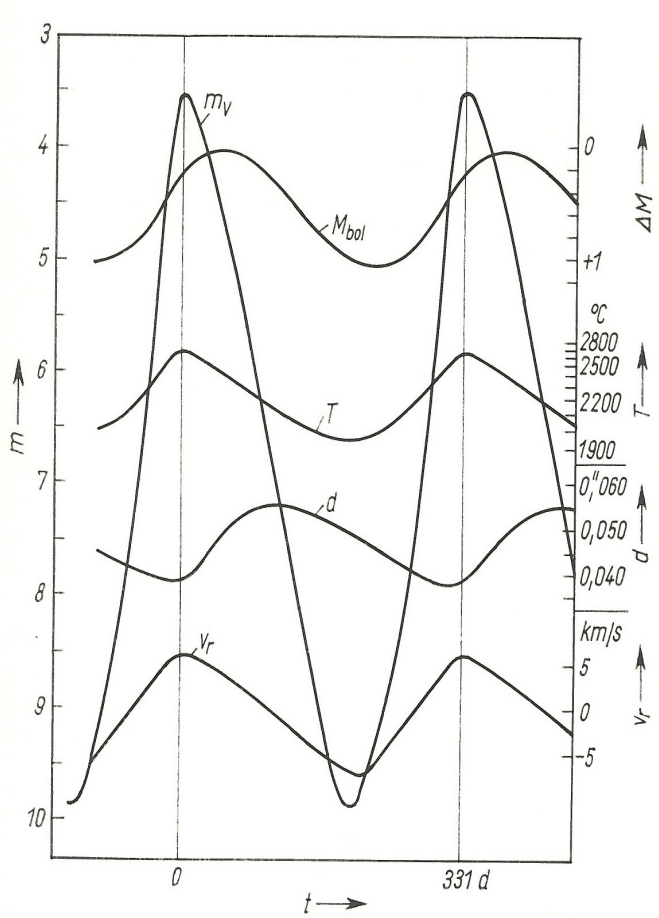
perature of inversion." Considerable advantage would be gained in operating the couple at the temperature, let us say, of liquid air, but the difficulties attending this modification of the apparatus have thus far prevented its successful application.



Types of Thermocouple Cells



Pettit & Nicholson 1933



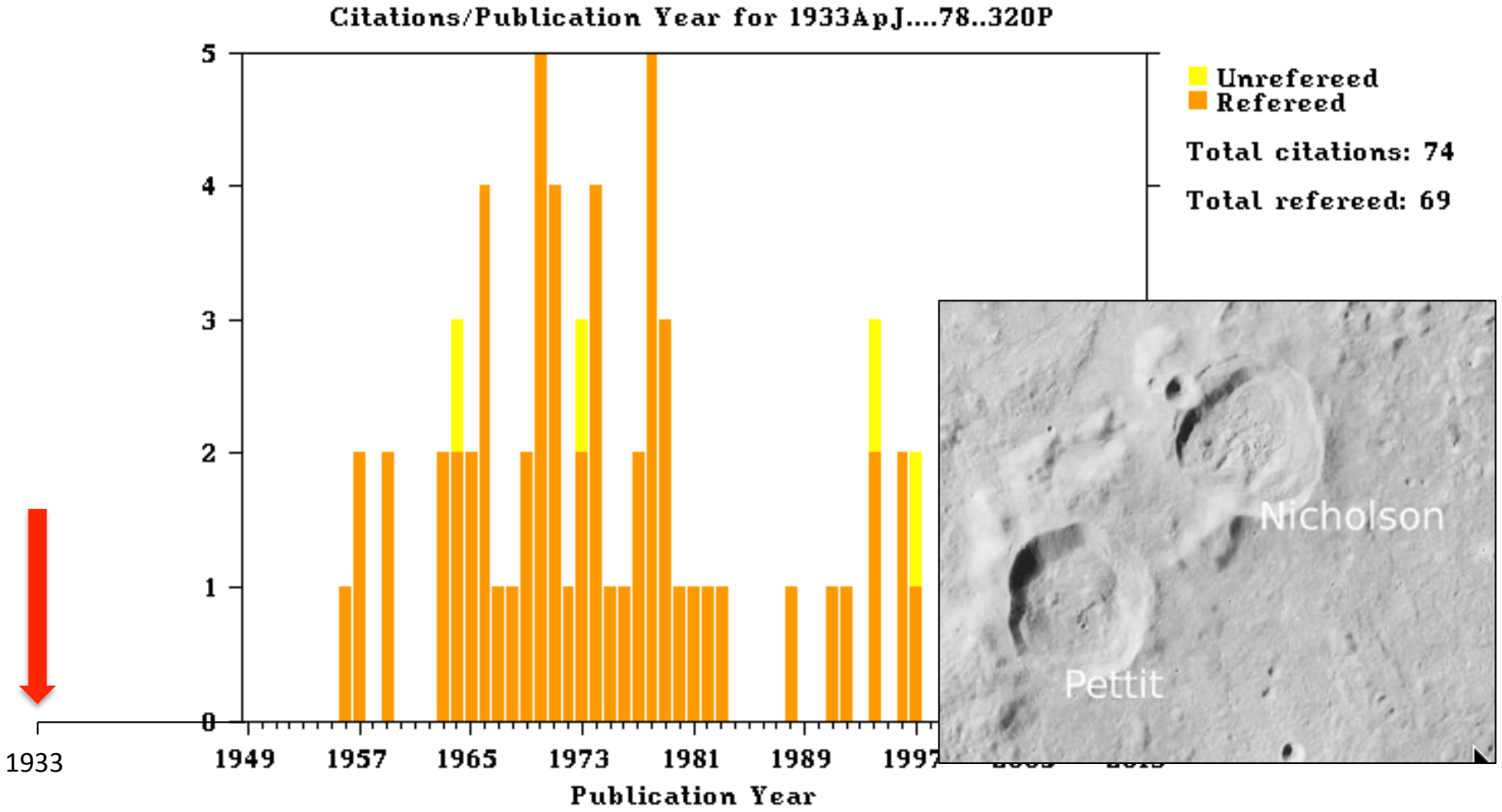
Veraenderliche Sterne
Hoffmeister, Richter, Wenzel
(Berlin: Springer, 1984, 2. ueberarb. Aufl.)

MEASUREMENTS OF THE RADIATION FROM VARIABLE STARS[1]

By EDISON PETTIT and SETH B. NICHOLSON

[1] *Contributions from the Mount Wilson Observatory, Carnegie Institution of Washington*, No. 478.

ApJ **78**, 320 (1933)



ASTRONOMICAL MEASUREMENTS IN THE INFRARED[1]

By Harold L. Johnson

Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona

ARA&A **4**, 193 1966

Discusses practically only stellar astronomy

For the purposes of this discussion, we will ... spectrum as follows:

(*a*) The Near Infrared ... region to approximately 1 μ. This region corresponds ... wavelength sensitivity range of photomultipliers ...

... Intermediate Infrared, covering the range of wavelengths from ... μ, approximately. This region corresponds to the wavelength range for optimum sensitivity of lead sulfide photoconductive cells, cooled by liquid nitrogen.

(*c*) The Far Infrared, covering the range of wavelengths from 4 μ to 22 μ, approximately. There are several newly developed detectors that are sensitive in this spectral region, but the most sensitive is the liquid helium-cooled germanium bolometer developed by F. J. Low (2).

Mid 1960s: The situation changes!

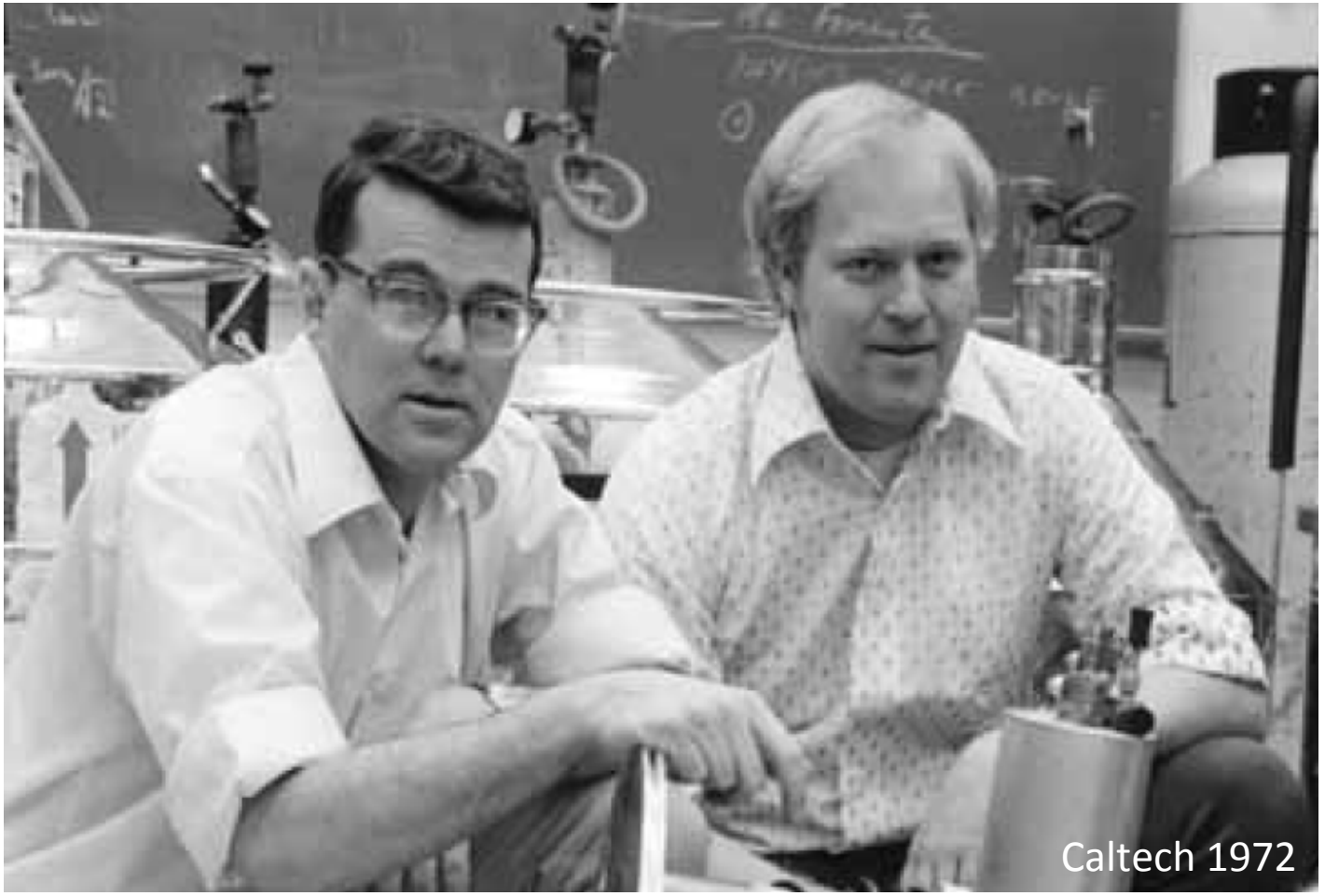
G. Neugebauer & R. B Leighton: Two-micron sky survey

- The Two Micron Sky Survey (TMSS; Neugebauer & Leighton 1969)
- scanned 70% of the sky
- detected 5612 celestial sources of infrared radiation. IRC …

Gerry Neugebauer
1932 –2014

Robert Leighton
1919-1997

Enter Eric (PhD 1968)



PHYSICAL REVIEW VOLUME 136, NUMBER 1B 12 OCTOBER 1964

Experiments on the Average Characteristics of Cascade Showers Produced in Lead by 500- and 1000-MeV Electrons*

B. Sc. Eric E. Becklin† and James A. Earl
School of Physics, University of Minnesota, Minneapolis, Minnesota

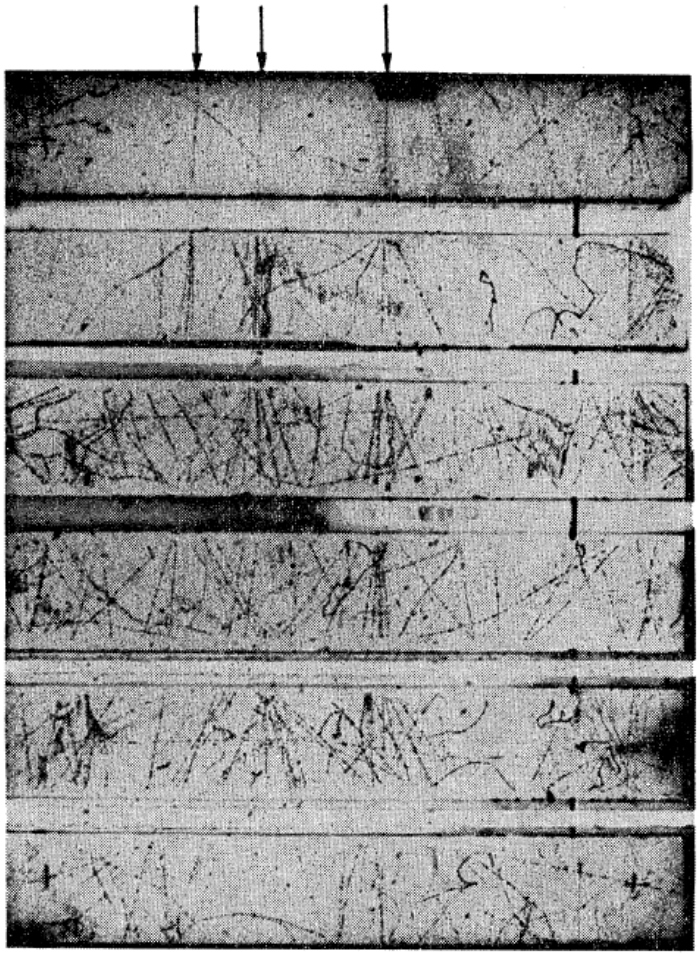
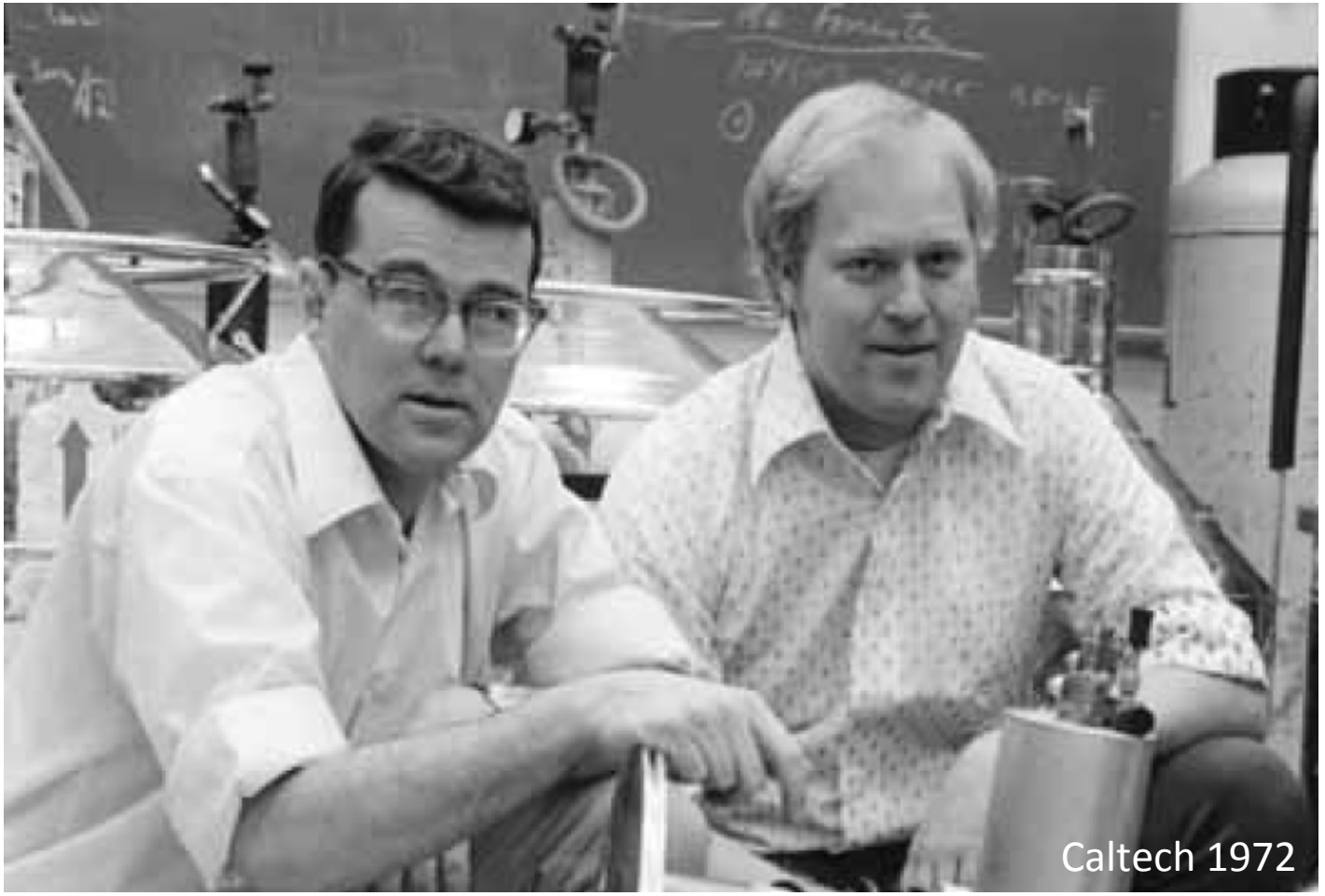
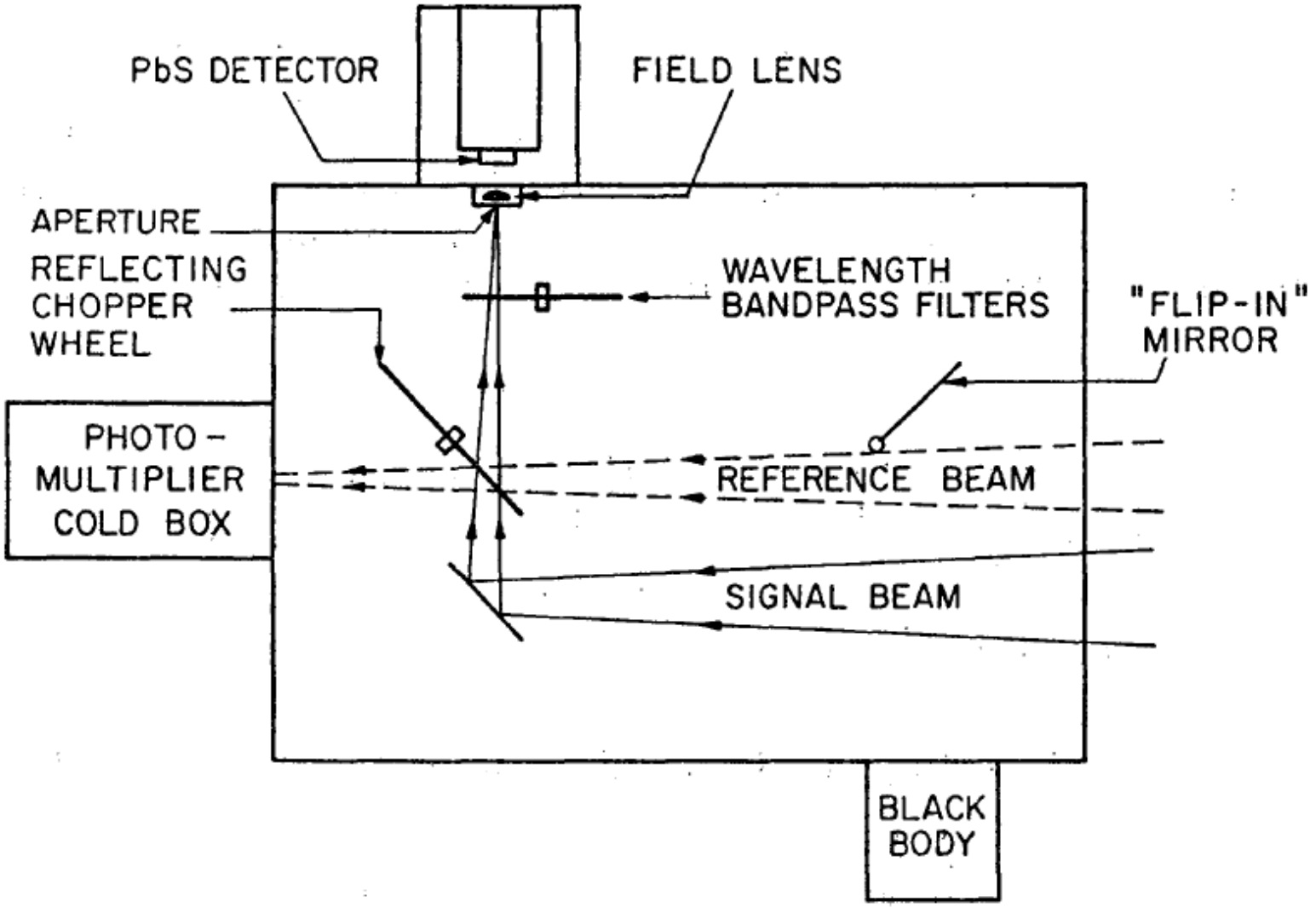


Fig. 1. Three typical 1000-MeV showers as observed in the five-plate cloud chamber.

Enter Eric (PhD 1968)



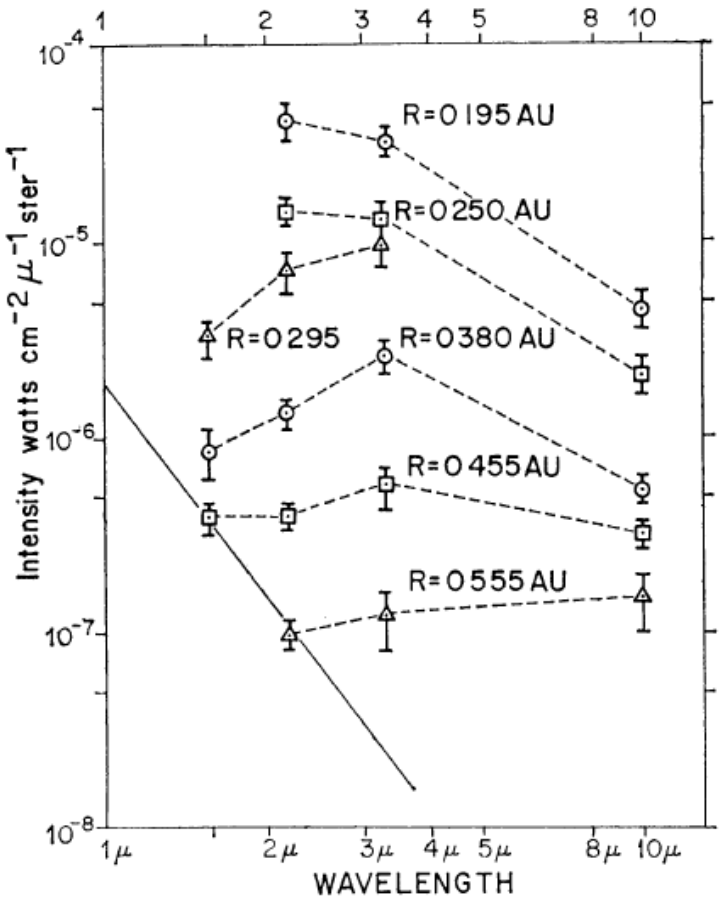
Becklin & Neugebauer's PbS Infrared Photometer

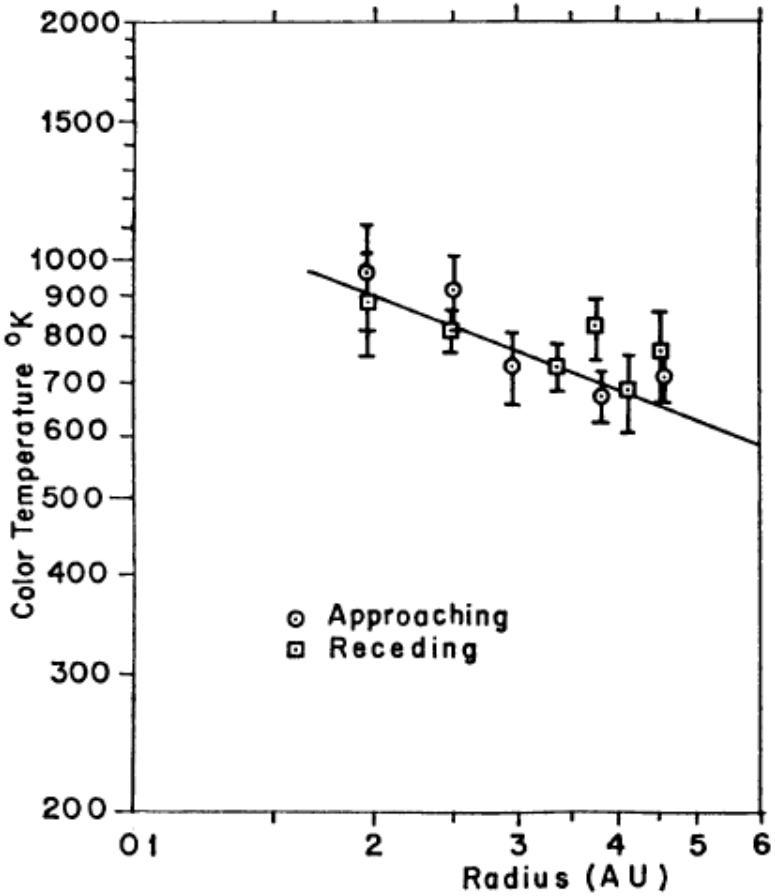


B & N 1968

INFRARED OBSERVATIONS OF COMET 1965f*

E. E. Becklin and J. A. Westphal†
California Institute of Technology
Received February 17, 1966
ApJ **145**, 445 (1966)



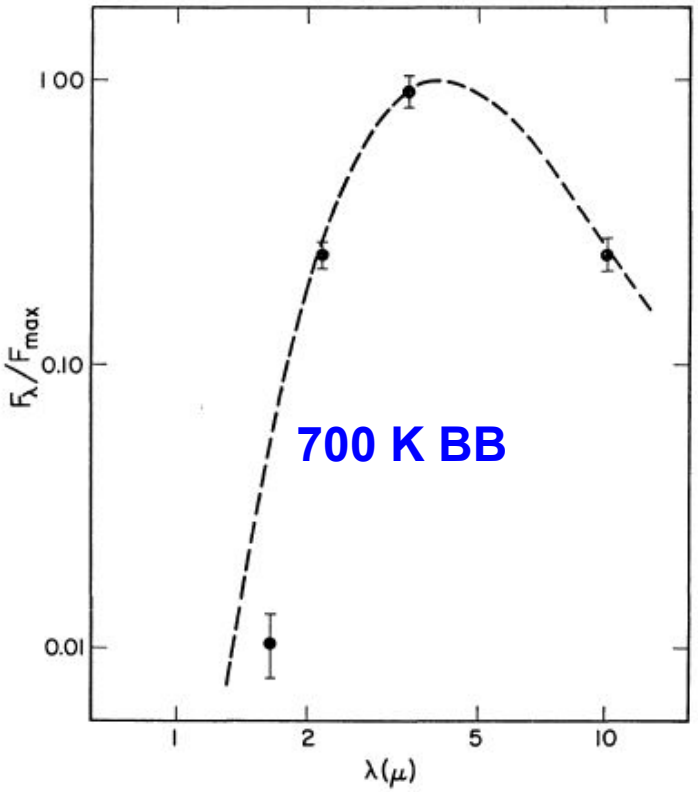


OBSERVATIONS OF AN INFRARED STAR IN THE ORION NEBULA*

E. E. Becklin
G. Neugebauer

September 12, 1966
California Institute of Technology
Pasadena, California

ApJ 147, 799 (1967)



Eric Becklin – Pioneering Infrared Astronomy

Karl Menten
MPIfR

THE ASTROPHYSICAL JOURNAL

LETTERS TO THE EDITOR

VOLUME 149 JULY 1967 NUMBER 1, PART 2

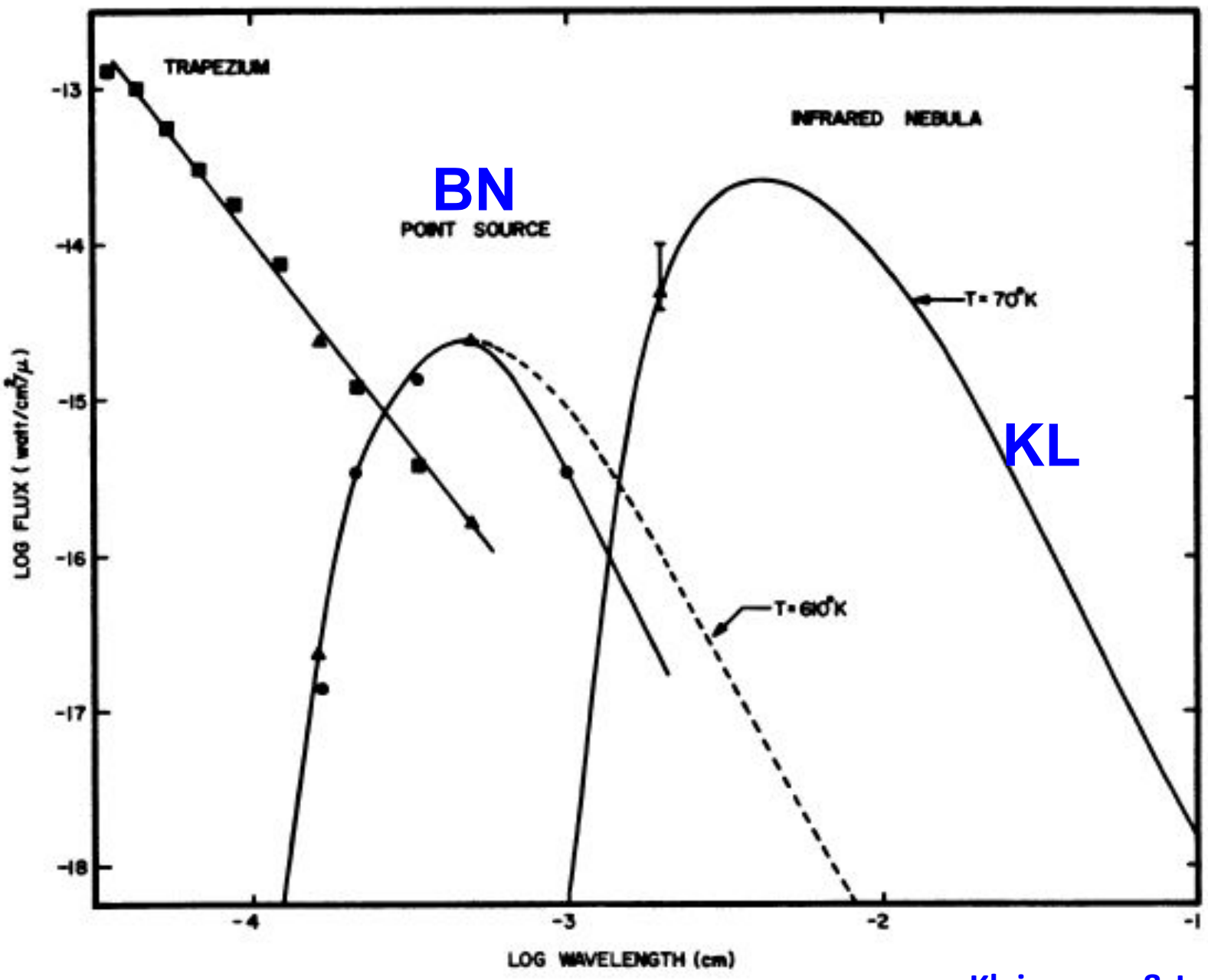
DISCOVERY OF AN INFRARED NEBULA IN ORION

D. E. KLEINMANN
Department of Space Science, Rice University

AND

F. J. LOW
Lunar and Planetary Laboratory, University of Arizona, and
Department of Space Science, Rice University

Received June 1, 1967



Kleinmann & Low 1967

PHYSICAL PARAMETERS

	Infrared Nebula	Point Source
$\alpha(1900)$	$5^h30^m19^s.4$ ($\pm 0^s.1$)	$5^h30^m19^s.7$ ($\pm 0^s.2$)
$\delta(1900)$	$-5°26'38''$ ($\pm 3''$)	$-5°26'19''$ ($\pm 6''$)
Angular diameter	$>30''$	$0''.06$
Magnitude	$Q=-7.0$ (30″ beam)	$M=-0.08$ (13″ beam)
22-μ flux	$>5\times10^{-15}$ watt cm^{-2} μ^{-1}	$<1\times10^{-16}$ watt cm^{-2} μ^{-1}
Distance	500 pc	500 pc
Linear diameter	2.3×10^{17} cm	4.8×10^{14} cm
Observed luminosity	3×10^3 $L\odot$	1.4×10^3 $L\odot$
Total luminosity	$>1\times10^5$ $L\odot$	1.4×10^3 $L\odot$
Effective temperature	$\sim70°$ K	$\sim610°$ K
Mass	10^2–10^3 $M\odot$	?
Lifetime	$\geq2\times10^3$ years	?

It follows from the above that the effective temperature is 70° K and the luminosity is

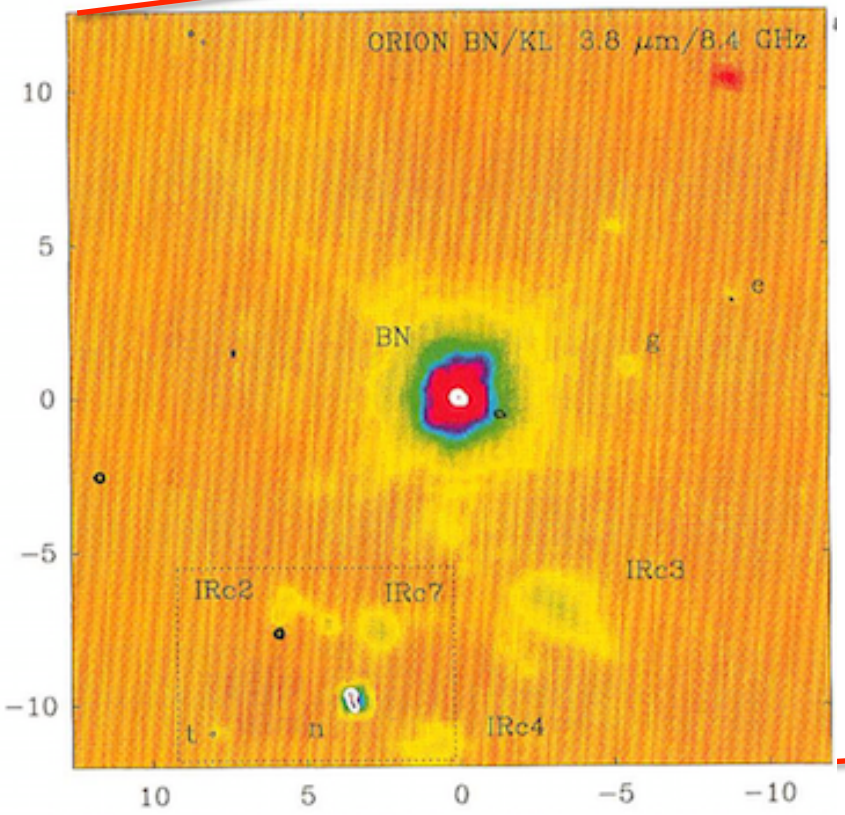
$$L = 4\pi\sigma T_e^4 R^2 \approx 1 \times 10^5 L\odot ,$$

K & L 1967

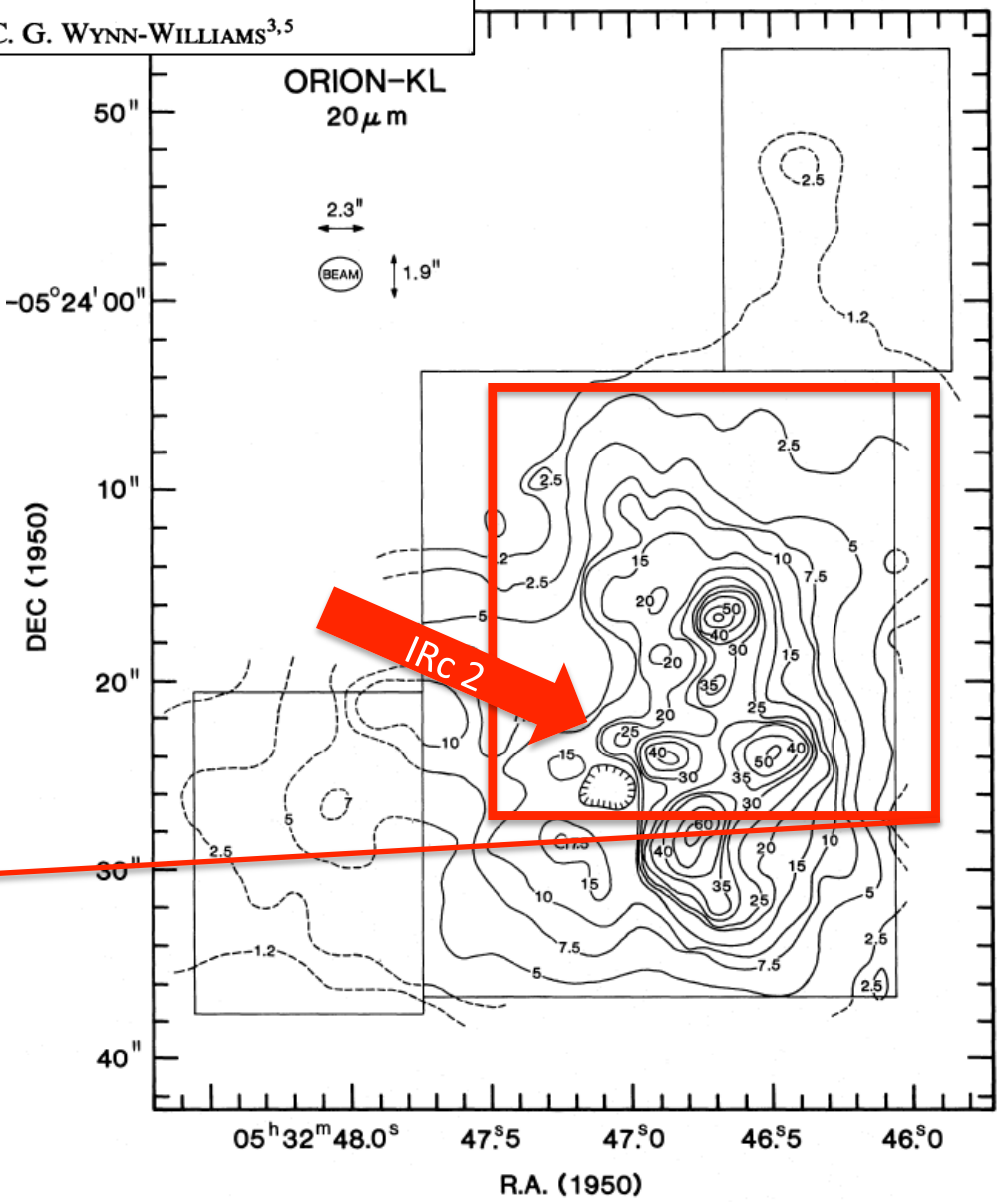
THE ASTROPHYSICAL JOURNAL, 244: 869–883, 1981 March 15

OUTFLOW OF MATTER IN THE KL NEBULA: THE ROLE OF IRc2

D. DOWNES,[1,5] R. GENZEL,[2,5] E. E. BECKLIN,[3,4] and C. G. WYNN-WILLIAMS[3,5]



Menten & Reid 1995



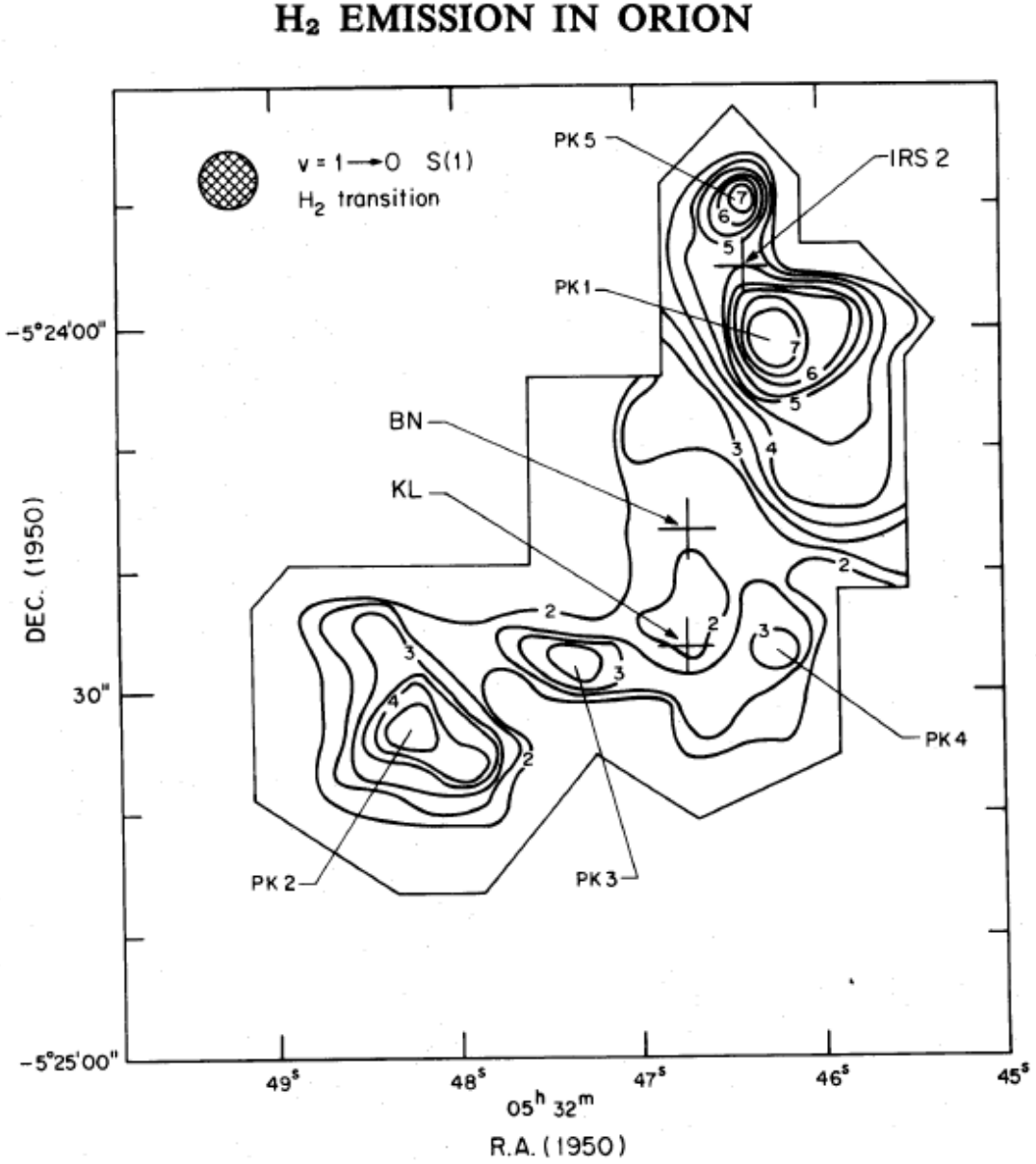
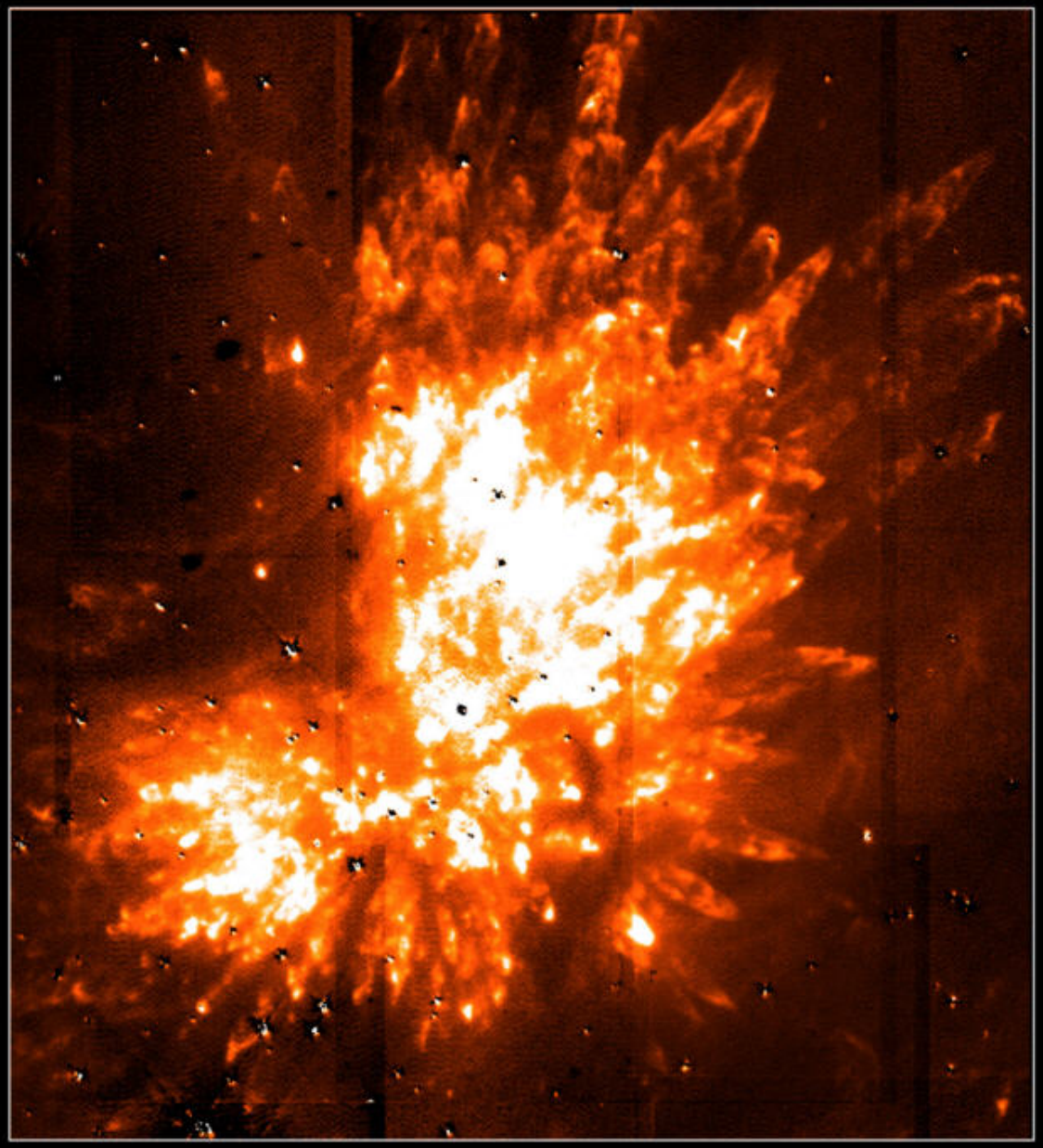


FIG. 2.—The molecular hydrogen emission in Orion as seen in the $v = 1 \rightarrow 0$ $S(1)$ transition with 5″ spatial resolution.

Beckwith, Persson, Neugebauer & Becklin 1978



Orion KL

Subaru Telescope, National Astronomical Observatory of Japan

CISCO (H_2 (v=1-0 S(1)) – Cont)

January 28, 1999

Kaifu et al. 2000

The Astronomical Journal, 129:2281–2293, 2005 May

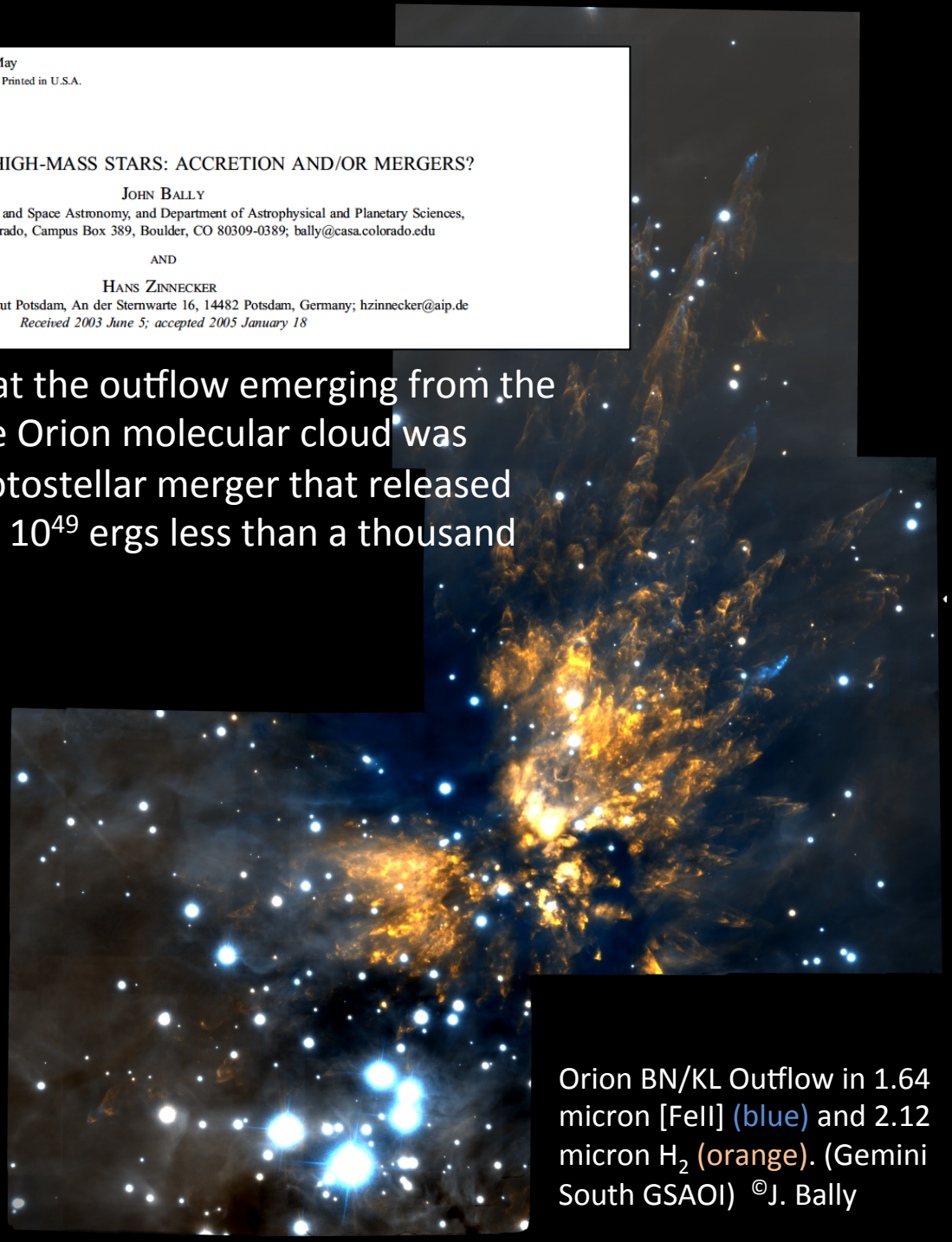
THE BIRTH OF HIGH-MASS STARS: ACCRETION AND/OR MERGERS?

John Bally
Center for Astrophysics and Space Astronomy, and Department of Astrophysical and Planetary Sciences, University of Colorado, Campus Box 389, Boulder, CO 80309-0389; bally@casa.colorado.edu

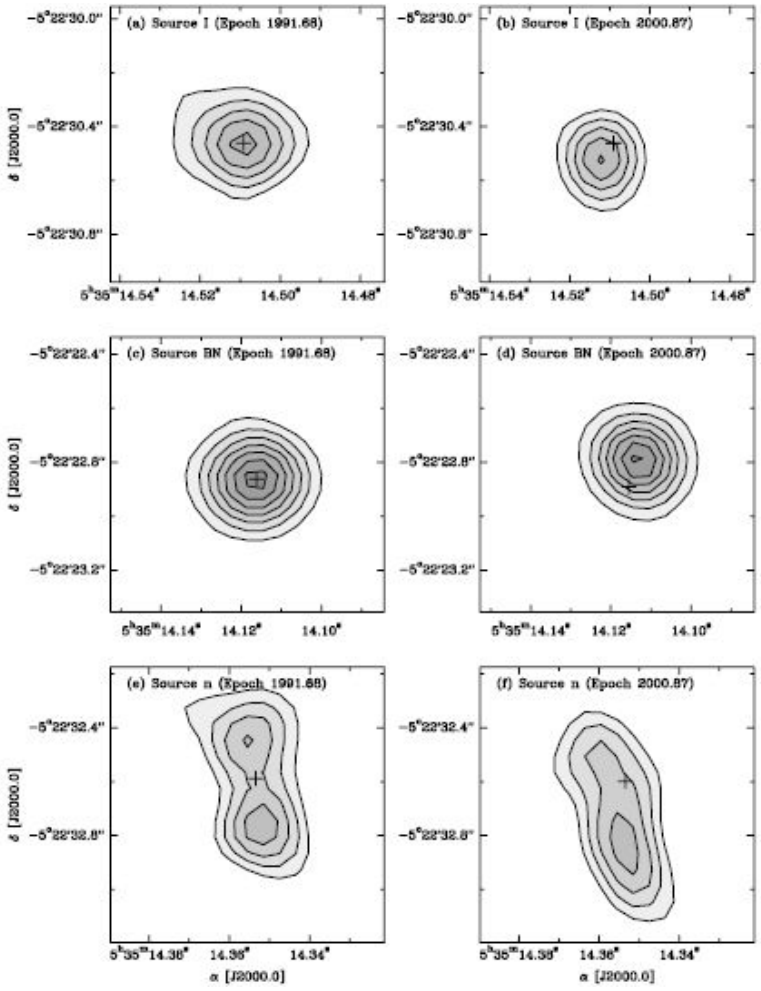
and

Hans Zinnecker
Astrophyskalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany; hzinnecker@aip.de
Received 2003 June 5; accepted 2005 January 18

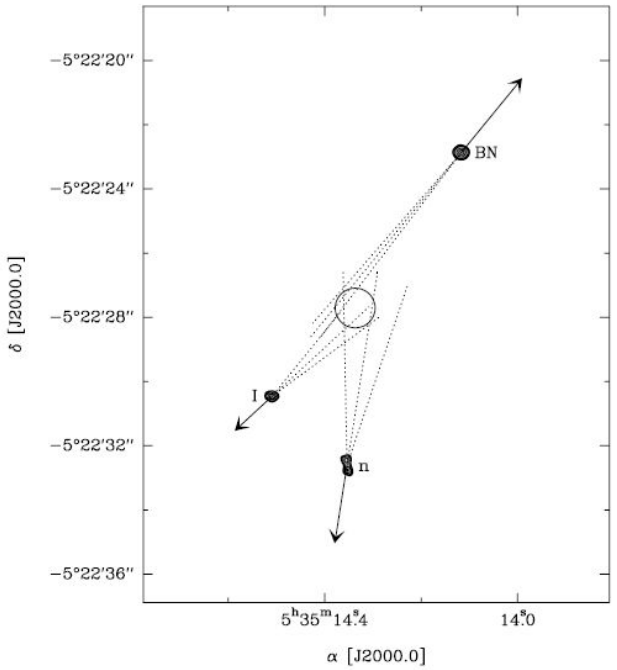
"It is proposed that the outflow emerging from the OMC-1 core in the Orion molecular cloud was produced by a protostellar merger that released between 10^{48} and 10^{49} ergs less than a thousand years ago."



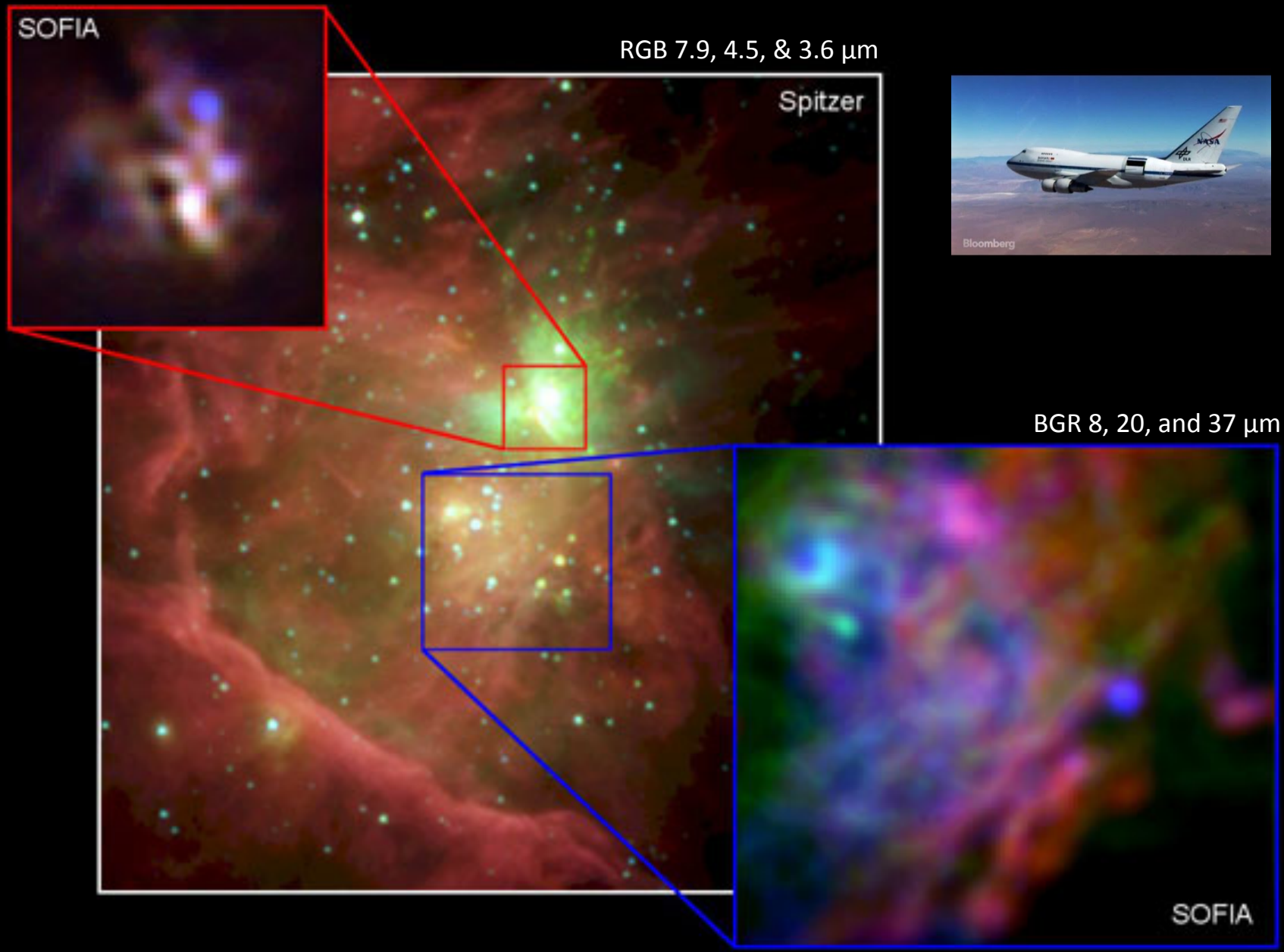
Orion BN/KL Outflow in 1.64 micron [FeII] (blue) and 2.12 micron H_2 (orange). (Gemini South GSAOI) ©J. Bally



Gomez et al. (2006) measured proper motions and found that BN, I, and n all move away from each othe



Time of event: about 500 y ago



Shuping et al. 2012
De Buizer et al. 2012

http://www.spaceref.com/news/viewpr.html?pid=35594

THE ASTROPHYSICAL JOURNAL, Vol. 158, December 1969

THE UNUSUAL INFRARED OBJECT IRC+10216*

E. E. BECKLIN†
California Institute of Technology, Pasadena

AND

J. A. FROGEL, A. R. HYLAND, J. KRISTIAN, AND G. NEUGEBAUER
Mount Wilson and Palomar Observatories, Carnegie Institute of Washington,
California Institute of Technology

Received 1969 October 22

ABSTRACT

IRC+10216 is an extended object located out of the galactic plane in an unreddened region. At 5 μ it is the brightest source observed outside the solar system; at 2.2 μ it varies by as much as 2 mag, with a time scale on the order of 600 days. Its energy distribution resembles that of a 650° K blackbody, and no spectral features have been observed in the wavelength range from 1.5 to 14 μ. The object is interpreted as being consistent with a galactic source surrounded by an optically thick dust shell.

630 days

THE ASTROPHYSICAL JOURNAL, 161:L95–L99, August 1970

SCANNER OBSERVATIONS OF THE LEO INFRARED OBJECT IRC+10216*

JOSEPH S. MILLER
Lick Observatory, Board of Studies in Astronomy and Astrophysics,
University of California, Santa Cruz

Received 1970 June 8

ABSTRACT

Scanner observations of IRC+10216 in 7000–11000 Å indicate the presence of three absorption features which are identified that the object is a carbon star surrounded by a dust cloud; the cloud i

It's a carbon star!

PHYSICAL JOURNAL, 162:L15–L18, October 1970

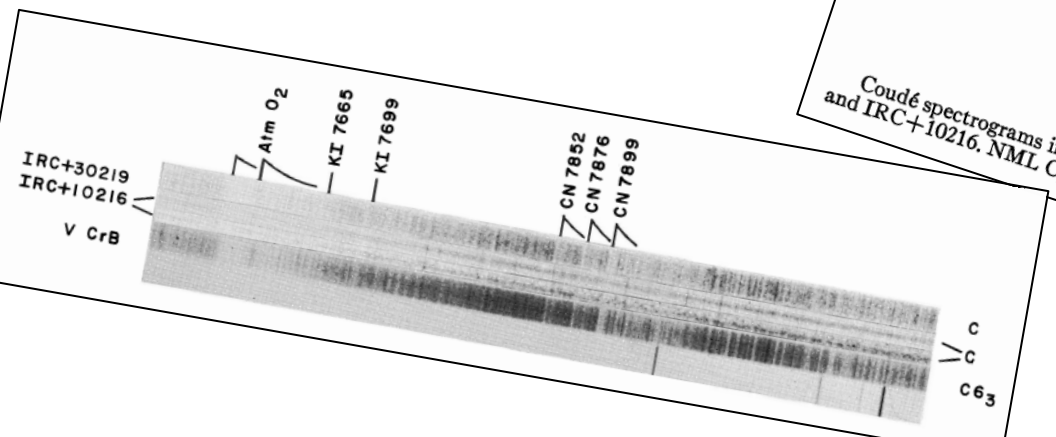
NEAR-INFRARED SPECTRA OF NML CYGNI AND IRC+10216*

G. H. HERBIG AND R. R. ZAPPALA
Lick Observatory, Board of Studies in Astronomy and
Astrophysics, University of California, Santa Cruz

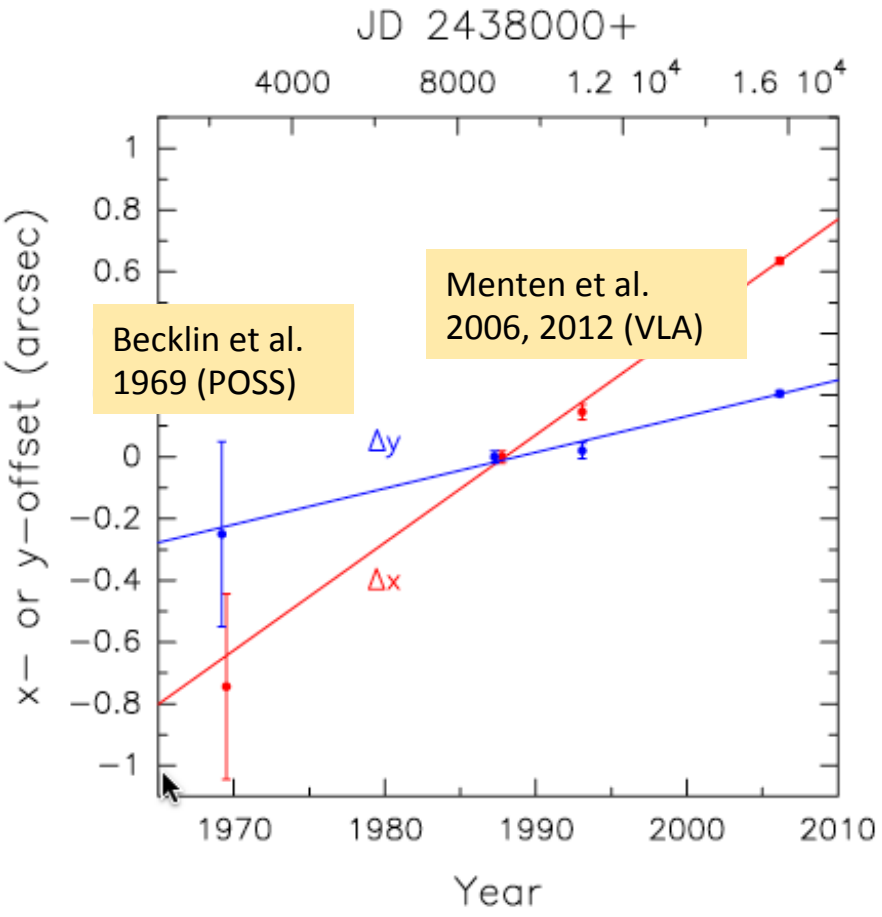
Received 1970 August 19

ABSTRACT

Coudé spectrograms in the 7500–8700 Å region have been obtained of the infrared sources NML Cyg and IRC+10216. NML Cyg appears to be a normal M6 III, while IRC+10216 is a late-type carbon star.



IRC+10216's Proper Motion



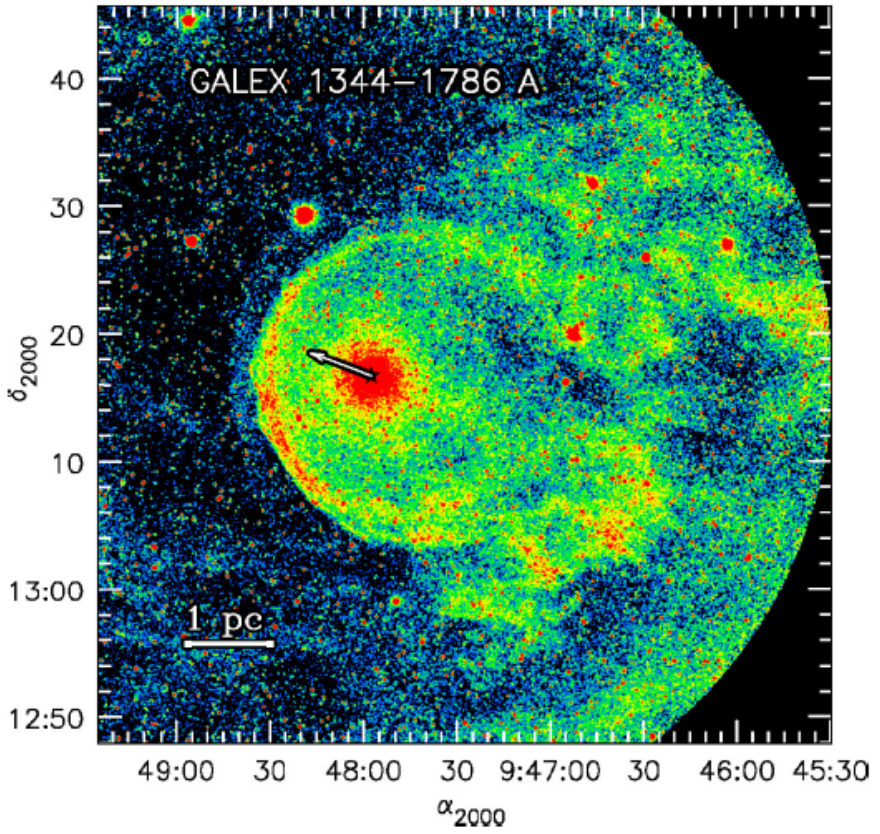
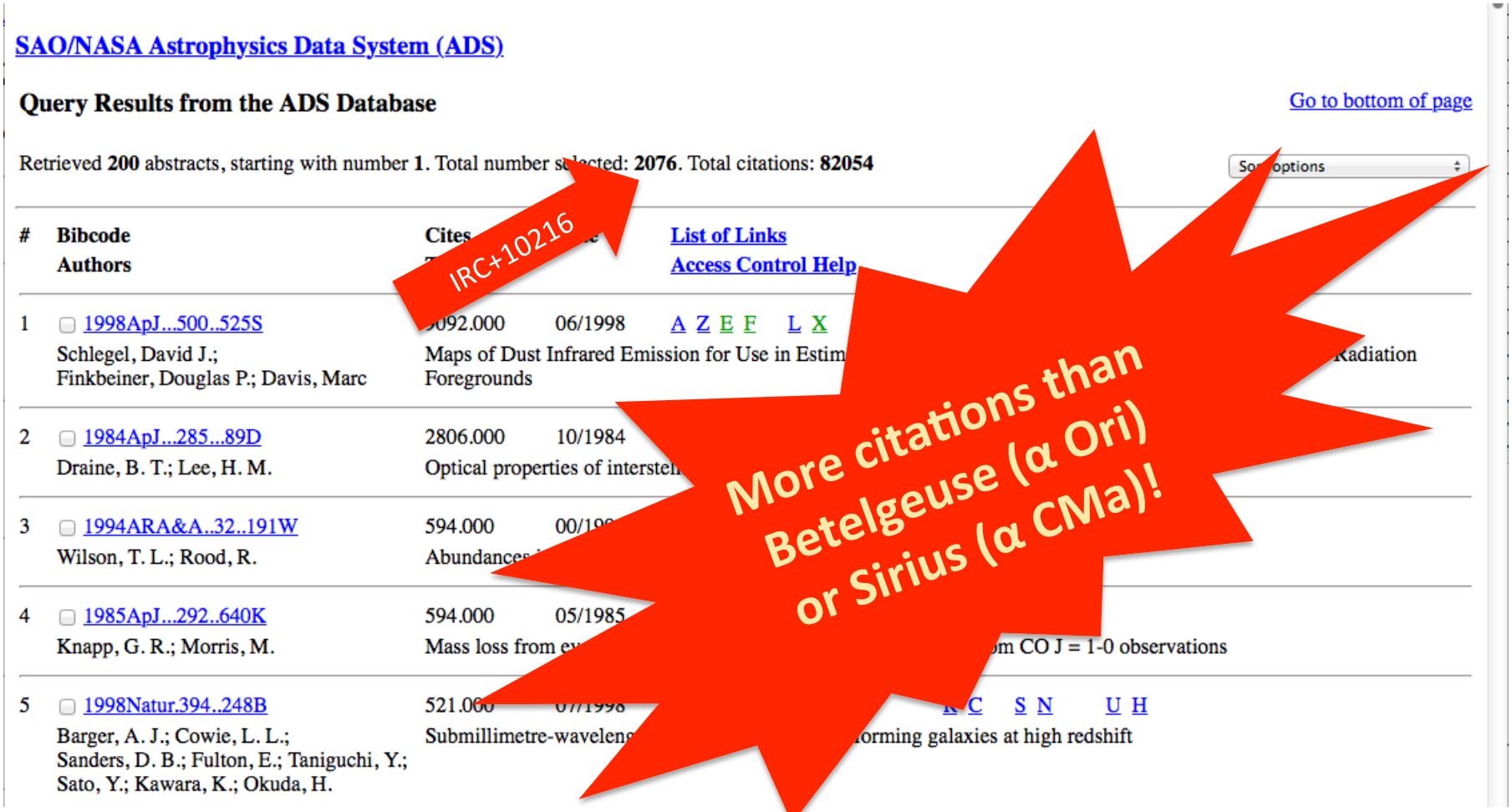


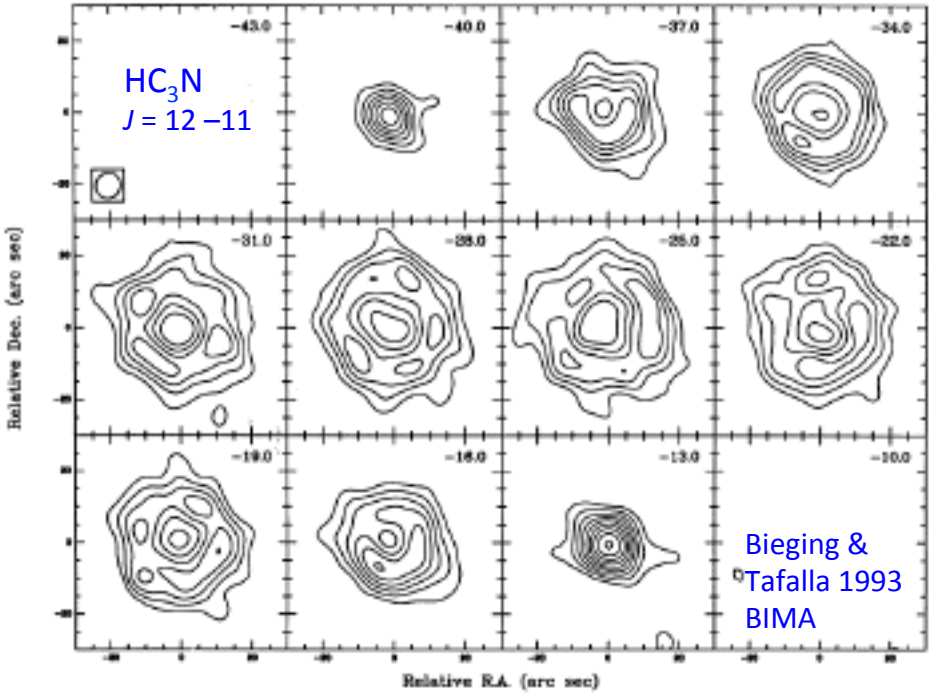
Fig. 4. IRC+10216 as seen by GALEX in 2008 in the FUV band (see

Menten et al. 2012

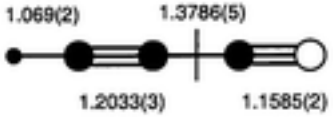
Eric made IRC+10216 (= CW Leo) one of the most famous stars in the sky



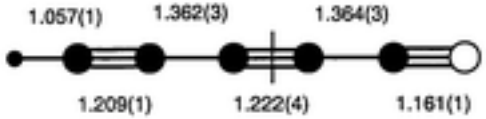
IRC+10216 is the richest source for circumstellar chemistry studies



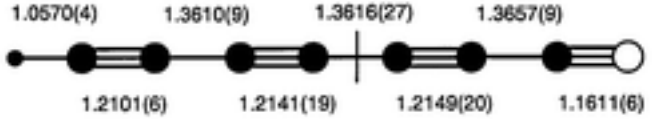
HC_3N



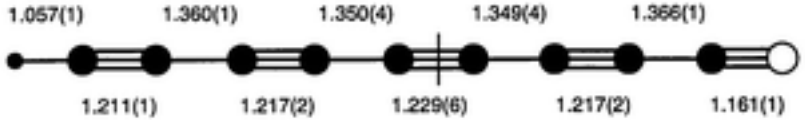
HC_5N



HC_7N



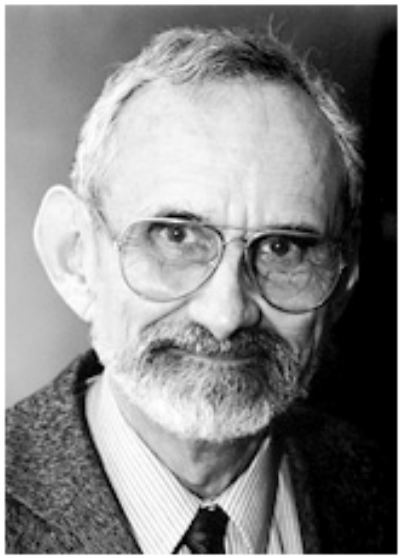
HC_9N



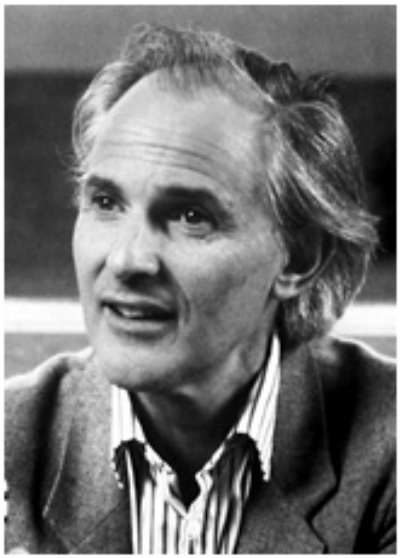
http://pubs.rsc.org/

The Nobel Prize in Chemistry 1996

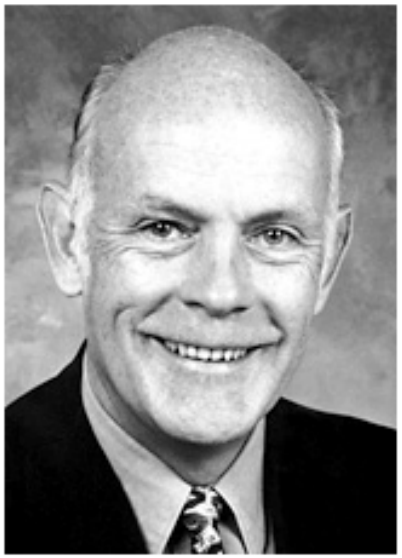
Robert F. Curl Jr., Sir Harold Kroto, Richard E. Smalley



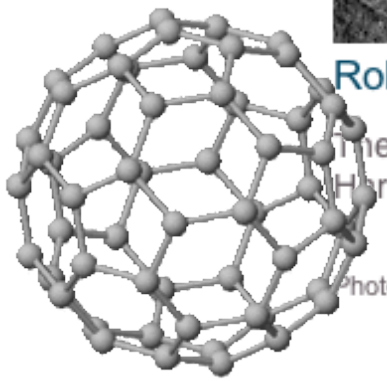
Robert F. Curl Jr.



Sir Harold W. Kroto



Richard E. Smalley



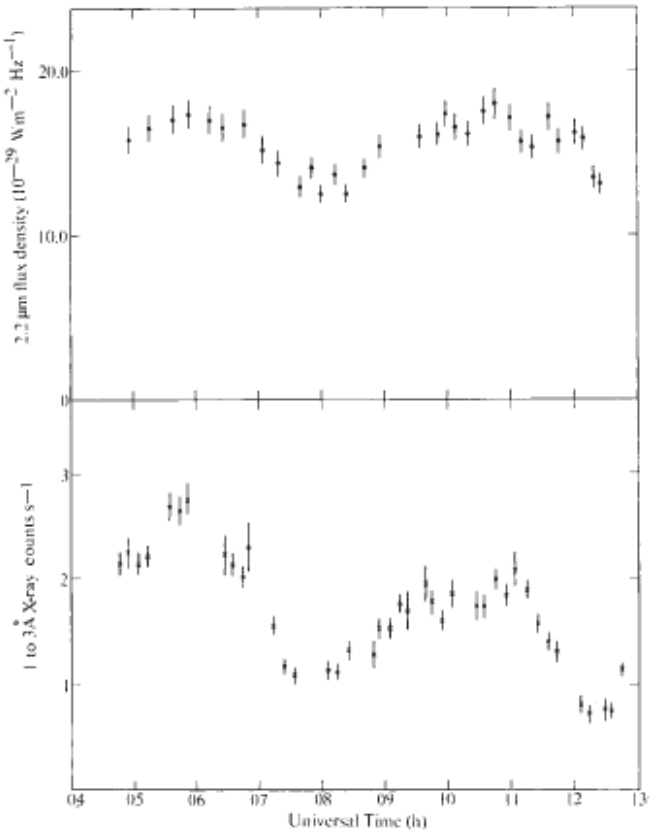
The Nobel Prize in Chemistry 1996 was awarded jointly to Robert F. Curl Jr., Sir Harold W. Kroto and Richard E. Smalley *"for their discovery of fullerenes"*.

Microquasars

LETTERS TO NATURE

Infrared and X-ray Variability of Cyg X-3

NATURE VOL. 245 OCTOBER 12 1973



IR Identification of the luminous X-ray and radio emitting high mass X-ray binary Cygnus X 3

- No optical ID
- Correlated X-ray and IR variability

Becklin et al. 1972, 1973, 1974

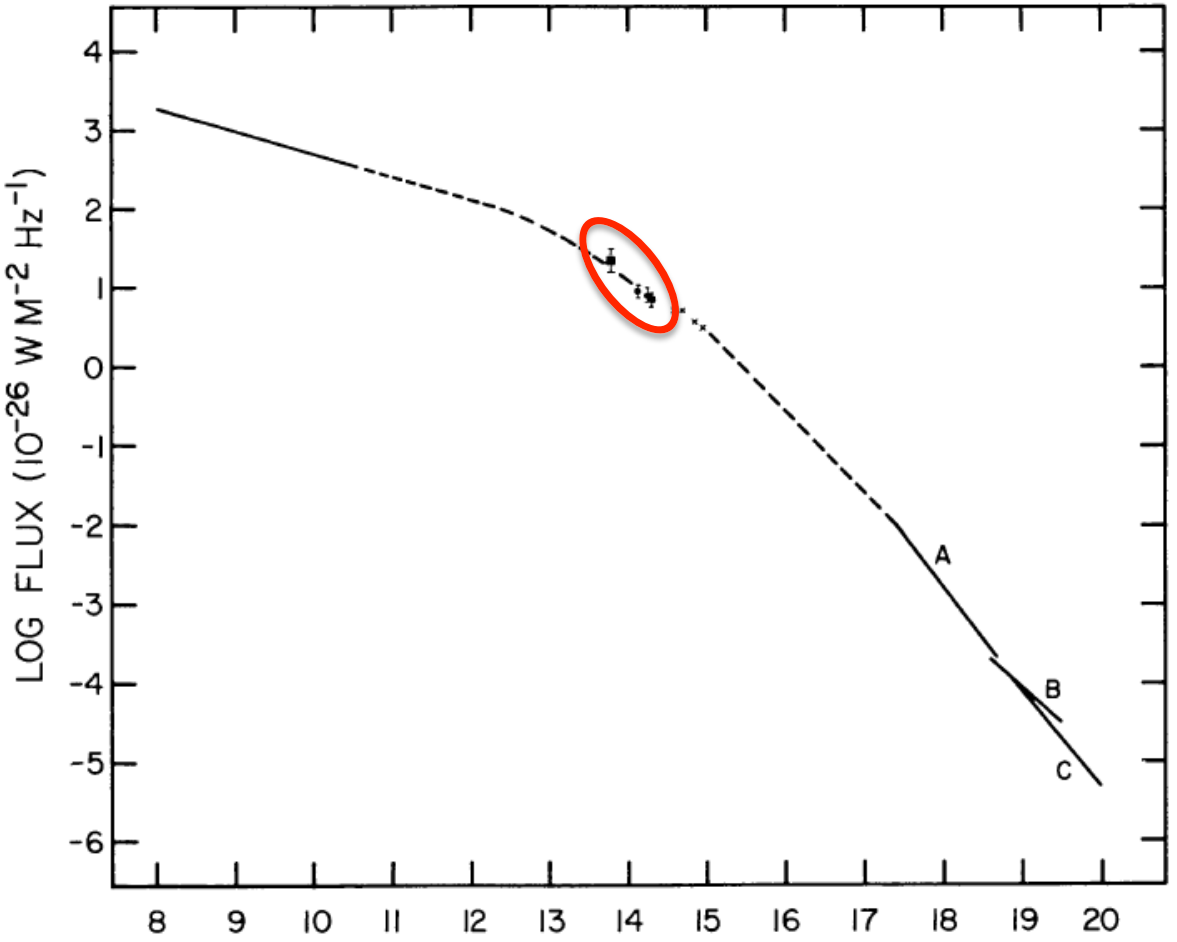
Also: SS 433 Wynn-Williams & Becklin 1979

THE ASTROPHYSICAL JOURNAL, Vol. 152, April 1968

INFRARED OBSERVATIONS OF THE CRAB NEBULA*

E. E. BECKLIN
California Institute of Technology, Pasadena
AND
D. E. KLEINMANN
Department of Space Science, Rice University, Houston, Texas

The Crab

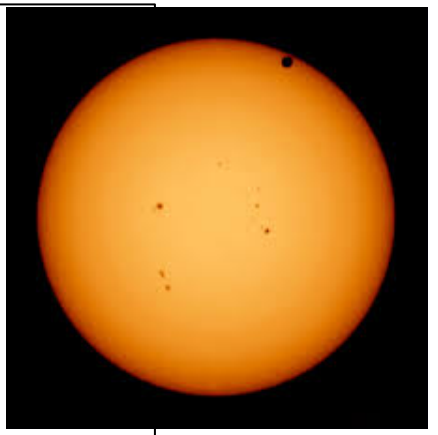


Submillimeter Solar Research with the KAO

E. E. Becklin
University of California, Los Angeles, CA 90024

C. Lindsey
National Solar Observatory, P. O. Box 26732, Tucson, AZ 85726-6732

1995



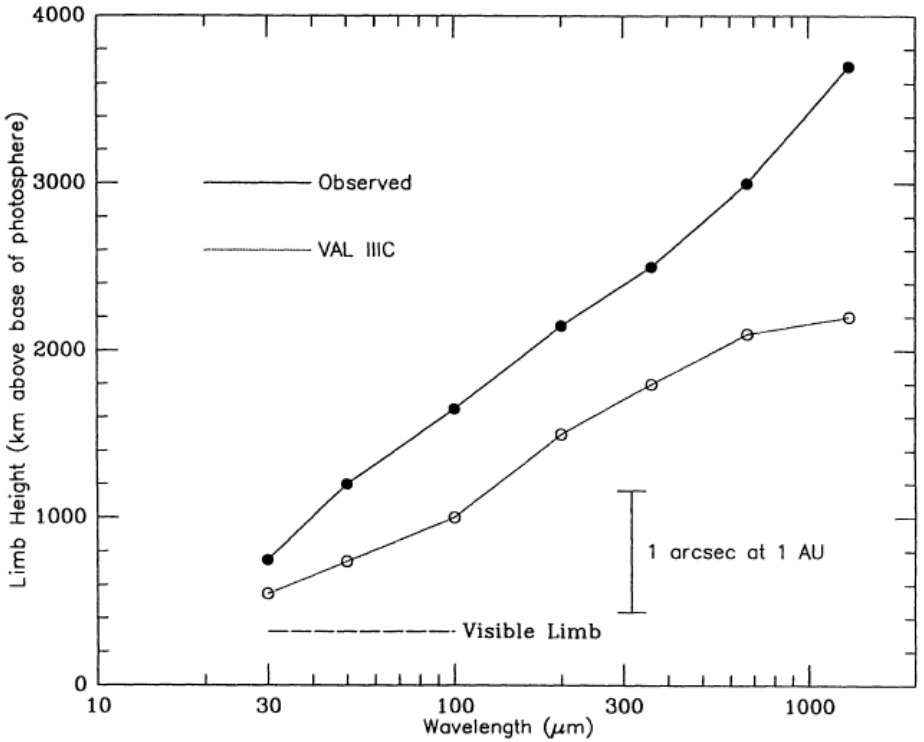
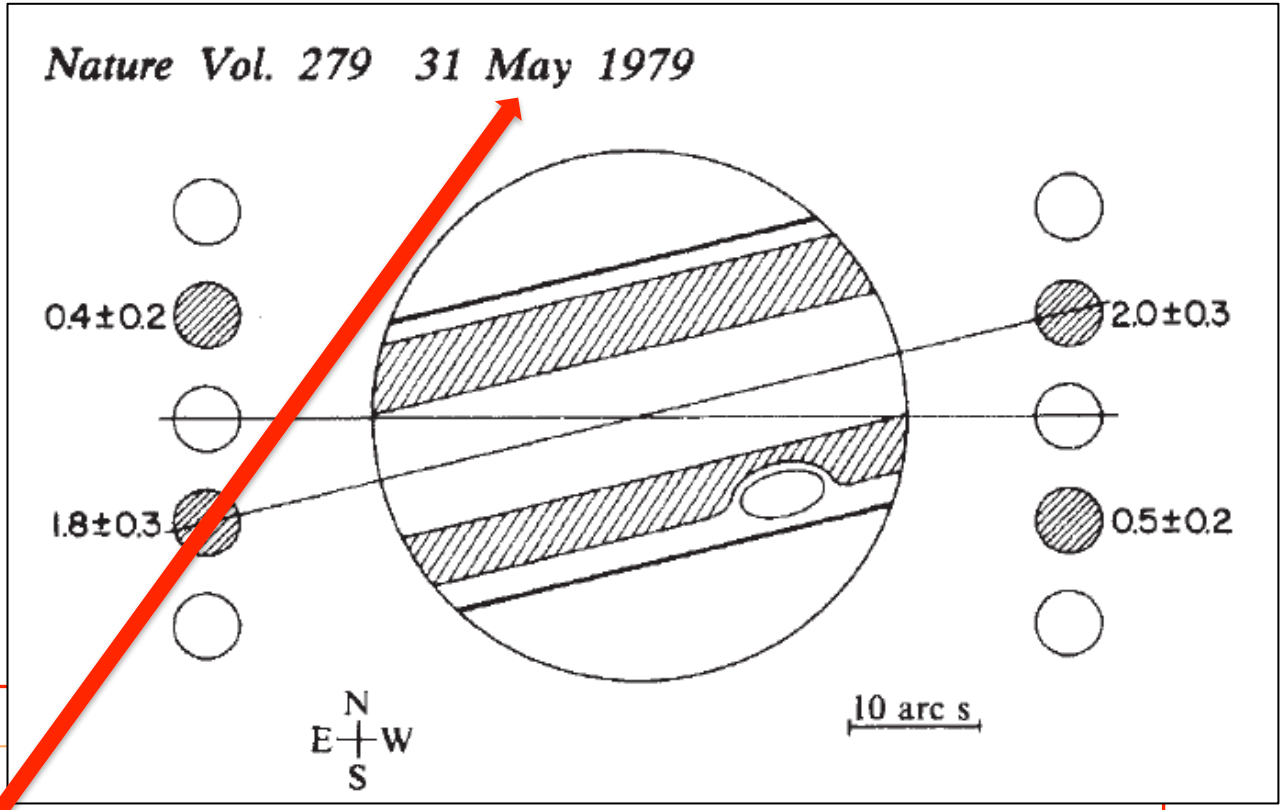


Figure 1. Limb heights determined by lunar occultation during a total solar eclipse are plotted (ordinate) against wavelength (abscissa). Solid points refer to observations; open circles refer to limb profile computations for Model C of Vernazza, Avrett & Loeser (1981). The

10^5 times fewer particles than Saturn's rings



nature

letters

Nature **279**, 400 - 401 (31 May 1979); doi:10.1038/279400a0

Detection of Jupi

E. E. BECKLIN & C. G. WYNN-WILLIAMS

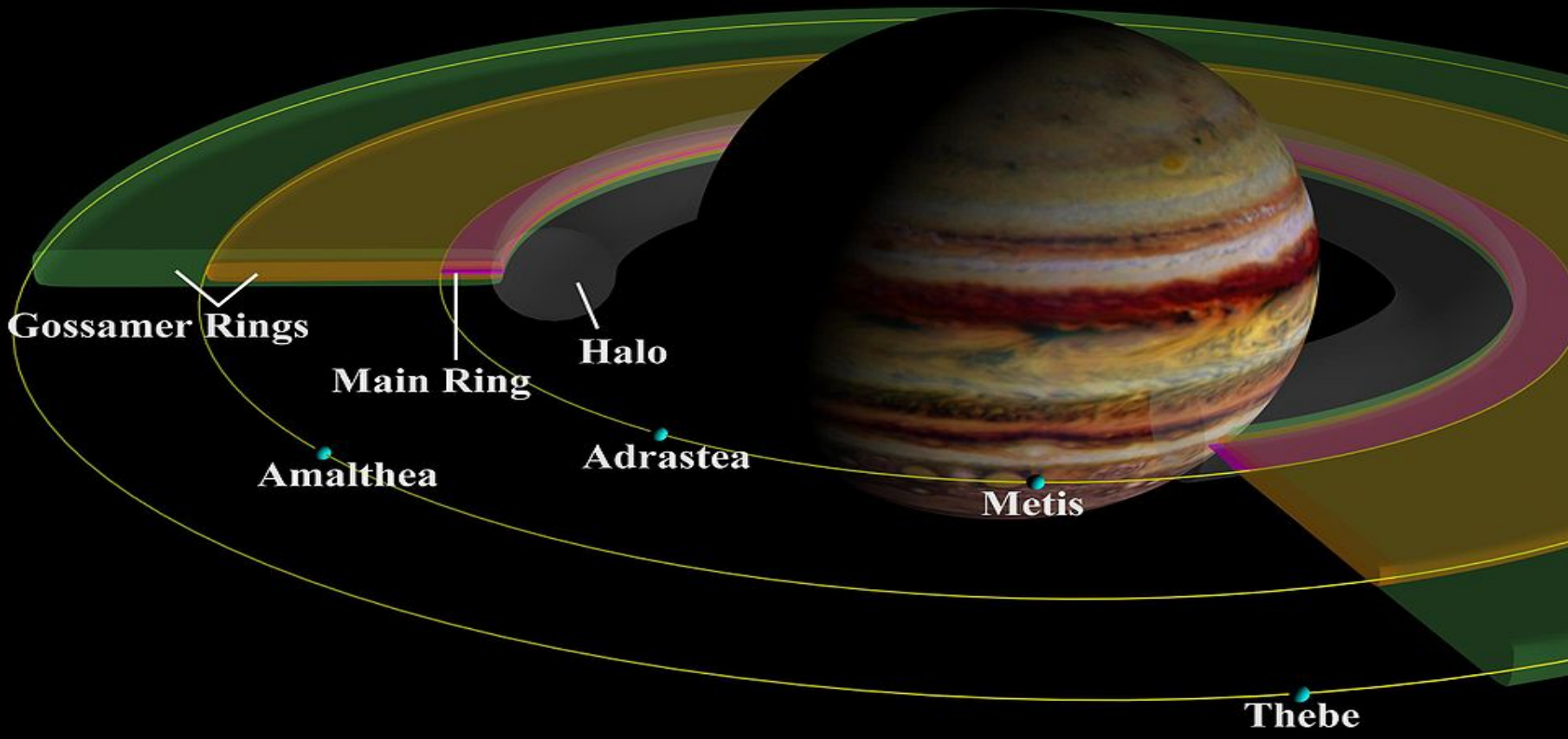
Institute for Astronomy, University of Hawaii, 2680 Woodlaw Drive, Honolulu, Hawaii 96822

FOLLOWING the announcement of the discovery of a ring around Jupiter by the Voyager spac sunlight from this ring at 2.2μm. We describe here the results of this experiment and the precautions taken to scattered radiation from the planet.

The observations were made on 10 and 11 March 1979 UT using the 2.2-m University of Hawaii telescope on Mauna Kea,

References

1. *Honolulu Advertiser*, (8 March 1979); *IAU Circ.* No. 3338 (1979); Smith, B. A. *et al. Science* 204 (in the press).
2. Danielson, R. E. *Astrophys. J.* **143**, 949 (1966).



http://photojournal.jpl.nasa.gov/catalog/PIA01627

Brown Dwarfs and Debris Disks

Turned out to be debris disk

Excess infrared radiation from a white dwarf—an orbiting brown dwarf?

B. Zuckerman* & E. E. Becklin†

* Department of Astronomy, University of California, Los Angeles, California 90024, USA
† Institute for Astronomy, University of Hawaii, 2680 Woodlawn Drive, Honolulu, Hawaii 96822, USA

We have discovered that the white dwarf star Giclas 29−38 appears to emit substantial radiation at wavelengths between 2 and 5 μm, far in excess of that expected from an extrapolation of the visual and near-infrared spectrum of the star. The infrared colour temperature of the excess radiation is 1,200±200 K and, at the distance of G29−38, corresponds to a total luminosity of 5×10^{-5} solar luminosities ($L_\odot$). If the excess 3.5-μm radiation is emitted by a single spherical body at 1,200 K, then its radius is 0.15 solar radii ($R_\odot$). These characteristics are similar to those that have been calculated for substellar objects called brown dwarfs. The most natural interpretation of our observations is that there is a substellar, somewhat Jupiter-like brown dwarf in orbit around G29−38.

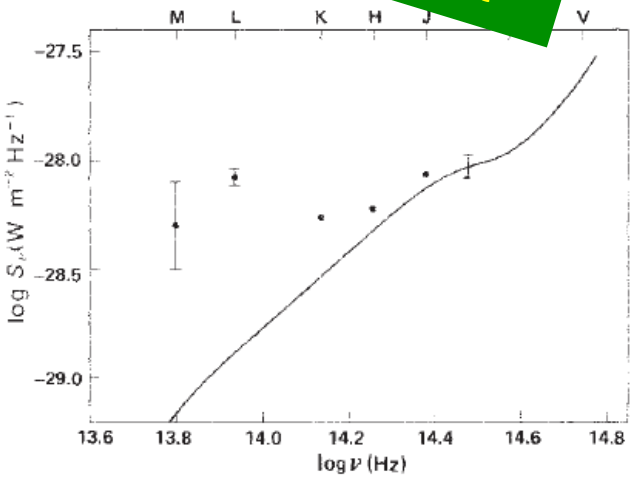


Fig. 1 Plot of flux density against frequency for G29−38. The black dots are the measured fluxes. The line is the flux that a star with the effective temperature of G29−38 might be expected to have based on the average fluxes measured for six of our program stars other than G29−38. The vertical bar on the line between J and I is a typical standard deviation in the colour about the mean of the six stars. The vertical bars on the M and L points are one standard error of the mean. The errors in the K, H, and J fluxes are equal to the size of the black dots. The width of the infrared bandpasses are of order 0.4 μm, except for L which is ~1 μm wide.

LETTERS TO NATURE

A low-temperature companion to a white dwarf star

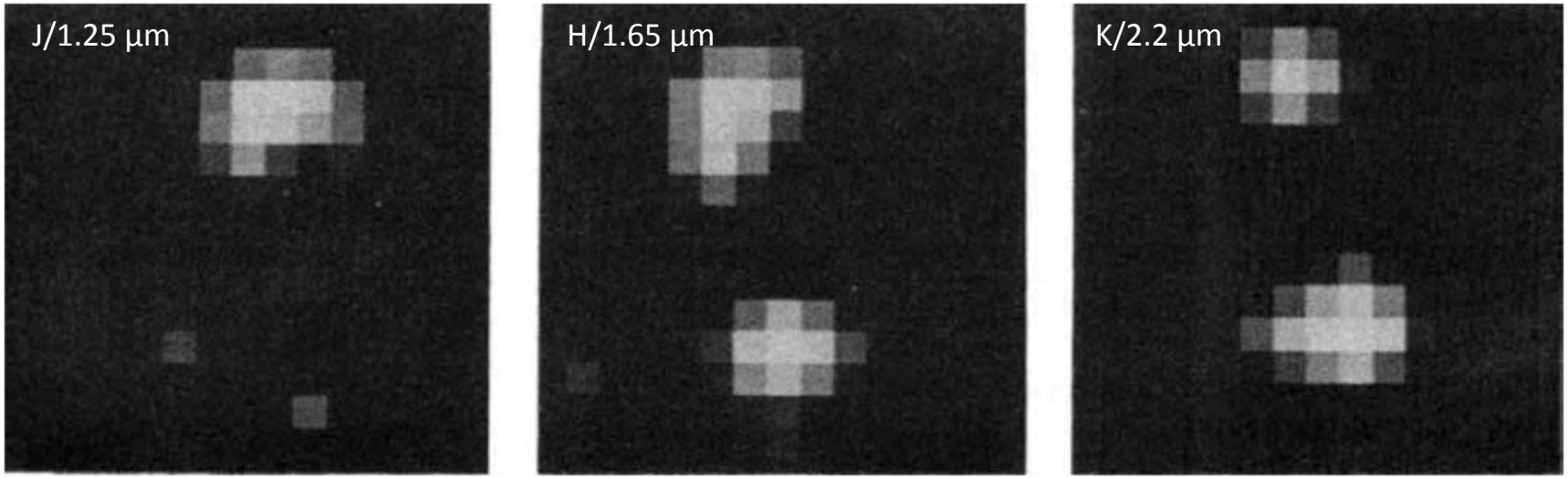
E. E. Becklin* & B. Zuckerman†

* Institute for Astronomy, University of Hawaii,
2680 Woodlawn Drive, Honolulu, Hawaii 96822, USA
† Department of Astronomy, University of California, Los Angeles,
California 90024, USA

Nature **356**, 656 (1988)

Gliese GD 165/165B

T = 2100 K



Debris

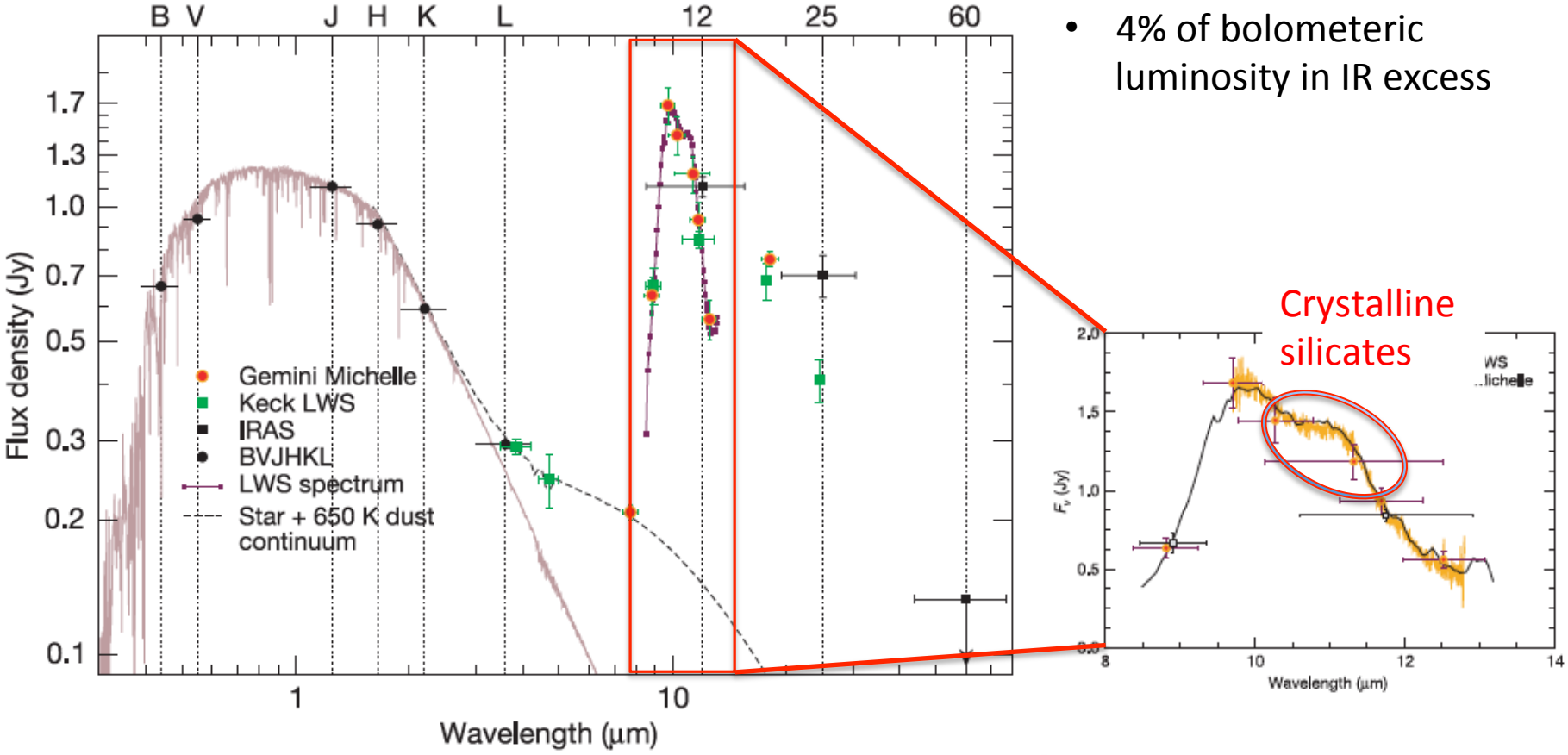
nature LETTERS

Extreme collisions between planetesimals as the origin of warm dust around a Sun-like star

Inseok Song[1], B. Zuckerman[2], Alycia J. Weinberger[3] & E. E. Becklin[2]

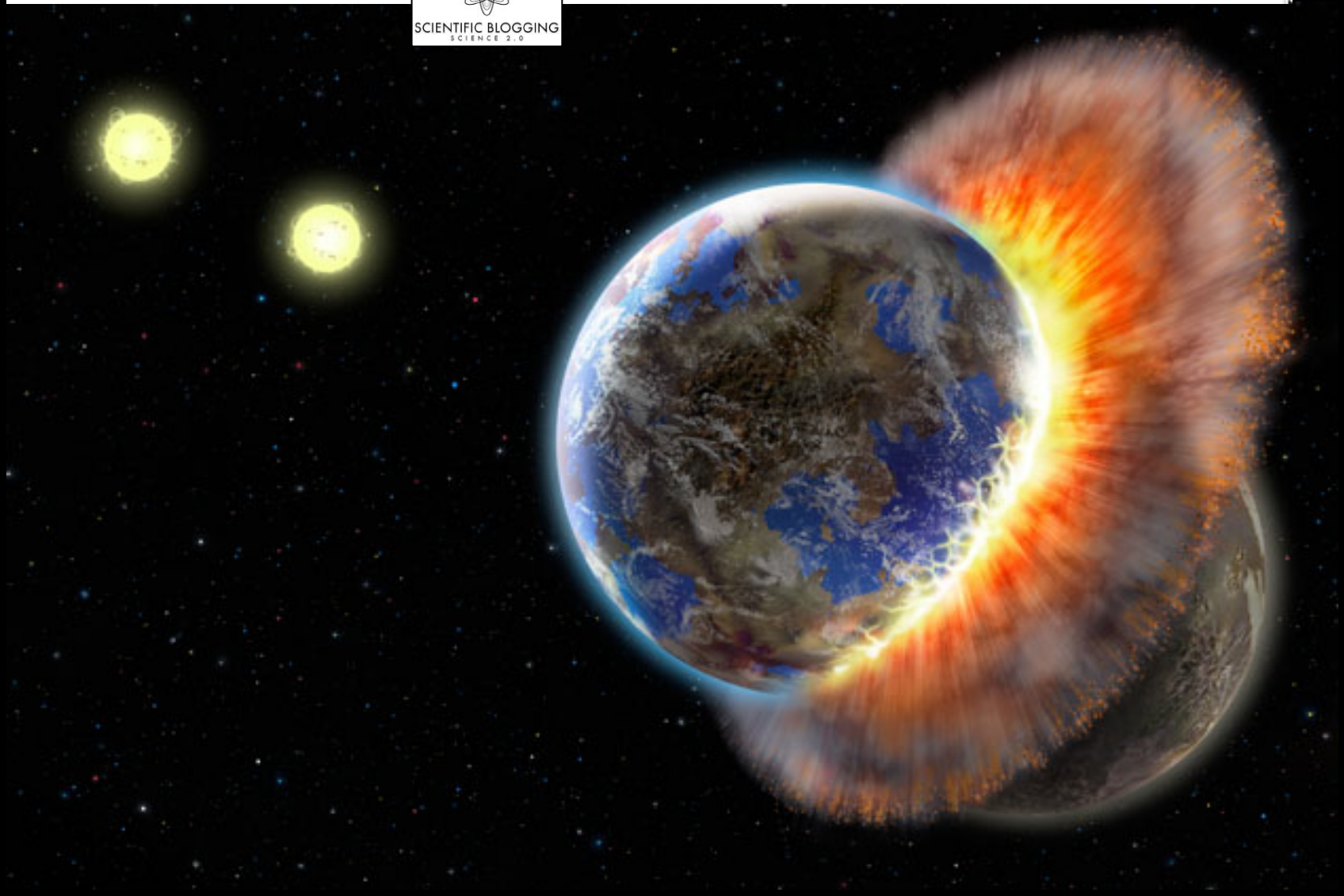
BD +20 307:

- 12+25 μm excess discovered by IRAS
- Dustiest known main-sequence star
- 4% of bolometeric luminosity in IR excess



2005

BD +20 307 Gives An Idea What Would Happen If Earth And Venus Collided



Zuckerman et al. 2008

Lynette Cook

SUBMILLIMETER STUDIES OF MAIN-SEQUENCE STARS

B. ZUCKERMAN AND E. E. BECKLIN
Department of Astronomy, University of California, Los Angeles, Los Angeles, CA 90024

ApJ **414**, 793 (1993)

3 x Fomalhaut at 870 µm

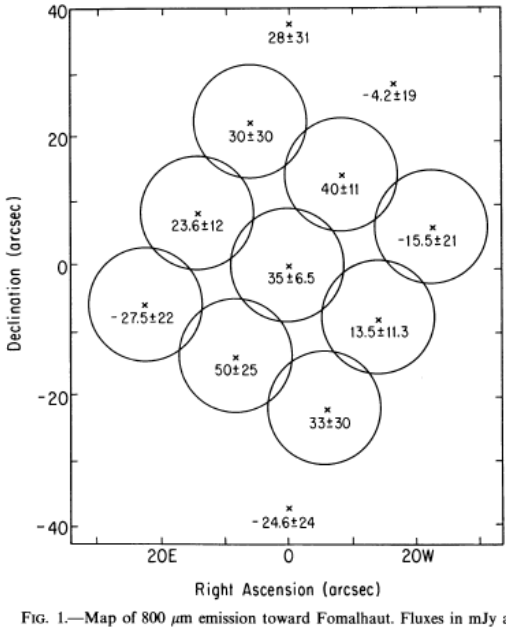
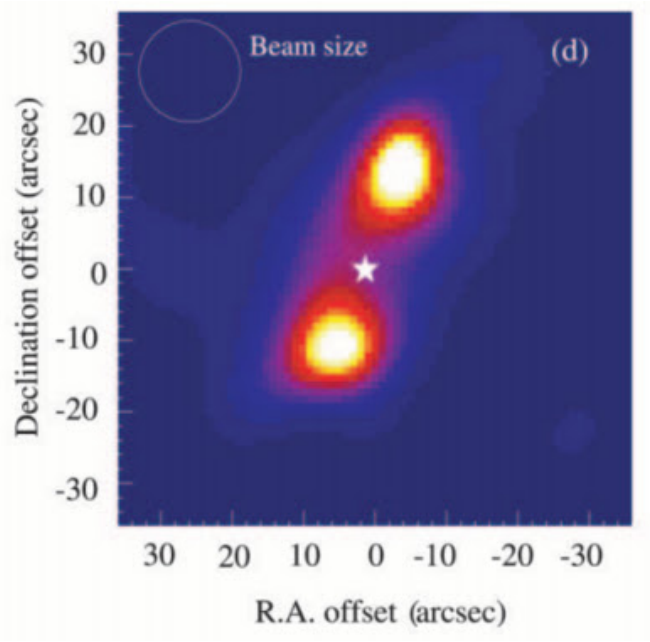
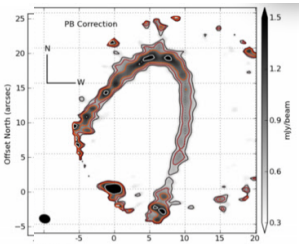


FIG. 1.—Map of 800 μm emission toward Fomalhaut. Fluxes in mJy



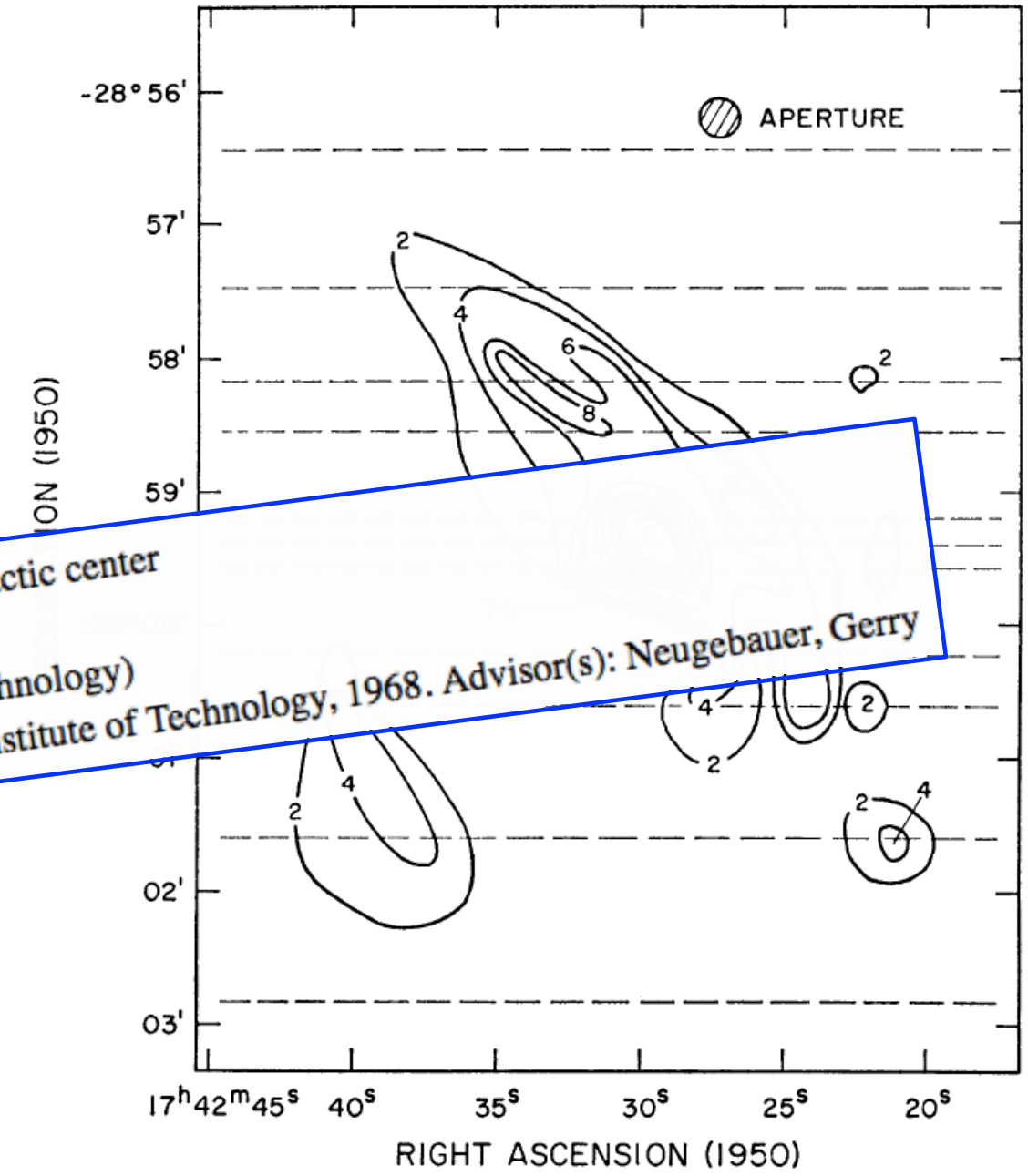


1993 Z&B/single pixel

2003 Holland et al./SCUBA

2012 Boley et al./ALMA

The Galactic center at 2.2 µm



Infrared observation of the galactic center

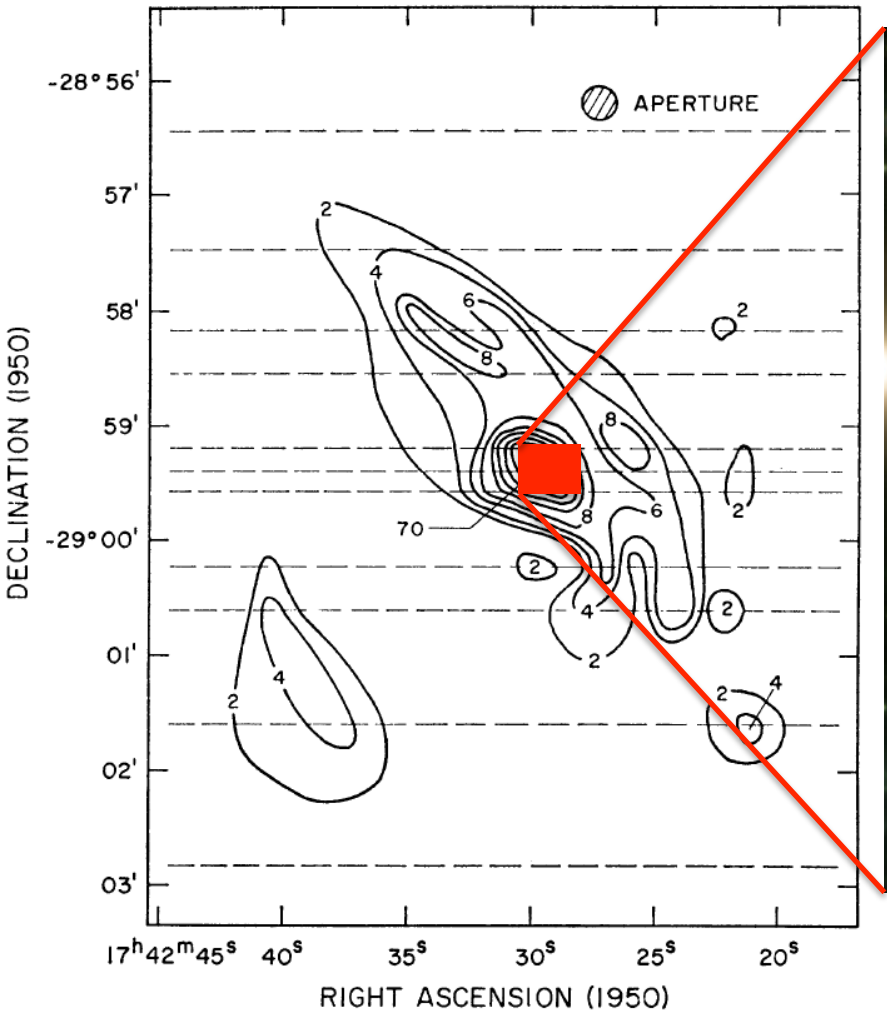
Becklin, Eric E.

AA(California Institute of Technology)

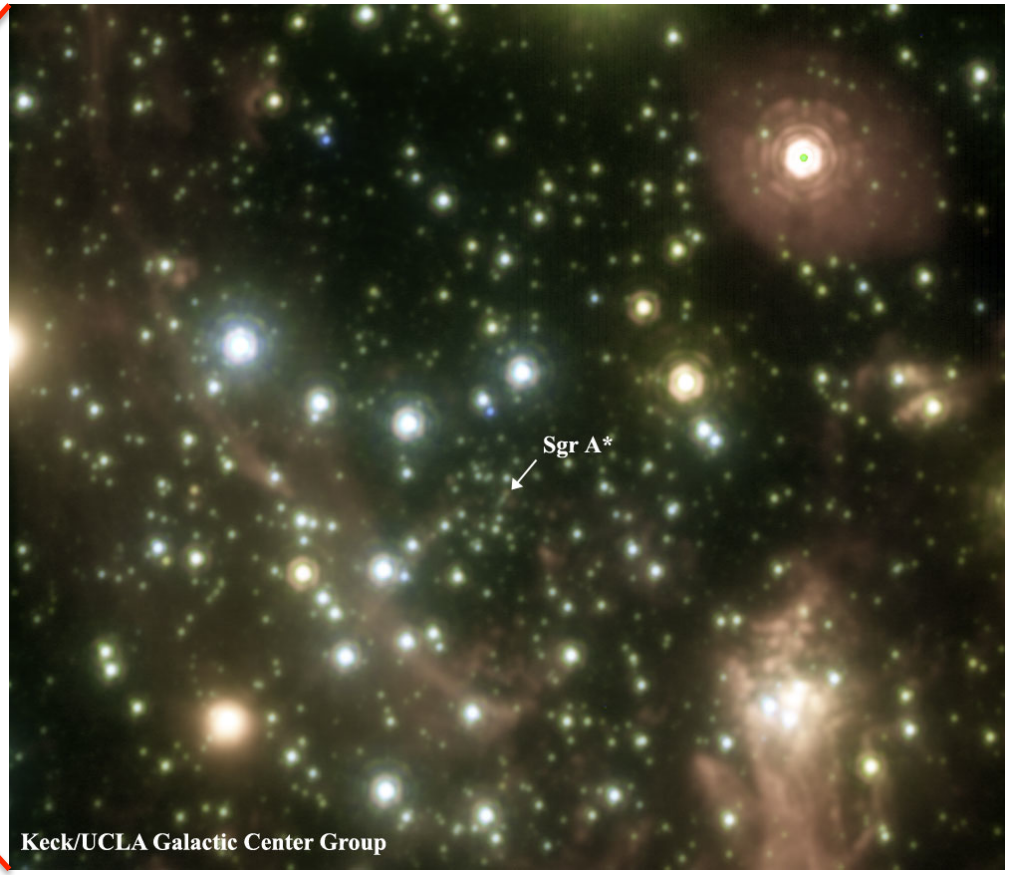
Thesis (Ph.D.) -- California Institute of Technology, 1968. Advisor(s): Neugebauer, Gerry

Becklin & Neugebauer 1968

Factor ~500 in angular resolution



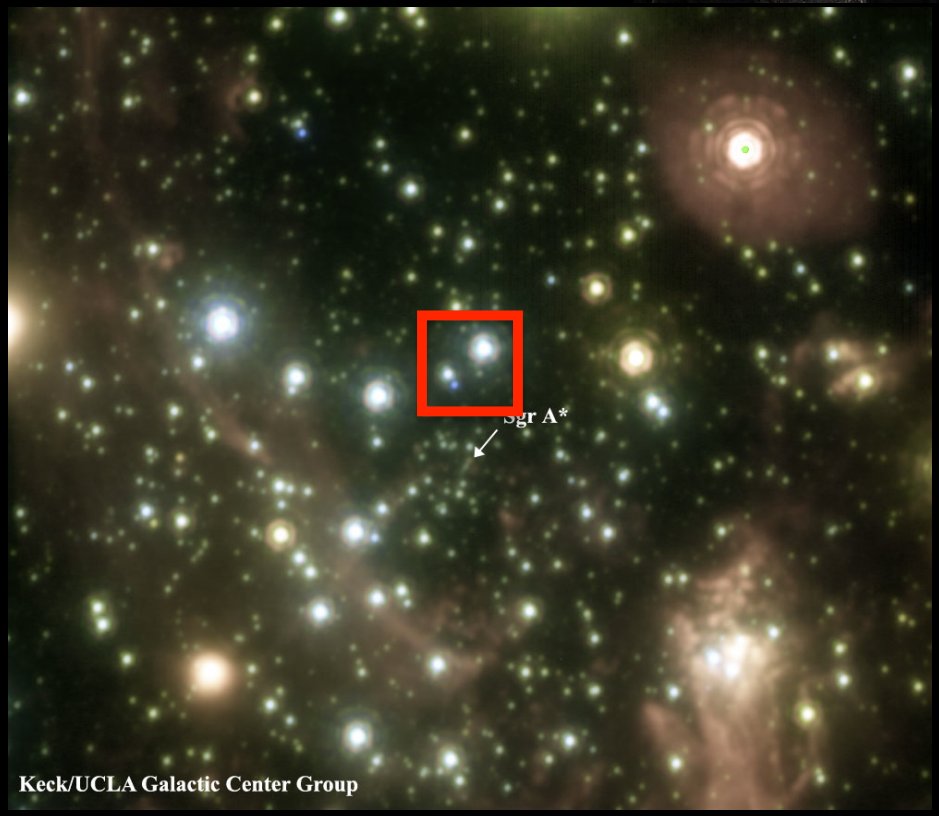
K-band: Becklin & Neugebauer 1968

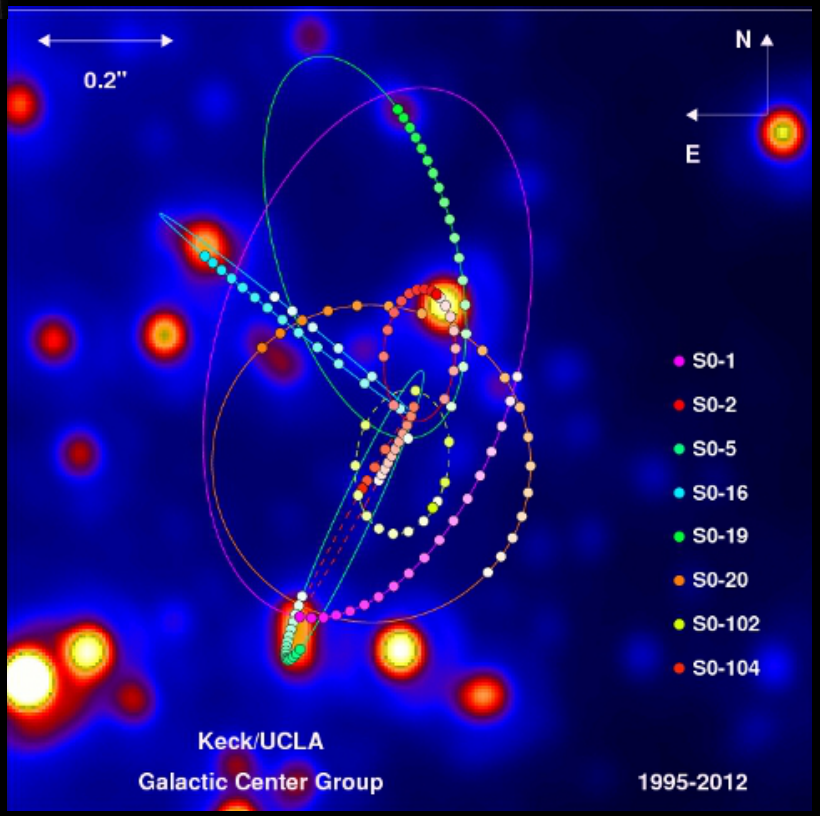


H, K, L A.O.: Ghez, Becklin, et al. ~2014

http://www.galacticcenter.astro.ucla.edu/science.html

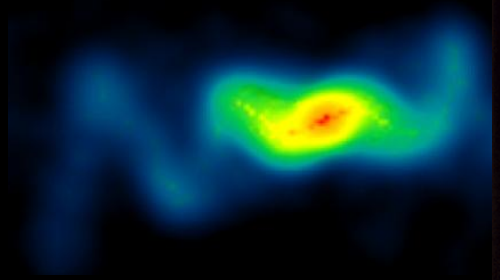
Andrea Ghez
UCLA

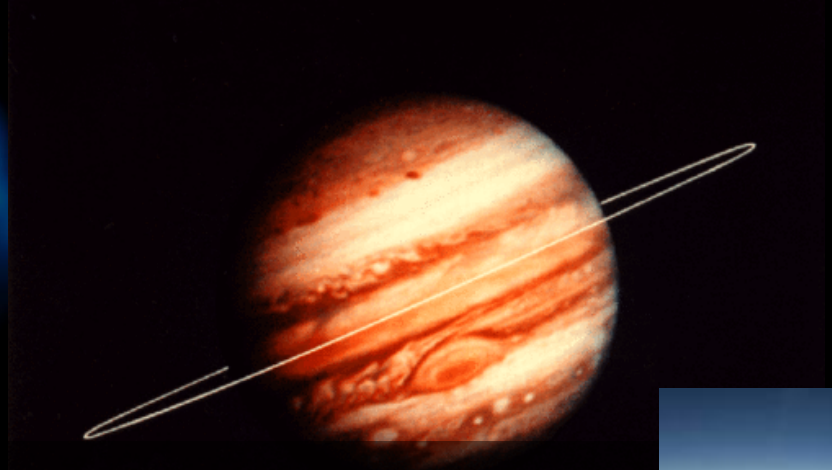




UCLA Galactic Center Group
W.M. Keck Observatory Laser Team

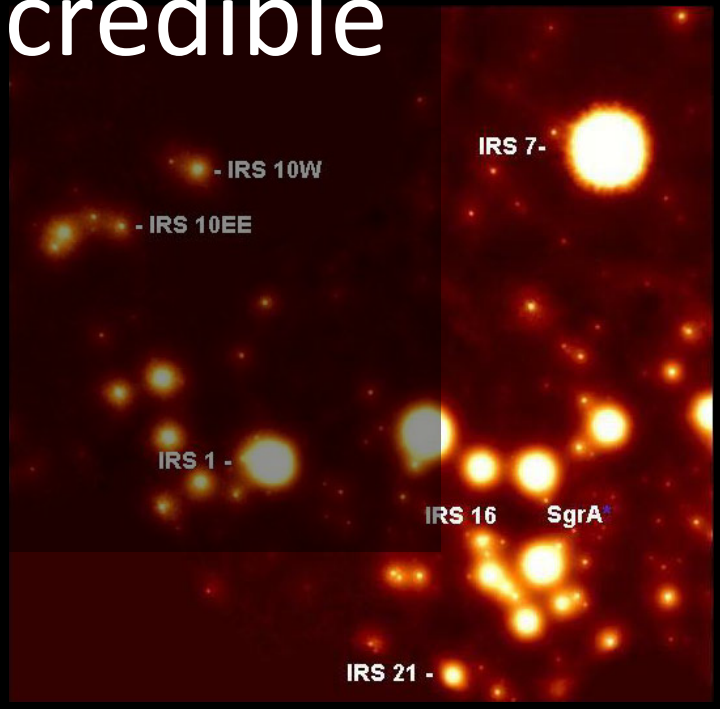
Since 1997: Chief Scientist of the SOFIA Project

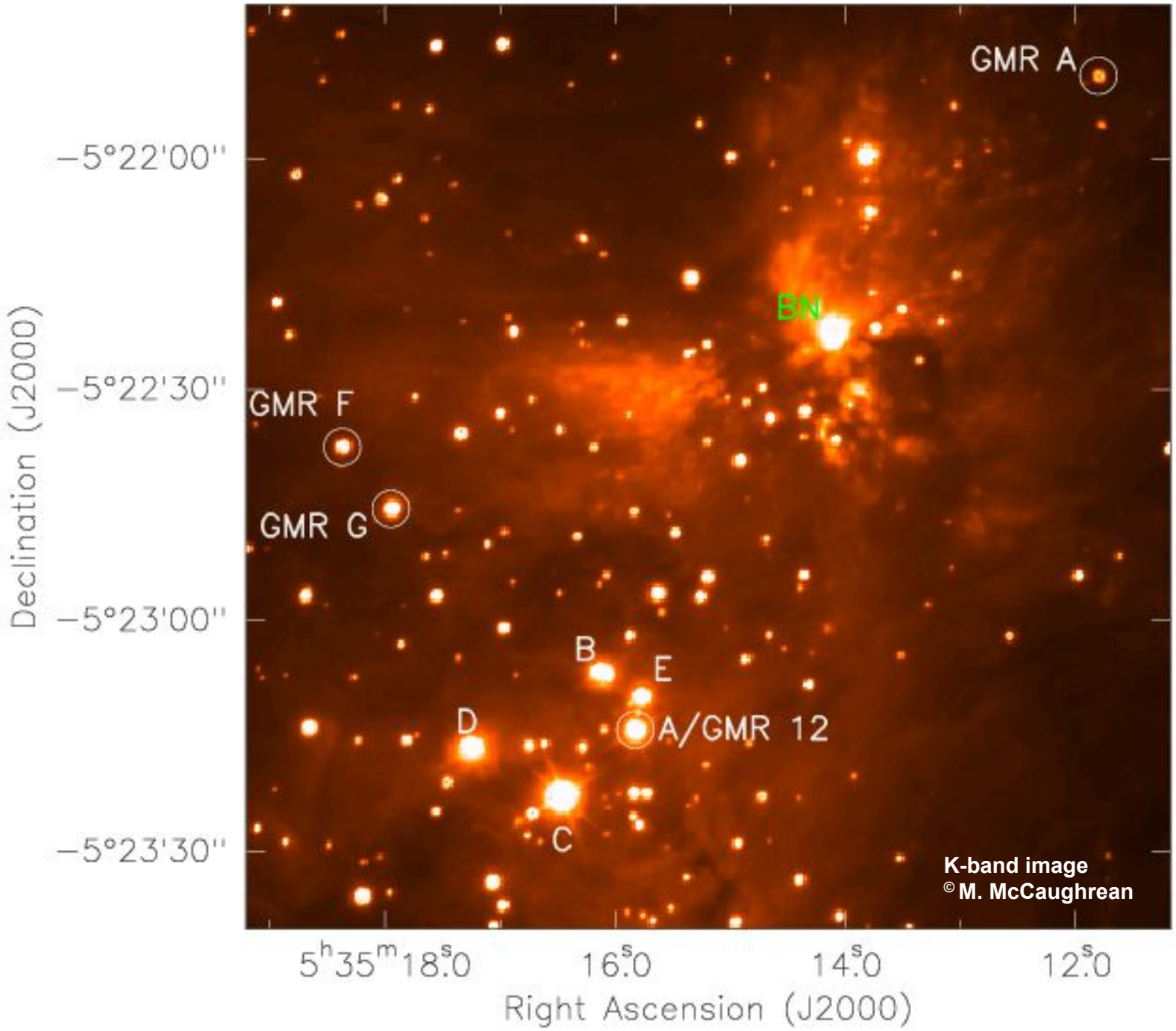




50 years of fundamental contributions to an incredible variety of subjects!

Thank you, Eric!

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K-band image
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