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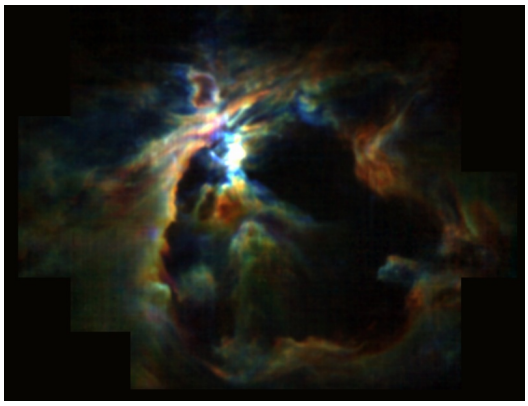
SOFIA Science in Nature: Lifting the Veil on Star Formation in the Orion Nebula



Paper: Disruption of the Orion molecular core 1 by wind from the massive star θ^1 Orionis C
Pabst et al. 2019, Nature,
doi:10.1038/s41586-018-0844-1

The stellar wind from a newborn star in the Orion Nebula is preventing more new stars from forming nearby, according to new research using NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA). These results were reported in the Jan. 7, 2019, issue of the journal *Nature*.

The Orion Nebula is among the best observed and most photographed objects in the night sky. It is the closest stellar nursery to Earth, and helps scientists explore how stars form. A veil of gas and dust makes this nebula extremely beautiful, but also shrouds the entire process of star birth from view. Fortunately, infrared light can pierce through this cloudy veil, allowing specialized observatories like SOFIA to reveal many of the star-formation secrets that would otherwise remain hidden.

At the heart of the nebula lies a small grouping of young, massive and luminous stars. Observations from SOFIA's instrument, the German Receiver for Astronomy at Terahertz Frequencies, known as GREAT, revealed, for the first time, that the strong stellar wind from the brightest of these baby stars, designated Theta^1 Orionis C (θ^1 Ori C), has swept up a large shell of material from the cloud where this star formed.

"The wind is responsible for blowing an enormous bubble around the central stars," explained Cornelia Pabst, a Ph.D. student at the University of Leiden in the Netherlands and the lead author on the paper. "It disrupts the natal cloud and prevents the birth of new stars."

At the center of the Orion Nebula, the stellar wind from θ^1 Ori C forms a bubble and

disrupts star birth in its neighborhood. At the same time, it pushes molecular gas to the edges of the bubble, creating new regions of dense material where future stars might form. These feedback effects regulate the physical conditions of the nebula, influence the star formation activity, and ultimately drive the evolution of the interstellar medium, the space between stars filled with gas and dust. Understanding how star formation interacts with the interstellar medium is key to understanding the origins of the stars we see today, and those that may form in the future.

SOFIA Special Publications

In addition to the above-mentioned publication of SOFIA science in *Nature*, the observatory was also the subject of the Astrophysical Journal Letters (ApJL) January 2019 Focus Issue and the Journal of Astronomical Instrumentation (JAI) December 2018 Special Issue.

The ApJL Focus Issue focuses on new results from SOFIA's Echelon-Cross- Echelle Spectrograph (EXES), the Far Infrared Field-Imaging Line Spectrometer (FIFI-LS), and High-resolution Airborne Wideband Camera-plus (HAWC+) instruments. The Focus Issue links to thirteen letters and papers, including among others a new insight on the age of the galactic center HII region Sgr B1, detailed imaging of the nearby galaxy M 51, and an upper limit to the total amount of water emitted from the recently discovered water plumes on Jupiter's moon Europa.

The JAI SOFIA Special Issue is a compilation of in-depth reports and analysis on the telescope, observatory operations, and its instrument suite. This collection of papers is the reference manual for the most up-to-date technical details on the SOFIA observatory.

- ApJL Special Issue: Focus on New Results from SOFIA -- available here
- JAI Special Issue: SOFIA -- available here

SOFIA at the 233rd AAS Meeting in Seattle

The aircraft tours scheduled to take place at Boeing Field during the AAS meeting were cancelled because SOFIA could not fly to Seattle due to the government shutdown. Although NASA Civil Servants did not attend the AAS meeting, SOFIA was well represented by contractors and university scientists who engaged with AAS attendees via multiple channels throughout the conference.

Numerous contributed talks and posters showcased SOFIA science results during the meeting. The SOFIA Science Center had organized a well-attended special session: *The Role of Magnetic Fields and Filaments in Star Formation*. It brought together the latest studies of magnetic fields in star forming regions and the galactic environment.

The exhibit hall booth displayed science posters of instrument-specific capabilities, with SOFIA instrument scientists present to answer questions and lead engaging discussions about the potential of the SOFIA instrument suite. The January 2019 edition of the printed SOFIA Newsletter was debuted at the booth, and the pdf is now available for download here.

A data analysis workshop designed to help participants begin their own research led eager-to-learn participants through analyzing grism spectra with the Faint Object infraRed CAmera for the SOFIA Telescope (FORCAST) and imaging polarimetry data with the High-resolution Airborne Wideband Camera-plus (HAWC+). Designed to benefit the entire astronomy community in the interest of advancing science, the workshop utilized publicly available, fully processed datasets from SOFIA's Strategic Director's Discretionary Time program. Those unable to attend this valuable training can still view the workshop slides here, and direct any specific questions about data analysis techniques to the helpdesk.

SOFIA Observing Cycle 7

SOFIA has officially announced the selected proposals awarded time for its Cycle 7 observing period, scheduled to begin in April 2019. Cycle 7 will feature exciting science probing a diverse range of astronomical phenomena, from the solar system, to stars and the interstellar medium, to extragalactic sources.

Cycle 7 also introduces SOFIA Legacy Programs: large programs that can span two observing cycles using about 100 hours of observing time. They are designed to enable community involvement in high-impact science by immediately releasing their fully reduced observational data for public use.

The following two SOFIA Legacy Programs have been selected for Cycle 7:

Constraining Recent Star Formation in the Galactic Center
PI: Matthew Hankins, Caltech
Proposal ID 07_0189

The Galactic Center presents the most extreme conditions for star formation, containing more than 80 percent of the Milky Way Galaxy's dense molecular gas, high temperatures, significant turbulence, complex magnetic fields, and a strong gravitational potential well. Despite the large amount of dense gas, observations reveal that the rate of star formation is only 0.1 solar masses per year out of the 1.2 solar masses per year produced by the entire galaxy -- 10 times less than predictions by current theoretical models.

This program aims at providing high-quality mosaics of bright infrared regions within the Galactic Center using the Faint Object infraRed CAmera for the SOFIA Telescope (FORCAST), which excels at producing images and spectroscopic data from infrared-bright areas. The FORCAST 25- and 37-micron bands will be used to create a searchable mid-infrared map of the Galactic Center and a point source catalog with an unprecedented spatial resolution -- six times higher than past observations.

These infrared maps will greatly aid in the creation of a census of massive young stellar objects, thereby updating constraints for the star formation rate in the Galactic Center and improve star formation models for this region.

Radiative and Mechanical Feedback in Regions of Massive Star Formation
Co-PIs: Alexander G.G.M. Tielens, University of Maryland; Nicola Schneider, University of Cologne, Germany
Proposal ID 07_0077

Massive stars are powerful and dynamic energy sources for the interstellar medium, capable of hindering star formation through molecular cloud dissolution or acting as a catalyst through cloud compression. Studying the radiative and mechanical feedback processes of massive stars on their environments therefore yields information about the evolution of the interstellar medium. In a sense, this SOFIA Legacy Program is the expansion of the study of the Orion Nebula published in Nature (see above) to other massive star-forming regions in our galaxy. This program will survey 11 regions including quintessential representatives of their type, including single O- or B-stars, small groups of O stars, rich stellar clusters, and mini starbursts, for a big-picture look at the interaction of massive stars with the interstellar medium throughout the universe.

Upcoming Tele-Talks

SOFIA Tele-Talks are scientific presentations given via phone, with slides distributed ahead of time. The talks are targeted broadly towards members of the astronomy community who are interested in SOFIA science and in the current and potential scientific capabilities of the observatory. The talks are organized by Dan Lester (Univ. of Texas, Austin) and held approximately twice a month on Wednesdays at 9:00am Pacific, noon Eastern.

For information on how to participate in the Tele-Talks, please check the SOFIA Tele-Talk page.

The next Tele-Talks are:

- February 13: Gordon Stacey (Cornell University); HIRMES Fabry-Perots
- February 20: Mikako Matsuura (Cardiff University); dust in SN1987A
- March 6: Terry Jones (University of Minnesota); FIR polarimetry of M82 and NGC253
- March 27: Yoko Okada (University of Cologne); LMC star forming regions

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Please feel free to direct questions and comments to the SOFIA Science Center help desk: sofia_help@sofia.usra.edu.