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April 2019

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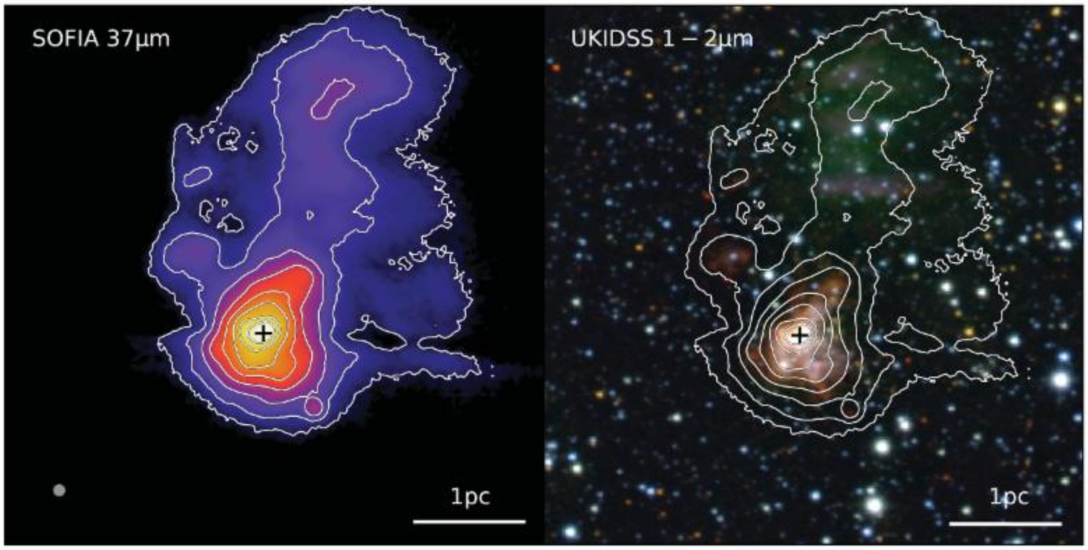
The Most Luminous Protostar

Massive stars burn bright throughout the galaxy and the universe. During their short, violent lives they impact their surroundings by radiating ultraviolet photons, blowing powerful winds and exploding, terminally, as supernovae, further spreading heavy elements forged in their cores out into the cosmos. By these actions, massive stars, especially those born with more than eight solar masses, help regulate the evolution of galaxies and the birth of other stars and planetary systems.

Massive stars themselves form from the densest, most dust enshrouded condensations within giant molecular clouds. These regions may at the same time fragment into star clusters. It is debated whether massive stars always form surrounded by a swarm of lower-mass companions. The presence of such a cluster may affect how gas joins the massive star. In particular, traditional theories involving relatively ordered collapse from a gravitationally bound gas core may not apply in such crowded regions. Other proposed formation mechanisms involving chaotic, competitive accretion and even agglomerative collisions between protostars have been proposed.

To help uncover the secrets of massive star birth, we are using the unique ability of the Faint Object infraRed CAmera for the SOFIA Telescope (FORCAST) to peer deep into molecular clouds at wavelengths about 50 times longer than that of visible light to carry out a survey of many massive star-forming regions that sample different masses, evolutionary stages and environments. The left panel of figure 1 shows a 37-micron image of G45.12+0.13, about 24,000 light years away. It is the most luminous source we have discovered to date in this SOFIA Massive (SOMA) star formation survey. The FORCAST images trace warm dust that is heated by the forming massive star or stars. Using these images, plus those from other telescopes, we measure the brightness of these sources over a large wavelength range – the spectral energy distribution (SED) – and derive the total energy output. In the case of G45.12+0.13, this is at least one million times that of our Sun! By comparison with theoretical models, we can estimate that the star has already reached a mass as high as 60 times our Sun's and is continuing to gather more material at a furious rate: another solar mass is added every thousand years.



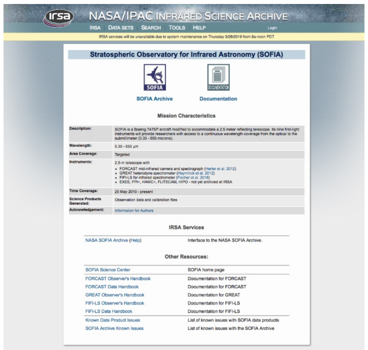
Left: SOFIA/FORCAST 37-micron image of the G45.12+0.13 protostar, showing thermal emission from heated dust. The grey circle in lower left shows the beam full-width at half-maximum of 2.9". *Right:* A three-color image of the same field of view, using J band (blue; 1.1 to 1.4 microns), H band (green; 1.5 to 1.8 microns) and K band (red; 2.0 to 2.4 microns) data from the United Kingdom Infrared Deep Sky Survey, revealing a near infrared nebula and surrounding stars of a protocluster. The white contours are the SOFIA/FORCAST data overlaid. (Liu, et al.)

The right panel of figure 1 shows the same region, now viewed at much shorter, near infrared wavelengths from 1 to 2 microns. This image reveals a diffuse glow from even higher temperature dust, but the overlaid 37-micron emission extends much further, showing the dramatic influence of the massive protostar out to tens of light years. Within this region, the near infrared image also shows the presence of a cluster of stars around the protostar, most of which are not strong emitters at 37 microns.

The precise role this cluster is playing in influencing the birth of this most luminous protostar remains to be determined. Also, this is only one region out of many that are being surveyed by FORCAST on SOFIA. Analyzing the growing sample, now about 40 strong, of sources observed by the SOMA survey will help answer the question whether massive stars can form from a relatively ordered collapse of a core of dense gas or whether that core will always fragment to form a cluster of low and high mass stars. These SOFIA observations will help to settle a long-standing debate on which formation mechanism dominates massive star formation.

Paper: Liu, et al. The SOFIA Massive (SOMA) Star Formation Survey. II. ApJ, 874/1 (2019)

SOFIA Data Available at IRSA



Selected raw and processed datasets from the Stratospheric Observatory for Infrared Astronomy (SOFIA) are now available via the Infrared Science Archive (IRSA), the Infrared Processing & Analysis Center (IPAC) Infrared Science Archive.

This first release of the SOFIA Archive at IRSA consists of Far Infrared Field-Imaging Line Spectrometer (FIFI-LS), FORCAST, and German REceiver for Astronomy at Terahertz Frequencies (GREAT) data from Observing Cycles Four and Five. SOFIA data from all instruments and all cycles that has completed its proprietary period will be available at IRSA with the second archive release later this year, at which point IRSA will become the primary SOFIA archive.

For tips on SOFIA specific archive searches and taking advantage of IRSA visualization features, check out the video tutorials here. Information about SOFIA data products, analysis recipes, and other useful resources can be found at the Data Resources page on the SOFIA Science Center website.

Request a SOFIA Community Day

The Cycle 8 Call for Proposals is opening at the end of May 2019, and the SOFIA Science Team is ready to help SOFIA's growing user community to prepare their proposals. For research institutes and university departments, an efficient way to become familiar with the scientific opportunities offered by SOFIA is to host a SOFIA Community Day between May and August 2019. SOFIA Science Team members can visit your institution to hold presentations, conduct tutorials, and provide targeted support to users and proposers – at no cost to your institution. If you are interested in hosting such an event, please contact us at sofia_help@sofia.usra.edu, preferably before May 1. We would be happy to design an event that fits the needs of your community.

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:

- April 17: Ryan Dungee (University of Hawaii); SO2 in Mon R2 IRS3
- May 1: Wanggi Lim (SOFIA Science Center); mid-IR survey of W51
- May 8: David Chuss (Villanova University); FIR polarimetry of OMC-1
- June 12: Jorge Pineda (JPL); [CII] in M51

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