

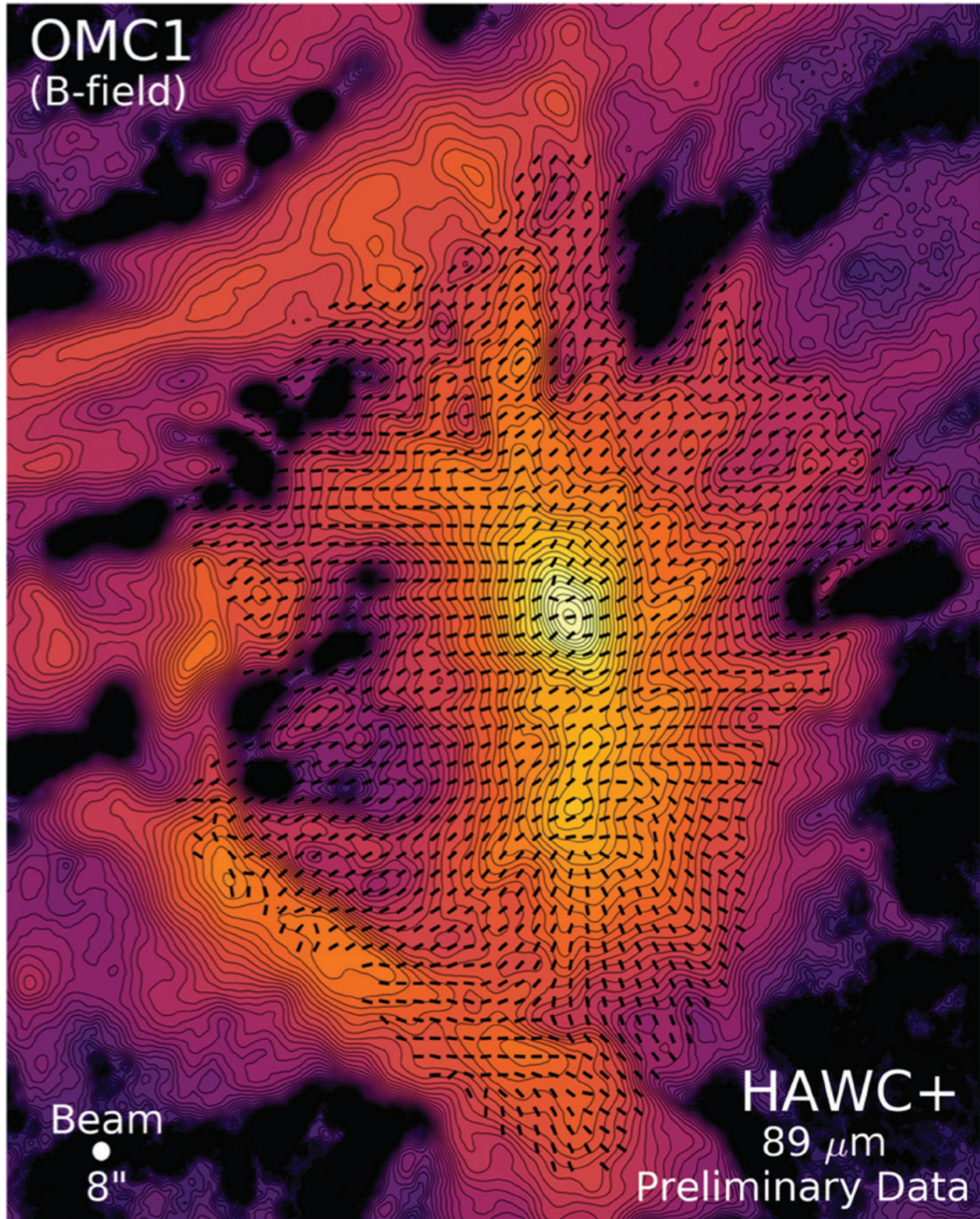
# SOFIA Newsletter



January 2018 • Volume 3, No. 1

[www.sofia.usra.edu](http://www.sofia.usra.edu)

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The High-resolution Airborne Wideband Camera-plus (HAWC+) instrument performed polarization measurements at 89  $\mu\text{m}$  to capture the structure of the magnetic field in the Orion star forming region. Each line segment represents the orientation of the magnetic field at that location, overlaid on an image of the total intensity at the same wavelength. (NASA/SOFIA/Caltech/Darren Dowell)

# SOFIA Observers Resources

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The SOFIA Science Center provides a wealth of information for researchers working with the observatory. Information about proposing and observing, our instrument suite, publications, meetings, and announcements can be found at: [www.sofia.usra.edu/science](http://www.sofia.usra.edu/science)

## Observer's Handbook

The Observer's Handbook provides detailed information about the instruments that will be available for observations during the current cycle. This document is the primary technical reference for astronomers who wish to submit a proposal in response to the Call for Proposals.

**Observer's Handbook for Cycle 6:** [www.sofia.usra.edu/science/proposing-and-observing/sofia-observers-handbook-cycle-6](http://www.sofia.usra.edu/science/proposing-and-observing/sofia-observers-handbook-cycle-6)

## Unified SOFIA Proposal and Observation Tool (USPOT)

All proposals are to be prepared and submitted using the Unified SOFIA Proposal and Observation Tool (USPOT). Initial submission is completed during Phase I, and those proposals awarded observing time will be required to submit further specifications regarding their observations during Phase II — all of which is completed via USPOT.

**USPOT:** [dcs.sofia.usra.edu/observationPlanning/installUSPOT/uspotDownload.jsp](http://dcs.sofia.usra.edu/observationPlanning/installUSPOT/uspotDownload.jsp)

The USPOT Manual is designed to guide users through the procedures for submitting SOFIA Observing Proposals containing Astronomical Observation Requests (AORs). The USPOT Manual includes specific instructions for each instrument for both Phase I and Phase II.

**USPOT Manual:** [www.sofia.usra.edu/science/proposing-and-observing/uspot-manual](http://www.sofia.usra.edu/science/proposing-and-observing/uspot-manual)

## Exposure Time Estimation Calculators

Estimations of exposure times for imaging with FLITECAM, FORCAST, FPI+, and HAWC+ can be made using the SOFIA Instrument Time Estimator (SITE), a web-based tool that provides total integration time or S/N for a given instrument, filter(s), source type (point, extended, emission line), and water vapor overburden.

**SITE:** [dcs.sofia.usra.edu/proposalDevelopment/SITE/index.jsp](http://dcs.sofia.usra.edu/proposalDevelopment/SITE/index.jsp)

## Atmospheric Transmission (ATRAN)

The atmospheric transmission as a function of wavelength may be obtained using the online tool ATRAN. The use of ATRAN is necessary for planning SOFIA high-resolution spectroscopic observations.

**ATRAN:** [atran.arc.nasa.gov/cgi-bin/atran/atran.cgi](http://atran.arc.nasa.gov/cgi-bin/atran/atran.cgi)

Additional resources can be found at the SOFIA Science Center website: [www.sofia.usra.edu](http://www.sofia.usra.edu) ■

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## Science Highlights

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W. T. Reach, *Chief Science Advisor*



### Year of Occultations

In the last half of 2017, SOFIA observed two occultations of stars by solar system bodies. The first was on July 10, while SOFIA was in New Zealand for its annual Southern Hemisphere deployment. It's a good thing we were already in New Zealand, because the shadow was predicted to sweep across the Earth's surface south of the equator and over the Pacific Ocean. The target for the observation was Kuiper Belt Object 2014 MU69, the next encounter target for the New Horizons spacecraft. New Horizons will fly by MU69 on New Year's Day 2019, and it is currently en route in a long cruise phase after its dramatic, successful flyby of Pluto that revealed unprecedented details and physical processes on the surface of that dwarf planet. In fact, SOFIA provided complementary observations for the 2015 New Horizons Pluto encounter by observing an occultation by Pluto just ahead of the spacecraft encounter while on another flight from New Zealand. The Pluto observations with SOFIA were precisely timed so that the aircraft flew through the centerline of the shadow at just the right time to observe a large central flash in the middle of the occultation caused by starlight refracted all the way around the planet.

This year, our scientific goals for observing the occultation by MU69 were different from those we had for observing Pluto because MU69 is thought to be far too small to harbor an atmosphere. Instead, we are hoping to refine the size and location of MU69 and to search for debris in orbit around or associated with the object. We used SOFIA's Focal Plane Imager to watch a 15th magnitude star be occulted. The observing team was led by Elliot Young of the New Horizons mission team and the Southwest Research Institute in Boulder, Colorado, and included Marc Buie, Simon Porter, and Alan Stern. According to Buie, "SOFIA's easiest and successful task was to probe for dangerous stuff around MU69 with a minimal chance of weather getting in the way. So far, the [path for New Horizons] appears to be clear. SOFIA's

mobility also meant we were able to get to a location that contributes to understanding the central body. All of the 2017 campaigns present a complicated puzzle and the data collected by SOFIA is an essential clue that was impossible to get with any other available tool."

A trio of occultations by MU69 occurred this summer, and the team coordinated observations with Hubble Space Telescope in addition to ground-based telescopes, using data from the European GAIA mission to refine astrometry on the occultation stars and the stars used to define MU69's orbit.

For the occultation on June 3, 2017, teams deployed with small telescopes to South America and Africa, and large telescopes in South Africa and Chile participated. Preliminary results presented at the October 2017 American Astronomical Society's Division for Planetary Sciences (DPS) meeting showed no detection of an occultation from this event. On July 10, the New Horizons team joined us on SOFIA in our attempt to fly through the shadow. The team arrived on-site days before the SOFIA flight to analyze their last installment of Hubble data and determine an updated flight plan for SOFIA. As reported at the 2017 DPS meeting, the SOFIA crew managed to fly our observatory to within four and one-half wingspans of the aircraft from the predicted centerline of the shadow. In real-time, we saw no evidence for the occultation, in part because the star was faint (magnitude 15.5) and very close to the Moon. However, there is a potential detection of MU69 as a very brief chord, which is being investigated further. On July 17, the New Horizons team deployed with small telescopes to Argentina, where they succeeded in obtaining a multi-chord detection indicating a bi-lobate shape of MU69. Using those results, the team made a "post-diction" of where the shadow was with respect to the SOFIA flight path for July 10 and the telescope locations for June 3. They found that the June 3 telescopes missed the edge of the shadow within only a few kilometers, while SOFIA was within  $5 \pm 8$  km of the body center. Models for the

## Science Highlights

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shape of MU69 are being constructed to satisfy the constraints posed by all three epochs and include the astonishing possibility that MU69 was a binary and SOFIA flew between the lobes, either nicking the edge of one of them (if a separated binary) or seeing the narrow, connected region (if a contact binary).

The second occultation observation during 2017 was Neptune's large moon Triton. These observations were the culmination of the research program initiated by Ted Dunham of Lowell Observatory in Flagstaff, Arizona, who designed and built the High-Speed Photometer for Occultations (HIPO) as part of the initial complement of first generation scientific instruments for SOFIA. The scientific goals of this occultation are similar to the those of the team's prior SOFIA observations of occultations by Pluto — and indeed Pluto and Triton are in many ways twins, being very nearly the same size and residing at nearly the same distance from the Sun. Triton's orbit is significantly different from that of a large, natural satellite (a near-circular orbit in the same plane and sense of revolution as the planet's spin), so it is likely Pluto and Triton had very similar origins and histories, until the latter was captured by Neptune. The ability to make simultaneous observations at visible and near-infrared wavelengths allows us to discern the properties of potential aerosols in Triton's atmospheres. Aerosols were inferred from SOFIA observations of Pluto's atmosphere and definitively observed as layers of haze in New Horizons images. More details are presented in the accompanying article (see pages 8 and 9) about the Triton occultation.

### Origin of Interstellar Dust in the Early Universe

The sensitivity and angular resolution of SOFIA in the mid-infrared enabled measurement of the amount and properties of dust around the pulsar-wind-nebula dominated supernova remnant G54.1+0.3. Researcher Tea Temim, from the Space Telescope Science Institute in Baltimore, Maryland, and collaborators observed the dust produced by the supernova explosion. The mid-infrared

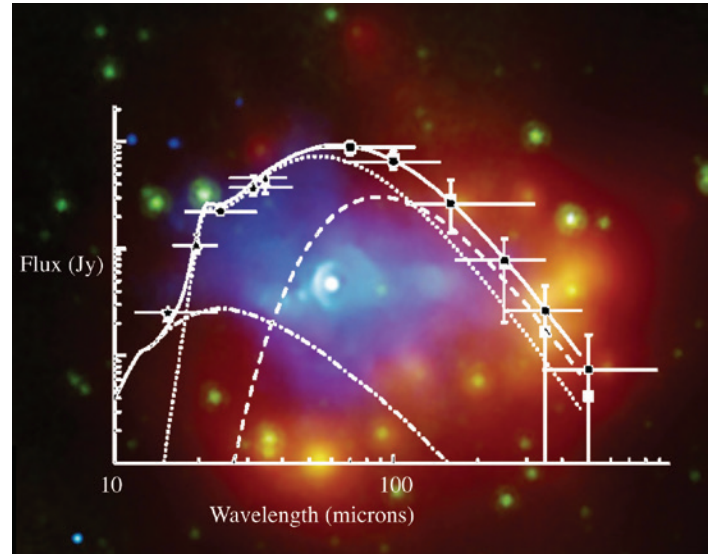
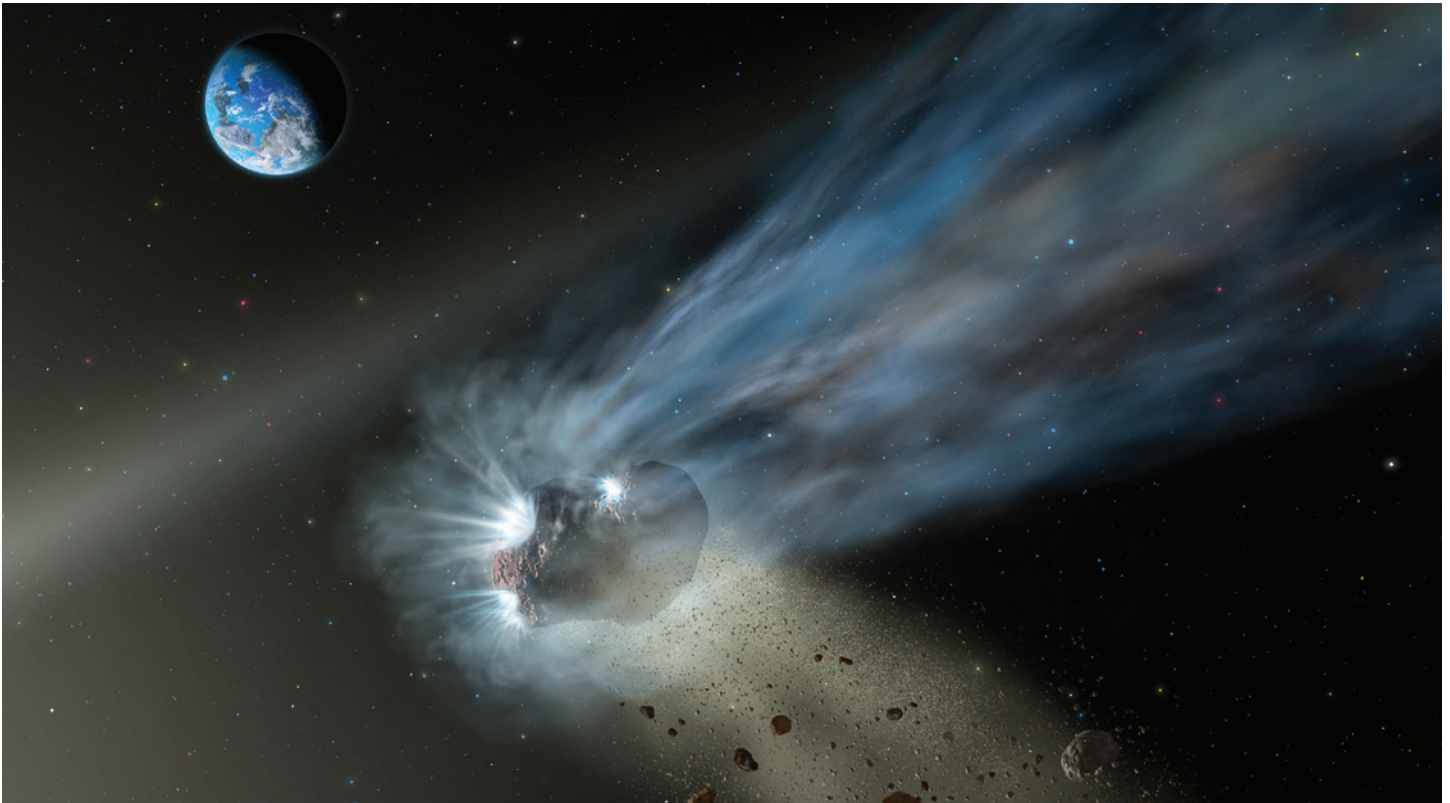


Image of the supernova remnant G54.1+0.3 combining X-rays from Chandra (blue), infrared PAH emission (green) and small dust grains (red) from Spitzer. The X-rays from the center of the supernova remnant arise from a pulsar wind nebula. The infrared emission from the supernova remnant arises from swept-up interstellar material and freshly-formed dust. Some of the stars are engulfed by supernova dust; those stars are surrounded by a yellow glow from the grains which are heated by the stars as they pass close by. The white graph shows the infrared spectral energy distribution of the shell, together with a model of emission from silicates and corundum (see Temim et al.; 2017 ApJ 836, 129). (Image: NASA/Chandra X-Ray Observatory and Spitzer Space Telescope; Graph: Tea Temim)

emission is observed in a rough shell surrounding the X-ray pulsar wind nebula. It is thought to arise from supernova dust and ejecta that are being heated by O and B stars belonging to the same stellar cluster as the supernova progenitor. "SOFIA's angular resolution was crucial in resolving the hotter dust around the stellar sources and confirming this scenario," said Temim.

Combining SOFIA data with other infrared observations by Spitzer, Herschel, and AKARI showed that there must be at least 0.3 solar masses of dust from the supernova. Dust pervades the interstellar medium in the Milky Way and even high-redshift galaxies. In the Milky Way, most of the dust is likely to originate from evolved stars that shed their outer layers before evolving to white

*(continued on page 12)*



Observations of a Comet's First Passage through the Solar System Reveals Unexpected Secrets (NASA/SOFIA/ Lynette Cook)  
More information: <https://go.nasa.gov/2AkN6aj>



SOFIA Finds Cool Dust Around Energetic Active Black Holes (NASA/SOFIA/ Lynette Cook) More information: <https://go.nasa.gov/2AjUPpi>

## Science Operations and Outreach

B-G Andersson, *Associate Director for Science Operations*



The SOFIA Cycle 5 year has been busy. We accomplished a lot of great science in all fields of SOFIA science (searching for water on Europa, mapping the magnetic field in the Galactic center, observing a  $z=3.9$  galaxy in the far infrared, etc.). The dual cryo-cooler system for upgraded German REceiver for Astronomy at Terahertz Frequencies (upGREAT) was activated, we increased the cryo-system hold time for High-resolution Airborne Wideband Camera-plus (HAWC+) up to the full SOFIA flight duration, and had a great Cycle 6 proposal response, but we also had some challenges.

Of the more operationally exciting activities, SOFIA carried out an occultation observation of MU 69, the next fly-by target for the New Horizons mission, as well as occultation observations of Neptune's moon Triton and a transit of the exoplanet Trappist-1b during a mini-deployment to Daytona Beach, Florida, in October. We also observed the accretion-induced outburst from the high-mass young stellar object S225IR-NIRS3 with the the Far Infrared Field-Imaging Line Spectrometer (FIFI-LS) and Faint Object infra-Red CAMERA for the SOFIA Telescope (FORCAST).

The second cryo-cooler unit was installed on the observatory, which allows upGREAT to run, for example, the low-frequency array and high-frequency array in parallel. The modifications to the HAWC+ refrigeration system over the summer were very successful and the instrument now has a cold-hold time long enough for the standard 10-hour SOFIA flight, and is producing some very exciting data both in imaging and polarimetry mode.

The Cycle 5 Southern Deployment to Christchurch, New Zealand, started out with a very successful GREAT series including the first science observations with the new 4GREAT module. In the middle of the GREAT series, SOFIA observed MU69 with the focal plane imager FPI+, and likely detected (final confirmation is still pending) the Kuiper Belt object. The FIFI-LS and FORCAST series had some problems with the plane unavailable due to maintenance considerations, but still produced science.

We are on track to complete 84 flights this cycle. We

had highly successful runs in the spring and early summer with the Echelon-Cross-Echelle Spectrograph (EXES), FIFI-LS, and GREAT. We were less successful with getting our FORCAST flights off. Due to a variety of factors, maintenance or weather related, we were unable to complete Observing Campaign 5D (OC5D) in April, two of the Southern Deployment FORCAST flights, and most of the OC5K series in September. Several flights of OC5E (HAWC+), OC5I (FIFI-LS, New Zealand) and OC5N (HAWC+) were also canceled for maintenance or weather reasons. Our science, flight planning, and mission operations teams quickly rescheduled these series to maximize the science return of the remaining flights.

During the summer, the operations center in Palmdale experienced a flooding event due to a burst pipe in the fire suppression system. This caused significant damage to the staff offices and the instrument labs. Fortunately, none of the SOFIA instruments experienced any significant damage and our mission operations, maintenance, and engineering staff kept our flights going. The limited lab access caused us to re-plan the end of the Cycle 5 schedule, trading the final GREAT series for a FORCAST series. This has the advantage that it will allow us to recover some of the lost FORCAST science from the earlier flight series.

### Cycle 6 Results

After the proposal deadline at the end of June, the SOFIA Cycle 6 proposals were considered by peer review panels in the United States and Germany in August and September, respectively. The NASA/USRA queue received proposals combining to an oversubscription rate of 4.1 (in time), with proposals received from 16 different countries, covering all of the usual SOFIA science categories, plus some new ideas. Both panels found the proposals to be of high quality, wanting to accept more projects than we have flights to execute.

Two new selection policies were put in place for the Cycle 6 round. First, a three-tier priority system was implemented, with Priority 1 ("Will do") designed to drive the schedule and, if not completed in the cycle, be carried

forward to the next cycle. Priority 2 (“Should do”) and Priority 3 (“Do if Time”) correspond roughly to the earlier “Must Do” and “Do if Time” categories. To focus the scheduling of the Priority 1 targets, only 25 percent of the available time was awarded in this category, with an additional 50 percent for Priority 2 programs.

Second, a new award category “Thesis Enabling programs” was offered in the call, aimed at enhancing support for graduate students. This category provides two years of fully burdened support for a graduate student for thesis projects based in a substantial part on SOFIA observations. A total of 10 proposals were received in this category and two were selected and funded. Congratulations to the successful students and their advisors!

After the review, the Science Mission Operations Director and his German deputy merged the recommendations of the two Time Allocation Committees, producing a list of 67 accepted proposals from the NASA/USRA queue and 16 from the German queue at the highest two priority ratings. Fifty-one proposals were accepted as filler “Do if Time” programs and three as surveys. Selection letters went out on November 1. Phase II preparations of the detailed observation definitions are underway as I write this in mid-November.

**Table 1. Time allocations in SOFIA Cycle 6**

Instrument	P1+P2	P3
	Hours	Hours
EXES	66	—
FIFI-LS	23	44
FORCAST	95	19
FPI+	7	—
GREAT	149	183
HAWC+	87	50

The Cycle 6 science program is quite exciting. Many of the highly ranked Priority 1 programs aim at probing the role of magnetic fields in different interstellar environments, others aim to probe the chemistry or dynamics of the Interstellar Medium — including a large [C II] map of the 30 Doradus region in the Large Magellanic Cloud. An occultation observation of Saturn’s moon Titan is also on that list.

*(continued on page 12)*

**Table 2. Cycle 6 Flight Series<sup>1</sup>**

Series	# Flights	Instrument	Dates
OC6A <sup>2</sup>	2	FORCAST	February
OC6B	5	HAWC+	February
OC6C	5	GREAT	Feb/March
OC6D	3	FIFI-LS	March
OC6E	8	EXES	April
OC6F	8	HAWC+	May
OC6G	3	GREAT	May
OC6H	16	GREAT (NZ)	June/July
OC6I	8	HAWC+ (NZ)	July
OC6J	10	FORCAST	Aug/Sep
OC6K	14	HAWC+	Sep/Oct
OC6L	5	EXES	October <sup>2</sup>
OC6M	3	FIFI-LS	November
OC6N	15	GREAT	Nov/Dec
OC6O <sup>3</sup>	4	FORCAST	January

1) Aircraft maintenance and other engineering activities are not shown

2) Continues FORCAST series OC5P

3) Includes a SOFIA visit to Seattle for the 2019 winter AAS meeting

# SOFIA Deploys to Daytona Beach for Triton Occultation

Raquel Destefano, *Project Specialist II*



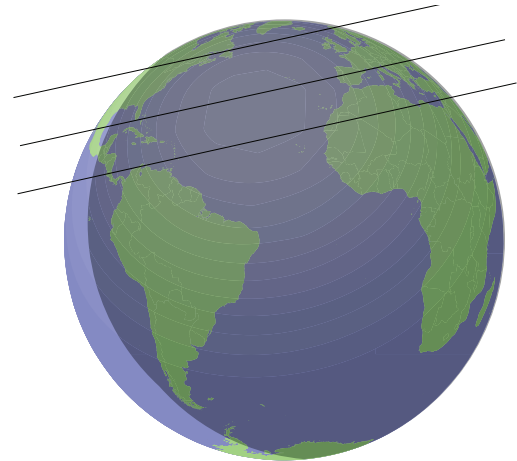
On October 5, 2017, Neptune's largest moon, Triton, passed in front of a star that allowed for the first measurement of Triton's lower atmosphere (~30–130 km above Triton's surface) in over 15 years. The star cast Triton's shadow out over the Atlantic Ocean, and SOFIA deployed to Daytona Beach, Florida, to observe the occultation event. The shadow crossed the Earth at 37,000 mph (~17 km/second) and SOFIA was able to detect the occultation's central flash.

Occultations enable astronomers to directly measure Triton's lower atmosphere to glean information on temperature, pressure, and particulate haze. Monitoring the atmospheric pressure over multiple occultations can tell whether the atmosphere is still expanding or has begun to collapse. Occultation observations detected a global expansion of Triton's atmosphere from the mid 1990s through 2001. After 2001, Triton began to pass through a sparse star field, making occultation observations impossible until this most recent event.

Observing the central flash of the occultation is critical for analysis of Triton's lower atmosphere. A central flash occurs due to partial focusing of the starlight by refraction through the occulting body's lower atmosphere. The geometric shape of the central flash is sensitive to the global structure of the atmosphere and, as such, is integral for research.

Furthermore, to record central flash profiles, astrometry must yield an accuracy of ~5 milliarcseconds to position SOFIA within Triton's central flash zone. During the Pluto occultation, SOFIA was within 1.5 milliarcseconds of Pluto's centerline, well within the central flash zone. For Triton, SOFIA was able to position the aircraft within just one mile of the predicted centerline at the mid-point of the event. Lead investigator Ted Dunham attests, "You often hear the comment 'I'd rather be lucky than good.' In my experience, you really need to be lucky *and* good." To enable such precision, the exact location of Triton was predicted by a combined effort of all observatories that participated in the event.

An occultation light curve can reveal much about the

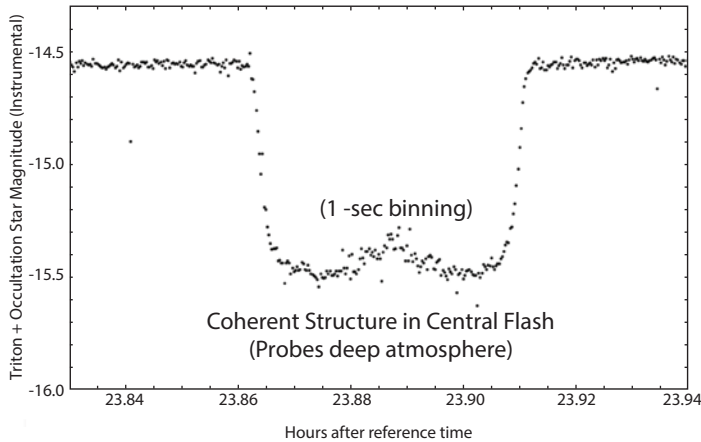


The Earth as viewed from Triton. Solid lines represent the predicted northern limb, central flash, and southern limb paths. (Person et. al. 2017, SOFIA Proposal; [hubble.mit.edu/prediction](http://hubble.mit.edu/prediction))

planetary body's atmosphere and inspire credible theories for further research regarding the conditions at lower altitudes. In general, variations within an occultation light curve can be attributed to changes in density: as the atmosphere becomes denser, less light from the occulting star will be directed toward Earth, resulting in a lower flux reading by the telescope's instrumentation. From this, it becomes evident that moving toward the center of the light curve is analogous to looking closer to the object's surface, the slopes of the ingress and egress lines are indicative of the vertical structure of the atmosphere, and fluctuations in otherwise smooth areas of the light curve are evidence of localized regions of different density and temperature due to atmospheric waves. Co-investigator Mike Person elaborates, "One theory to explain small spikes in flux during the occultation are temperature inversion layers, such as those we see on Earth. On Triton these could be indicative of waves propagating upward through Triton's atmosphere, or possibly atmospheric tides raised by Neptune."

Seasonal increases in surface temperature may have a dramatic effect on Triton's overall atmosphere. Triton's primarily nitrogen (N<sub>2</sub>) atmosphere is believed to exist in vapor pressure equilibrium with nitrogen surface ice.





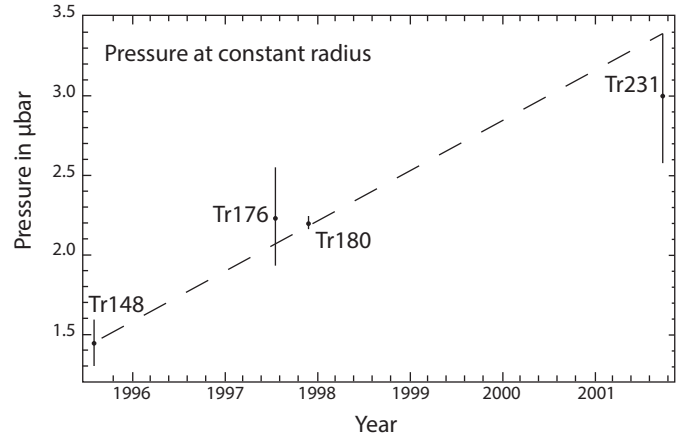
The HIPO\_RED light curve, one of the four light curves obtained by SOFIA during the 2017 Triton occultation. (Person et. al. 2017, in preparation)

(Elliot, et. al., *The Astronomical Journal*, 126:1041-1079, August 2003) Seasonal changes in surface temperature therefore result in large changes atmospheric pressure.

Global expansion of Triton’s atmosphere as seen before 2001 is thus theorized to be attributed to seasonally increased surface temperature, which results in the sublimation of surface ice. However, if Triton’s atmosphere is found to be increasing, it would provide evidence of larger ice reserves than previously conceived. Mike Person explains, “Our atmospheric models are at least as much concerned with where exactly the ice is as with how much of it there is, and how much these ice emplacements are encountering sunlight.”

The presence of atmospheric haze could provide additional evidence for these seasonal changes. Haze in general is either chemically sourced (as seen in Titan’s atmosphere) or physically lifted from the surface of the planetary body. Earlier Voyager spacecraft observations have provided strong evidence for winds in excess of 223.6 mph (~100 meters/second) based on large distortions in the light curves generated. (Elliot et. al., *Icarus* 148, 347-369; 2000)

In attempt to establish whether Triton’s atmosphere contains haze, SOFIA utilized its capacity to conduct simultaneous data acquisitions from multiple instruments,



Pressure results for four of the five pre-2017 Triton occultations. (Person et. al. 2017, in preparation)

including the FLITECAM-HIPO combination and FPI+ at optical through near-IR wavelengths. Chief Science Advisor Eric Becklin explains, “What we had wanted to do was what we had also done with Pluto, which was to see how deep down does the bottom [of the light curve] go. If there is [haze] in the atmosphere, then the four different light curves will look different in the bottom and the infrared should be the highest if there’s [haze].” In the 2015 Pluto occultation, haze was indeed indicated by the observations using the same aggregate of instruments onboard SOFIA.

Associate Director for Science Data Systems Bill Vacca said it best, “It wouldn’t be SOFIA if there wasn’t drama, anxiety, excitement, and ultimately elation — all the elements of a made-for-TV movie. In the end, we obtained superb data on Triton and the occulted star and were easily able to see the occultation — in the FPI+, HIPO, and even the raw FLITECAM data. A quick post-occultation analysis of the data from all three instruments showed a small central flash!”

SOFIA’s growing occultation resumé now features successful observations examining MU69, Pluto, and Triton. The astronomy community can look forward to new additions to this list with a centaur or trans-Neptunian object in Cycle 6 or Cycle 7 and Titan in Cycle 6, which begins this February 2018. ■

## German Perspective

Holger Jakob, *Science Mission Acting Deputy Director*



In the past Deputy Science Mission Operations Director Hans Zinnecker used this space to greet you with a special insight on the German side of the SOFIA Program. With his retirement last year I accepted to step in as acting deputy until the new deputy director has been appointed. The search was conducted by a committee that has recently converged on a candidate. The announcement is expected in early 2018.

Hans Zinnecker, although retired, agreed to extend his support for SOFIA and continue as the German Time Allocation Committee (TAC) chair in the evaluation of the German Cycle 6 proposals. In this round we were especially excited that three out of the 27 received proposals were submitted to the German TAC under a new student category. With the new Thesis Enabling Program, DLR is encouraging Master's and PhD candidates to utilize SOFIA data as a key part of their thesis. A selected student is mentored by a senior SOFIA expert and is guided through the proposal process and observing challenges.

For early May 2018, we are planning a SOFIA workshop in Stuttgart, Germany, aimed at communicating the latest news regarding the Cycle 7 Call for proposals, including instrument upgrades, training potential users and students on how to write SOFIA proposals, and at demonstrating the quality of SOFIA science results. Stay tuned for the announcement.

Our German instruments continue to expand their capabilities. Just in time for the 2017 New Zealand deployment the new onboard closed-cycle compressors became available, providing the 4K temperature platform to operate the detectors for the German REceiver for Astronomy at Terahertz Frequencies (GREAT) heterodyne instrument. This allowed for the first time to operate the two upGREAT arrays LFA and HFA with in total then 21 pixels simultaneously on sky. During the deployment the commissioning of the latest addition to GREAT, 4GREAT with four single-pixel detectors covering — in parallel — selected frequencies between 0.49 and 4.7 THz, was started. In the future, 4GREAT will replace the liquid-Heli-

um cooled single-pixel receivers used so successfully during the last five years.

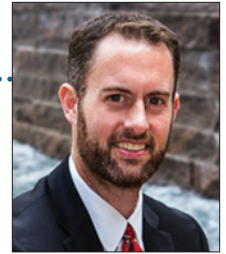
FIFI-LS (for Far Infrared Field-Imaging Line Spectrometer) is completing an upgrade of its filter set just in time for Cycle 6. This will significantly improve the transmission in the short wavelength band of the instrument between 50 $\mu$ m and 65 $\mu$ m. Especially, observations at the [OIII] 51.8 $\mu$ m line, which is a unique FIFI-LS/SOFIA capability, will benefit strongly from the higher transmission. The line ratio of this line with the [OIII] 88.4 $\mu$ m (also available with FIFI-LS) is essential to probe the density in HII regions. With the spatial resolution of SOFIA and the improved sensitivity it is now possible to go for fainter objects like extragalactic HII regions. On brighter objects the observing efficiency is increased by 30–50 percent.

Our Focal Plane Imager (FPI+) had its première as primary Science Instrument when the TNO MU69 was occulted on June 10. The FPI+ also observed the shadow of Neptune's moon Triton together with HIPO and FLITECAM on October 5th. SOFIA enabled the first comprehensive study of Triton's atmosphere since the 1990s. It was joined by more than 70 observatories along the US East Coast and in Europe to observe this unique stellar occultation. Karsten Schindler (DSI) coordinated the ground campaign in Europe and worked with the observers up to the last minute to set up equipment, discuss observing strategies and optimize science return. SOFIA was deployed from Daytona Beach (Florida), heading toward the Atlantic on a course to intercept Triton's shadow right at the predicted centerline about 1500 miles off Florida's coast. High cloud layers and a last minute shift of the centerline prediction to the south made this a challenging mission, but everyone stayed calm, focused and made the observations a success.

And also this past year our engineering team in Palmdale made substantial progress to keep the Telescope Assembly (TA) in an operating state. A new set of power units have just now become available to improve the reliability of the TA. We consider upgrade engineering a key to keep SOFIA successful over the 20 years lifetime. ■

# Next Generation Science Instrument Call for Proposals

Alan C. Rhodes, *SOFIA Science Instrument Development Manager*

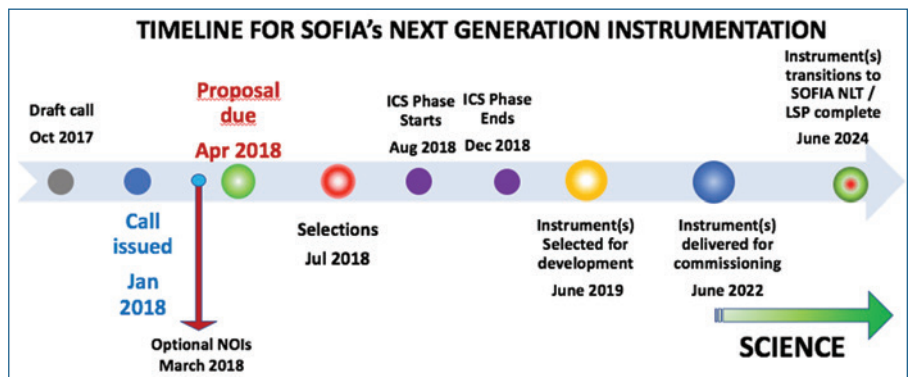


**S**OFIA has just released a draft call for proposals for the Next Generation SOFIA Science Instrument!!

Unlike most space missions, SOFIA's scientific instruments can be exchanged periodically to accommodate changing science requirements and to incorporate new technologies, which is a tremendous advantage. A key part of the SOFIA project has always been to include an instrumentation program that would periodically introduce new technologies in order to enable new scientific frontiers to be explored. NASA is soliciting proposals for compelling science that will ultimately lead to the development of one or more new science instruments and/or upgrades to existing science instruments.

## Key Points of the Call for Proposals:

- The next generation science instrument(s) must be motivated by compelling science.
- Selected team(s) must execute and deliver well-defined Legacy Science Program(s) of high scientific value that the team will execute with the instrument they build and deliver. The Legacy Science Program is a scientifically ambitious investigation with long-lasting and impactful science that motivates development of the proposed instrument.
- Prioritize instruments that enable broad community usage and/or data of high archival value, but also allow for agile, "niche" instruments to solve important/outstanding science questions.
- Allow for new instruments or upgrades/modifications to existing instruments; also allow for flexibility for future enhancements and modifications to the next generation science instrument.
- Allow for a nominal three-year development period after funding begins but also allow for longer or shorter development timescales for optimal science return.
- Allow for schedule and budget flexibility; make selections based on science return on investment.



- Reduce requirements for the instrument concept study phase compared to previous solicitations.
- Make instrument development and acceptance process easier for teams (using lessons learned from past experience)

The draft call is posted at: <https://go.nasa.gov/2jyHGly>

Please review the proposal and provide any comments or questions via email to [kartik.sheth@nasa.gov](mailto:kartik.sheth@nasa.gov) by 11:59pm, Eastern time, January 14, 2018. The anticipated date for the release of the solicitation is January 19, 2018 with proposals due 90 days after the release.

Along with your review, the SOFIA team requests that you share this information with any of your colleagues that would be interested in proposing.

As we embark upon this new era of exploration with SOFIA, we invite you all to review and share this information and Come Explore With Us! ■



## Science Highlights

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*(continued from page 4)*

dwarfs. But high-redshift galaxies are not old enough to have such evolved stars and need another dust source. Type I supernovae are due to white dwarf conflagrations and therefore also require time for stellar evolution. Type II supernovae are due to core collapse of massive stars, whose lifetimes are short enough that they could already have occurred in high-redshift galaxies. Before infrared observations with the European Space Agency's Infrared Space Observatory showed clear evidence of dust in the ejecta of the Type II supernova remnant Cassiopeia A (Cas A), it was not known whether a significant amount of dust

was produced. The new measurement of a large dust mass in G54.1+0.3 joins that observed in SN 1987A as an indicator that Type II supernovae are plausibly significant sources of dust in the early universe.

**Author's Note:** *Now is the time to get your SOFIA observing projects published. We would like all of our data to see the light of day. This year is especially important if you value SOFIA as an observatory, because our productivity will be part of the Senior Review in 2019. All SOFIA observers should expect to see a survey in the email-box. If you could take a minute to fill it out, we'd appreciate it!* ■

The Science Highlights section of the SOFIA Newsletter features recent SOFIA scientific achievements. Researchers interested in showcasing their work in this section may submit an image and short write-up for consideration to [wreach@sofia.usra.edu](mailto:wreach@sofia.usra.edu).

## Science Operations and Outreach

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*(continued from page 7)*

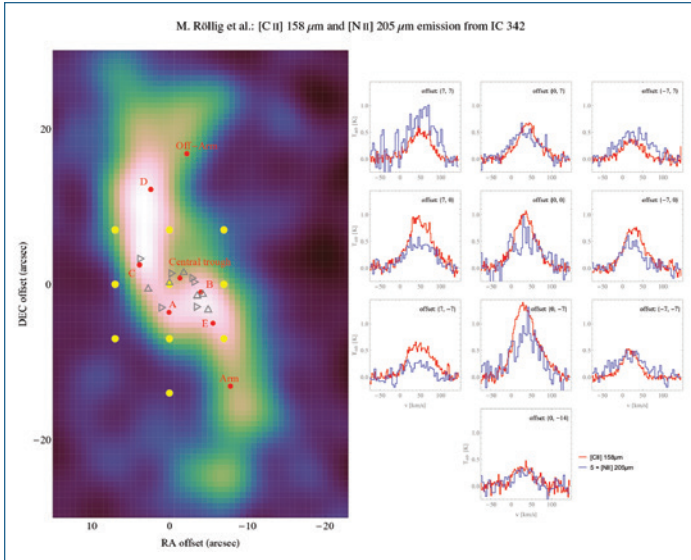
The Cycle 6 instrument schedule, laid out based on the Priority 1 and 2 selections and programmatic requirements is shown in Table 1 (page 7). In Cycle 6 we are limited to two instruments for the Southern Deployment. Based on the proposal pressure these were selected to be GREAT and HAWC+. The deployment for Cycle 6 has been moved earlier than in previous cycles by about three weeks to take better advantage of the longer nights as well as drier atmosphere above New Zealand. In addition to the planned regular science flight series, the program manager is considering several high-priority activities in the Cycle, most prominently a visit to Boeing Field in Seattle during the American Astronomical Society (AAS) winter meeting in January 2019.

### Happy New SOFIA Year

The SOFIA Operations team is busy supporting the Cycle 6 phase II ingest and detailed planning for the new Cycle, as well as executing the remaining Cycle 5 program. As last year, we have several active job postings out on the AAS Job register for instrument scientists, which we bring to your attention. We're looking forward to seeing many of you at the Washington, D.C., AAS winter meeting, to discuss SOFIA science, plans, and jobs!

Please join us for the SOFIA Town Hall meeting in Washington, and to celebrate the achievements of this year's AAS Henry Norris Russell lecturer and SOFIA Chief Science Advisor, Erick Becklin.

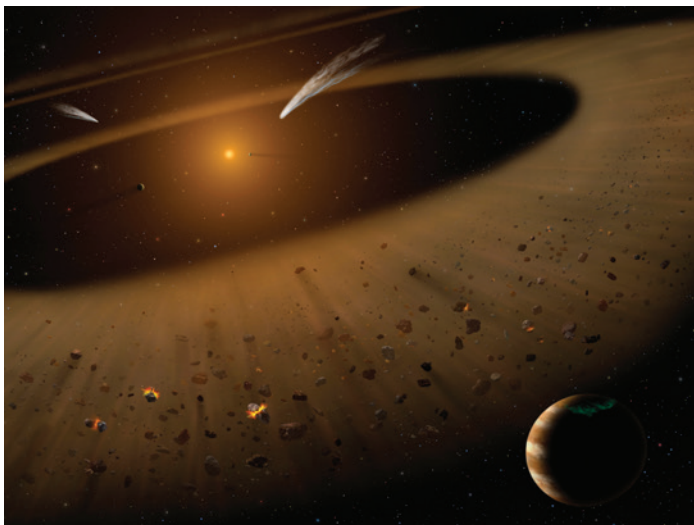
We wish you many warm Season's Greetings and a Happy and Productive New SOFIA Year! ■



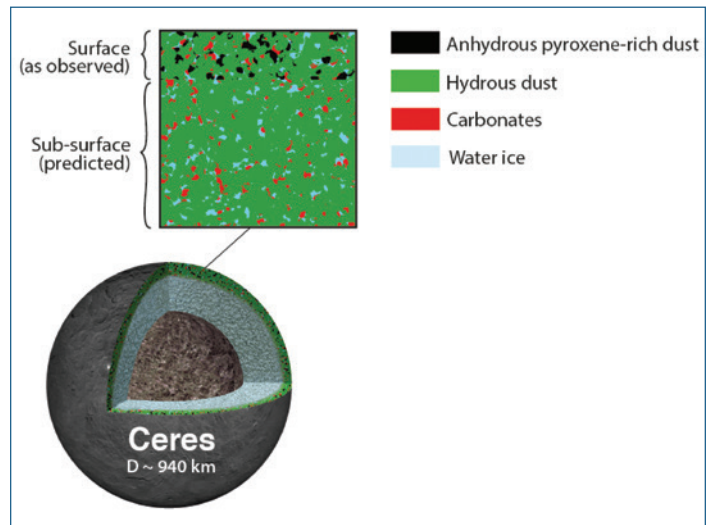
[C II] 158  $\mu\text{m}$  and [N II] 205  $\mu\text{m}$  emission from IC 342  
 Röllig, M. et al. *A&A* Volume 591, July 2016  
 More information: <https://go.nasa.gov/2Ak2jc2>



Understanding Star Formation in the Nucleus of Galaxy IC 342  
 Röllig, M. et al. *A&A* Volume 591, July 2016  
 More information: <https://go.nasa.gov/2AlQtOr>



SOFIA Confirms Nearby Planetary System is Similar to Our Own  
 (NASA/SOFIA/Lynette Cook)  
 Su, K. et al. *The Astronomical Journal*, Volume 153, Issue 5, article id. 226,  
 12 pp. (2017)  
 More information: <https://go.nasa.gov/2Al4snD>



Don't Judge an Asteroid by its Cover: Mid-infrared Data from SOFIA Shows Ceres' True Composition (Pierre Vernazza, LAM-CNRS/AMU)  
 Vernazza, P. et al. *The Astronomical Journal*, Volume 153, Issue 2, article id. 72, 10 pp. (2017)  
 More information: <https://go.nasa.gov/2Aljbiw>

## Airborne Astronomy Ambassadors

Dana Backman, *Manager, NASA Airborne Astronomy Ambassadors program*



The SETI Institute's NASA Airborne Astronomy Ambassador (AAA) program was one of 27 organizations from across the United States selected in October 2015 by NASA's Science Mission Directorate for cooperative agreement awards. In ensemble, those awards implement a new strategic approach for more effective engagement by learners of all ages in NASA's science education programs and activities. SETI Institute AAA program staff include Dr. Dana Backman, Coral Clark, and Pamela Harman.

The AAA program is comprised of: (1) pre-flight teacher professional development including webinars, on-line content learning, and hands-on workshops (Figures 1, 2, 3), (2) a STEM immersion experience at the NASA Armstrong



Figure 2: Participants in AAA Northern California workshop, June 2017.



Figure 1: Cycle 5 AAA Northern California professional development workshop, June 2017.

Flight Research Center's Building 703 in Palmdale, California, (Figures 4 and 5), and (3) follow-through involving webinars fostering connections with astrophysics and planetary science subject matter experts plus ongoing participation in the AAA community of practice.

During 2016–17, the SETI Institute AAA staff worked in partnership with seven school districts in Northern, Central, and Southern California plus WestEd education consultants to select 39 Ambassador teachers for flights during SOFIA Cycles 5 and 6 (2017–18). The 2017–18 AAA

selection announcement is available on line at [go.nasa.gov/2ldWICd](http://go.nasa.gov/2ldWICd).

Teacher eligibility criteria included three-plus years of teaching experience and current assignments to teach at least two sections, in any combination, of high school (non-AP) Physics, Physics of the Universe (CA integrated science curriculum), Astronomy, or Earth and Space. (*Important note: In the current mode, applications for AAA participation are accepted from school districts, not individual teachers.*) WestEd evaluators then randomly



Figure 3: Participants in AAA Southern California workshop, June 2017.

## Airborne Astronomy Ambassadors

assigned the selected AAAs to Cycle 5 or Cycle 6 groups. The Cycle 5 group began their professional development in spring 2017 in preparation for Palmdale visits and SOFIA science flights during fall 2017 and winter 2018.

Following their SOFIA flights, the Cycle 5 teachers are implementing a two-week Electromagnetic Spectrum and Multi-wavelength Astronomy curriculum module produced by AAA SETI Institute staff that includes illustrative examples from SOFIA science observations. Cycle 6 teachers are serving as the curriculum control group during the 2017–18 school year, then will start their professional development in early 2018 to prepare for SOFIA flights in fall 2018.

The primary AAA program goal is to demonstrate student gains in content knowledge fostered by the new curriculum, measured via pre- and post-curriculum delivery tests. The two-week curriculum module component is carefully designed in alignment with the national Next Generation Science Standards (NGSS) and corresponding California Science Framework. An important secondary goal is measurement of changes in student attitudes and engagement with STEM (Science, Technology, Engineering, and Math).

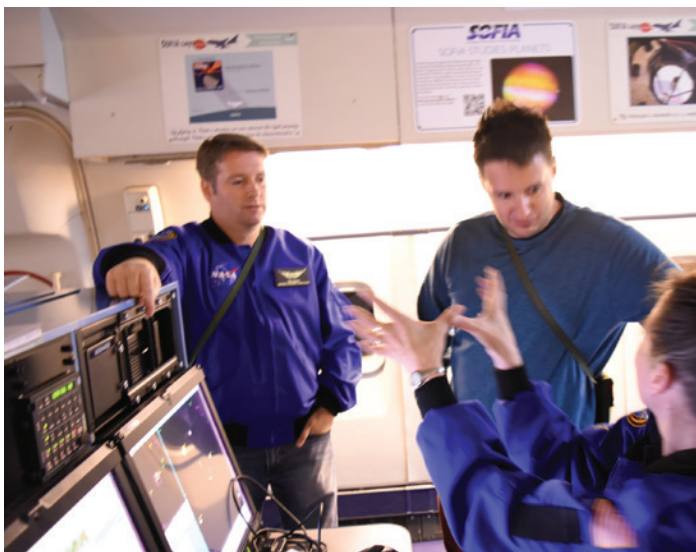


Figure 4: Cycle 5 AAAs and flight facilitator in flight, Oct. 2017.



Figure 5: Cycle 5 AAAs and flight facilitators, Oct. 2017.

“The Airborne Astronomy Ambassadors program gives science teachers a unique opportunity to witness scientific research with all the blood, sweat, and tears as it really happens,” said AAA co-Investigator Pamela Harman. “These teachers can then convey to their students the wide range of professional expertise supporting that research, and, we hope, lead the students to see themselves someday in STEM careers.”

“Educators need these opportunities to push themselves to expand their subject knowledge,” said AAA participant Peter Renders. “This will, in turn, inspire their students to do the same.”

AAA participant, Lisa Maya Lock said, “This amazing opportunity will deepen my knowledge and enhance engagement and impact in my classroom.”

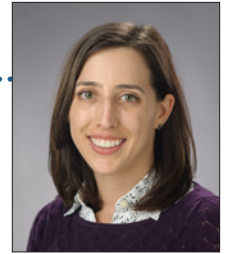
Note to SOFIA Guest Observers: If you are in Palmdale during a week when an AAA group is scheduled to fly, the AAA program staff and participants will be grateful if you can spare some time, pre-flight or during your flight, to talk with the teachers about your research project. ■

For more information about the Airborne Astronomy Ambassadors program, visit

[www.seti.org/aaa](http://www.seti.org/aaa)

# SOFIA to Explore Magnetic Universe and Beyond

Kassandra Bell, SOFIA Public Affairs – Social Media Lead



NASA's Stratospheric Observatory for Infrared Astronomy, SOFIA, is preparing for its 2018 observing campaign, which will include observations of celestial magnetic fields, star-forming regions, comets, Saturn's giant moon Titan and more.

This will be the fourth year of full operations for SOFIA, with observations planned between February 2018 and January 2019. Research flights will be conducted primarily from SOFIA's home base at NASA's Armstrong Flight Research Center. Highlights from these observations include:

- The observatory's newest instrument, [the High-resolution Airborne Wideband Camera-Plus, called HAWC+](#), will continue research with its polarimeter, a device that measures the alignment of incoming light waves. These investigations will help researchers understand how magnetic fields affect the rate at which interstellar clouds condense to form new stars.
- One such program will use the instrument to understand the impact magnetic fields have on stars forming inside a dark cloud, a stellar nursery filled with dust and molecules, called L1448.
- The HAWC+ instrument will also be used in a joint research program with the [Atacama Large Millimeter/submillimeter Array](#) to trace magnetic fields to better understand how planets form.
- Another program using the HAWC+ instrument will help astronomers better understand how [energetic, active black holes](#) contribute to the most luminous, distant galaxies. These observations will help them learn whether the luminosity of these active black holes is driven by star formation or accretion of material onto the central black hole.
- Researchers will continue to search for methane on Mars. SOFIA will conduct observations during the same Martian season that the [Curiosity Rover previously detected the gas](#) to better understand how methane levels change with the Red Planet's seasons.

- Another team of researchers is planning to study comet 46P/Wirtanen as it passes close to the Earth, to search for clues in the comet's dust that may help better understand the evolution of the [early solar system](#).

In June and July, SOFIA will [return to Christchurch, New Zealand](#), to study objects that are best viewed from the Southern Hemisphere, including neighboring galaxies the Large and Small Magellanic Clouds. Observations planned while operating from there include:

- Researchers will create a large-scale map of the biggest star-forming region in the Large Magellanic Cloud, [30 Doradus, \(also known as the Tarantula Nebula\)](#). This map will be used as a template for understanding bursts of star formation that are the origin of a large part of the stars in all galaxies.
- The HAWC+ instrument will be onboard SOFIA for its first observations from the Southern Hemisphere, to study magnetic fields in star-forming regions and around black holes in the Large and Small Magellanic Clouds.
- Researchers will utilize SOFIA's mobility to study the atmosphere of Saturn's moon Titan by studying its shadow as it passes in front of a star during an [eclipse-like event](#) called an occultation. These occultation observations are part of an effort to monitor changes in Titan's atmosphere over time now that the [Cassini spacecraft's mission](#) has ended. ■

