National Aeronautics and Space Administration

Cosmic Origins Newsletter

March 2016 Volume 5 Number 1

Winter/Spring 2016 Cosmic Origins Program Update

Mansoor Ahmed, *COR Program Manager*
Susan Neff, *COR Program Chief Scientist*

Welcome to the March 2016 Cosmic Origins (COR) newsletter. In this issue, we provide updates on several activities relevant to the COR Program objectives. Some of these activities are not under the direct purview of the program, but are relevant to COR goals; therefore we try to keep you informed about their progress.

The January 2016 AAS meeting culminated in formalizing NASA's plan for developing viable concepts for potential Astrophysics Large missions to follow after *WFIRST*. The process started in January 2015 when Dr. Paul Hertz (Director, NASA Astrophysics) asked the Program Analysis Groups (PAGs) for obtaining the community input to narrow down the list of large missions to focus on, in preparation for the 2020 Decadal Survey. Four Large Mission Concept Studies have been identified for focused studies, funded by NASA. Two of these studies, Large UV-Optical-near IR telescope (LUVOIR) and Far-Infrared Surveyor, fall within the purview of the COR Program. The articles by **Paul Hertz** and by **Deborah Padgett** summarize plans and activities around these studies, and the status of team formation. We strongly encourage all astronomers and astro-technologists to participate in this process, which will help shape the future of space astrophysics.

During the AAS meeting, Dr. Hertz also presented his initial thoughts on studying possible Astrophysics Probe missions prior to the Decadal Survey. He charged the PAGs to discuss this in the community and report back in March.

The COPAG has been busy in other areas as well. The full COPAG met at the January 2016 American Astronomical Society (AAS) to explore the possible scope of Astrophysical Probe mission concepts, as described **Paul Scowen's article**. All three of the COPAG's Science Interest Groups (SIGs) also met at the AAS meeting. This issue of the newsletter contains reports from the **UV/ Optical SIG** and the **Cosmic Dawn SIG**.

We particularly encourage young researchers to participate in the community SIGs and SAGs, as well as the large mission studies, as they will be the primary users of the future observatories. We introduce a *Hubble* **fellow, Dr. Katherine Alatalo**, who is currently working on giant elliptical galaxies, looking for evidence of remaining star-formation fuel, molecular gas and dust.

Hubble continues to make scientific breakthroughs, and collect stunning images of the Universe. *Hubble's* 24th call for proposals is out, proposals are due in April. *Spitzer* announced selections for its 12th call for proposals. ***SOFIA*** is operating well and is moving ahead with its third generation instruments. We include highlights of a few recent science results in boxes throughout the newsletter.

Good progress is also being made with in missions not formally part of the COR program. The *James Webb Space Telescope* (*JWST*) continues towards its planned 2018 launch on time and on budget. We provide a **quick status** as well as an **article about how the flight mirrors are installed**. The *Wide-Field-Infrared Survey Telescope* (*WFIRST*) has successfully completed the review to enter into mission formulation. The *WFIRST* project office also

Inside this Issue

announced selections of the *WFIRST* Science Team that will work with the *WFIRST* project office over during the formulation phase to refine the science requirements. We offer an article describing the ***WFIRST* status**.

A key part of the COR Program is managing development of the technologies required for future COR discoveries. The Strategic Astrophysics Technology (SAT) program is designed to bring important technologies to a level of development that can be infused into flight missions. The community's input regarding the important technology gaps is extremely helpful in identifying the relevant technologies. We provide an overview of the **COR program's plans for this year's technology gap request**.

The suborbital program is a major part of the technology maturation process, as well as an excellent training ground for young instrumentalists. We present an **article on a balloon payload** that is flying an innovative lightweight 2.5 m mirror, and an MKID microwave detector array, as it maps magnetic field structures in our Galaxy.

It is an exciting time in Cosmic Origins, as we look to the future. Please, become involved, if you are not already.

• • •

Message from the Astrophysics Division Director

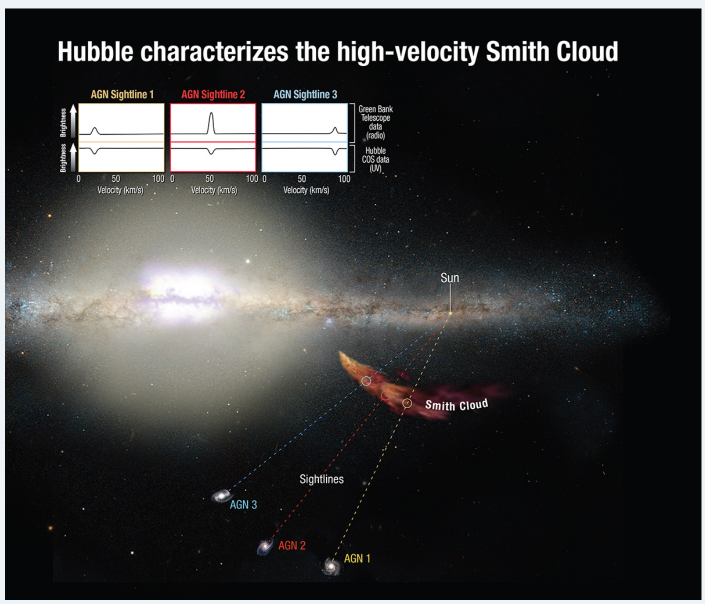
Paul Hertz, *Director, Astrophysics Division, Science Mission Directorate, NASA Headquarters*

The Astrophysics Division is preparing to execute a rich portfolio of activities in the New Year, as I described during the NASA Town Hall at the 227th meeting of the American Astronomical Society in Kissimmee, FL. The fiscal year (FY) 2016 appropriation provides funding for NASA astrophysics to continue its programs, missions, projects, and supporting research and technology. The operating missions continue to generate important and compelling science results, and new missions are under development for the future. Progress is being made toward recommendations of the 2010 Decadal Survey.

- The National Academies has formed an ad hoc Committee, chaired by Dr. Jacqueline Hewitt, to conduct a Review of Progress Toward the Decadal Survey Vision in *New Worlds, New Horizons in Astronomy and Astrophysics*. The committee has held three meetings so far. Details, including my presentations, may be found at **http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_161177.**

Hubble Finds Monstrous Infalling Gas Cloud Originated in Our Galaxy

Although hundreds of enormous, high-velocity gas clouds populate the outskirts of our Galaxy, the "Smith Cloud" is unique because its trajectory is very well known. Astronomers long thought that the Smith Cloud might be a failed, starless galaxy, or gas falling into the Milky Way from intergalactic space. If either of these scenarios proved true, the cloud should contain mainly hydrogen and helium, not the heavier elements made by stars. However, if it came from within the Galaxy, it would contain more of the elements found within our sun.



Hubble/COS sightlines through an infalling cold gas cloud were used to measure the chemical composition of the high-velocity "Smith Cloud", and trace it to an origin in the Milky Way. Image credits: NASA, ESA, and A. Feild (STScI)

Astronomers led by Andrew Fox at Space Telescope Science Institute in Baltimore, Maryland used *Hubble Space Telescope* to determine the Smith Cloud's chemical composition for the first time, observing ultraviolet light from the bright cores of three active galaxies billions of light-years beyond the cloud. The Cosmic Origins Spectrograph measured how ultraviolet light filters through the cloud.

The team found that the Smith Cloud is as rich in sulfur as the Milky Way's outer disk (about 15,000 light-years farther out from the galaxy than our sun and solar system). This means that the Smith Cloud was enriched by material from stars, and is not pristine hydrogen from outside the galaxy. Instead, the cloud appears to have been ejected from within the Milky Way and is now boomeranging back.

The new observations suggest it was launched from the outer regions of the galactic disk, around 70 million years ago. The cloud is now on a return collision course and is expected to plow into the Milky Way's disk in about 30 million years. When it does, astronomers believe it will ignite a spectacular burst of star formation, perhaps providing enough gas to make 2 million suns.

"The cloud is an example of how the Galaxy changes with time," explained Fox. "It's telling us that the Milky Way is a bubbling, very active place… Our Galaxy is recycling its gas through clouds … and will form stars in different places than before."

As often happens in science, answering one question leads to others: What calamitous event could have catapulted the cloud from the Milky Way's disk? How did it remain intact? Could it be a region of dark matter—an invisible form of matter—that passed through the disk and captured Milky Way gas? The answers may be found in future research.

Full story at: **http://hubblesite.org/newscenter/archive/releases/2016/04/full/**

• NASA Research and Analysis (R&A) funding continues to grow. NASA also funds the community through the mission Guest Observer (GO) programs. In 2015, NASA received ~3750 proposals for R&A or GO funding. The selection rate in 2015 was 24% for R&A proposals and 28% and for GO proposals. 100% of the 2015 selections were announced within 155 days or proposal submission. This year, in addition to the regular research opportunities solicited through the Research Opportunities in Space and Earth Science (ROSES) NASA Research Announcement and mission GO programs, a fall 2016 release date is targeted for a Medium-class Explorer (MIDEX) solicitation (**http://explorers.larc.nasa.gov/APMIDEX2016/**). Note that there are changes in ROSES regarding public access to Federal research. Please read ROSES-2016 carefully, and consult the FAQs at **http://science.nasa.gov/researchers/sara/faqs/dmp-faq-roses/**.

• *JWST* continues to make technical progress during its integration and test phase according to its plan. The Telescope Structure (TS) has been completed and shipped to Goddard Space Flight Center for integration of the mirrors; the second Telescope Pathfinder test at Johnson Space Center is complete; the Spacecraft Bus Structure has been delivered for Integration and Testing at the prime contractor's facility in California. Mirror installation into the Telescope Structure was completed in January 2016 and can be observed on the WebbCam at **http://jwst.nasa.gov/**. Plans for 2016 include completion of cryovacuum testing of the Integrated Science Instrument Module including all four instruments, installation of the Integrated Science Instrument Module into the Telescope Structure, secondary mirror installation, and completion of fabrication of the Flight Sunshield membranes. *JWST* remains on cost and on schedule for an October 2018 launch.

• The *Wide-Field Infrared Survey Telescope* (*WFIRST*) starts formulation in February 2016 when it passes its review by the NASA Agency Program Management Council. In December 2015, the mission completed its Mission Concept Review, all of the technology development milestones for the two instruments were achieved on schedule, and the Formulation Science Working Group and Science Investigation Teams were selected following a peer review of competitive proposals. In 2016, the Science Working Group will develop the *WFIRST* science requirements, the mission concept will be matured, and technology development for the widefield instrument and the coronagraph instrument will be further advanced to TRL-5.

• NASA intends to partner with ESA on the ESA-led Large 3 (L3) gravitational wave mission with launch in 2034. This responds to the recommendations of the 2010 Astrophysics Decadal for a space-based gravitational wave observatory. Following the successful launch of the LISA Path Finder, NASA has formed an L3 Study Team (L3ST) drawing membership from members of the US astrophysics community. The L3ST Charter and list of selected members can be found at **http://pcos.gsfc.nasa.gov/studies**.

• The Japanese X-ray observatory *Hitomi* (formerly *ASTRO-H*), including NASA provided elements of the Soft X-ray Spectrometer and the Soft X-ray Telescope, was launched successfully on 17 February 2016 (**https://heasarc.gsfc.nasa.gov/docs/astroh/**). The *Hitomi* Cycle 1 GO call is planned for April 2016.

• NASA is developing two astrophysics experiments for launch to the International Space Station. The Cosmic Ray Energetics and Mass for the ISS (ISS-CREAM) (**http://www.nasa.gov/mission_pages/station/research/experiments/1114.html**) experiment was delivered to Kennedy Space Center in August 2015; it is awaiting a ride to the Space Station on the Commercial Resupply Service SpaceX-12 launch, planned for summer 2017. The *Neutron Star Interior Composition Explorer* (*NICER*) (**https://heasarc.gsfc.nasa.gov/docs/nicer/**) has entered its final integration and test phase; *NICER* will be completed by late summer 2016 and will await its ride to the Space Station on CRS SpaceX-11, planned for winter 2017.

• NASA's standard Announcement of Opportunity (AO) revision process is being revised with goals of reducing the burden on proposers and increasing the efficiency of review (**http://soma.larc.nasa.gov/standardao/sao_templates.html**).

• The restructuring of the Science Mission Directorate's education program is nearing completion. Of the 73 compliant proposals submitted to the Science Education Cooperative Agreement Notice solicitation last year, 27 have been selected for execution. Fifteen of these include Astrophysics content (three of them are exclusively Astrophysics.) A meeting of the Principal Investigators was held in Westlake, TX on January 19–21, 2016, to form additional partnerships to leverage off each other's strengths.

• The Senior Review of the NASA astrophysics operating missions in extended phase will be held in February and March 2016. We expect to release the review report to the community by June 2016. More information may be found on **http://science.nasa.gov/astrophysics/2016-senior-review-operating-missions/**.

• Preparations for the 2020 Decadal Survey are well under way. The three Astrophysics Program Analysis Group reports on large mission concepts were presented to the Astrophysics Subcommittee in October 2015 and are available at **http://cor.gsfc.nasa.gov/copag/rfi/**. NASA is initiating community-led studies of four large mission concepts by chartering Science and Technology Definition Teams for each of the four mission concepts. The charter and management plan for these mission concept activities are available at **http://science.nasa.gov/astrophysics/2020-decadal-survey-planning/**.

My entire Town Hall Presentation from the January AAS meeting, is available at **http://science.nasa.gov/astrophysics/documents/**.

• • •

Large Mission Concept Studies Begin

Deborah Padgett, *COR Program Deputy Chief Scientist*

Last year, APD director Paul Hertz charged the NASA Astrophysics Program Analysis Groups (PAGs) with evaluating a short list of potential large astrophysics mission concepts to be studied by NASA. These were drawn from the recommendations of the 2010 Decadal Survey and the NASA Visionary Roadmap document. The groups, representing Cosmic Origins (COPAG), Physics of the Cosmos (PhysPAG), and Exoplanet Exploration Science (ExoPAG), polled their respective communities and crafted joint

Standing room only at the Winter 2016 AAS Splinter Session on Large Astrophysics Mission Concept Science and Technology Definition Teams (STDT).

and individual responses to the charge, which were presented to the NASA Astrophysics Subcommittee in October. In summary, the PAGs endorsed the following concepts for further NASA study: a Large UV/Optical/Near-infrared Telescope (LUVOIR), a Habitable Planet Imager (HabEx), the X-Ray Surveyor (XRS), and the Far-IR Surveyor. The full reports can be seen at **http://cor.gsfc.nasa.gov/copag/rfi/**. At the 2016 Winter AAS meeting, Hertz announced a call for membership in the community-based Science and Technology Definition Teams (STDT) for each of the large mission concepts. These teams are charged with formulating science cases, developing a design reference mission, performing trade studies to optimize science versus cost, and identifying technology requirements in order to enable early investments by the NASA Strategic Astrophysics Technology (SAT) program. NASA Centers will provide study managers and engineering support for the studies (LUVOIR, Far-IR - GSFC; HabEx - JPL, and MSFC – XRS). The Call for STDT Membership concluded on February 1. NASA is now in the process of populating the teams from a large pool of outstanding applicants. The STDTs will meet for the first time in April 2016, and final reports will be presented to the 2020 Decadal Survey committee in 2019.

• • •

Far-Infrared Surveyor Decadal Mission Concept Study

Dave Leisawitz, *Study Scientist,NASA/GSFC*
Kartik Sheth, *Deputy COR Program Scientist, NASA HQ*

The Far Infrared Surveyor, like the Large UV / Optical / IR Surveyor and the X-ray Surveyor, was born out of NASA's 30 Year Astrophysics Visionary Roadmap, "*Enduring Quests, Daring Visions*". The Roadmap emphasizes the wide range of science that could be done by a future FIR telescope that incorporates significant advances in sensitivity, spectroscopy, and/or angular resolution over previous missions.

Expected to operate at wavelengths between ~30—300 microns (in the range between *JWST* and *ALMA*), such a mission would transform our understanding of astrophysical phenomena from planets, moons and comets in our own solar system, to newly forming exoplanets and planetary systems around nearby stars, to the formation of stars and galaxies near and far, and perhaps even the astrophysics of the interstellar medium immediately after the Big Bang. The quest to understand water transport in protoplanetary disks and the formation of a planet like Earth would be a particularly compelling science goal, especially if sub-arcsecond spatial resolution can be achieved. More information on science enabled by one potential implementation of a Far Infrared Surveyor can be found in the report "***From Early Galaxies to Habitable Planets***" that was authored by the community at a workshop last year.

These and other visionary science goals and measurement requirements for the Far-IR Surveyor will be established by a community-based Science and Technology Definition Team (STDT). The STDT will be supported by a NASA Center Study Office based at NASA's Goddard Space Flight Center, with partners at several other NASA Centers and industry. Drs. Asantha Cooray (UC Irvine) and Margaret Meixner (STScI) were selected to serve as STDT Co-Chairs. The STDT members will be chosen from 90 applications, and the membership will be announced in early March. The final selections will be posted at **http://science.nasa.gov/astrophysics/2020-decadal-survey-planning/** and at **http://cor.gsfc.nasa.gov/studies/fred.php.** Dave Leisawitz is the NASA Study Scientist, and Kate Hartman is serving as interim Study Manager. The NASA HQ Program Scientist for this study is Kartik Sheth.

NASA's Astrophysics Roadmap, *Enduring Quests, Daring Visions*, recognized the need for a Far-IR Surveyor mission with enhanced measurement capabilities relative to those of the *Herschel Space Observatory*, such as a three order of magnitude gain in sensitivity, angular resolution sufficient to overcome spatial confusion in deep cosmic surveys or to resolve protoplanetary disks, and new spectroscopic capability. Inspired by the Roadmap, the Far-IR Surveyor Study Team will develop a scientifically compelling, executable mission concept for presentation to the Decadal Survey in 2019.

• • •

Large Ultraviolet, Optical, and Near-Infrared Observatory Mission Concept Study

Aki Roberge, *Study Scientist, NASA/GSFC*

The Large UV / Optical / IR Surveyor (LUVOIR) is a concept for a highly capable, multi-wavelength observatory with ambitious science goals. This mission would enable a great leap forward in a broad range of cosmic origins science, from the epoch of reionization, through galaxy formation and evolution, to star and planet formation. LUVOIR also has the major goal of characterizing a wide range of exoplanets, including those that might be habitable —or even inhabited.

Like two of the other Decadal Mission concepts, LUVOIR was born out of the 2013 Astrophysics Visionary Roadmap, "*Enduring Quests, Daring Visions*". In the Roadmap, LUVOIR was identified as one of the highest priority flagship candidates for COR science in the 2030s, and the highest priority for exoplanets in that timeframe. More information on the science enabled by LUVOIR may be found in "Cosmic Birth to Living Earths", a recent report on a LUVOIR-like mission concept (the High-Definition Space Telescope) commissioned by the Association of Universities for Research in Astronomy (**http://www.hdstvision.org/report/**).

The LUVOIR study is being executed by Goddard Space Flight Center, under the leadership of a Science and Technology Definition Team (STDT) drawn from the community. As of this writing, the STDT chairs and members are being chosen from the 137 nominations received; the final selections will be posted in early March at **http://science.nasa.gov/astrophysics/2020-decadal-survey-planning/** and at **http://cor.gsfc.nasa.gov/studies/luvoir.php**. The LUVOIR study scientist is Aki Roberge and the study manager is Julie Crooke, both of GSFC. The NASA HQ Program Scientist for this study is Mario Perez.

• • •

COR Technology Gaps and the Four Large Mission Concept Studies Starting this Year

Thai Pham, *Program Technologist*
Opher Ganel, *Program Technologist*

In January 2016, NASA Astrophysics Division Director Paul Hertz **introduced off Science and Technology Definition Teams (STDTs) to study four large mission concepts to inform the 2020 decadal survey**. He announced that NASA is initiating mission concept studies of the following four large mission concepts:

- Far-IR Surveyor;
- Habitable Exoplanet Imaging Mission;
- Large UV/Optical/IR (LUVOIR) Surveyor; and
- X-ray Surveyor.

In April he will charge the STDTs to develop the science case, flow that science case into mission requirements, vet the technology gaps list, and direct trades of science vs. cost/capability. Of the four concepts, the LUVOIR and Far-IR Surveyors fall within the Cosmic Origins (COR) science theme.

Study deliverables include the following that affect astrophysics technology development:

- "Deliver Initial Technology Gap Assessment" by June 30, 2016 (optional)
- "Complete Concept Maturity Level 2 Audit … Identify, quantify and prioritize technology gaps for 2017 technology cycle" by February 2017 (required)
- "Update Technology Gap Assessments" by June 2017 (optional)
- "Interim report … Deliver initial technology roadmaps" by early December 2017 (required)
- "Update Gap Assessments … In support of 2018 technology cycle" by June 2018 (required)
- "Final Report … Finalize technology roadmaps, tech plan and cost estimates for technology maturity" by January 2019 (required)

As described in our **2015 COR Program Annual Technology Report** (PATR), our technology development and maturation process revolves around inputs from the community. This includes input to the decadal survey, submission of technology gaps for prioritization, responding to COR Strategic Astrophysics Technology (SAT) calls, and maturing technologies that will enable the future of COR science. None of this changes as a result of the STDTs' work. At the same time, the above deliverables will likely have a significant and gradually growing impact on COR technology gap prioritization in 2016–2019.

In terms of technology planning, the STDT process concentrates community effort and expertise relevant for each mission concept. However, this should not be seen as precluding community contributions from non-STDT members. It takes a joint NASA/community effort to identify and prioritize technology gaps, and then solicit, fund, and manage the technology maturation projects that will close them. We thus invite all community members to consider where gaps in key technologies separate today's state of the art from the performance needed to make strategic astrophysics missions successful. Then, use this **downloadable form** to submit those gaps.

As in 2015, our Technology Management Board (TMB) considers in July gaps submitted prior to June 1, while those missing that cutoff date are deferred to the following year. This June 1 deadline applies to gaps proposed outside of the STDT process, allowing the COR Program Analysis Group (COPAG) Executive Committee (EC) the time needed to consolidate new gaps with last year's list, crafting a comprehensive, compelling, and non-redundant set of gaps for TMB prioritization in July. Gaps submitted by the STDTs are due by June 30, and are considered in parallel to non-STDT gaps. Note that given the level of expertise residing in the COPAG EC, we would not be surprised to see

Spitzer and WISE Identify Bow Shocks Around Speeding Stars

Astronomers are finding dozens of the fastest stars in our galaxy, using images from NASA's *Spitzer Space Telescope* and from the *Wide-field Infrared Survey Explorer*, or *WISE*. Cosmic bow shocks occur when massive stars zip through space, pushing material ahead of them in the same way that water piles up in front of a race boat. The massive stars produce high-speed winds that smack into this compressed material. The end result is pile-up of heated material that glows in infrared light.

"Some stars get the boot when their companion star explodes in a supernova, and others can get kicked out of crowded star clusters," said astronomer William Chick from the University of Wyoming in Laramie.

Chick and his team used archival infrared data from *Spitzer* and *WISE* to identify new bow shocks. Their initial search turned up more than 200 cases of fuzzy infrared-bright arcs. They then used the Wyoming Infrared Observatory, near Laramie, to follow up on 80 of these candidates and identify the sources behind the suspected bow shocks. Most turned out to be massive stars. The findings suggest that many of the bow shocks are formed by speedy runaways given a gravitational kick by other stars.

"The bow shocks are new laboratories for studying massive stars and answering questions about the fate and evolution of these stars," said astronomer Henry "Chip" Kobulnicky, also from the University of Wyoming.

Another group of researchers, led by Cintia Peri of the Argentine Institute of Radio Astronomy, is also using *Spitzer* and *WISE* data to find new bow shocks in space. However, instead of searching for the arcs at the onset, they start by observing known speedy stars to look for bow shocks. "*WISE* and *Spitzer* have given us the best images of bow shocks so far," said Peri. "In many cases, bow shocks … can now be resolved, and … we can see new details of the structures."

Full story at **http://www.spitzer.caltech.edu/news/1842-feature16-01-Runaway-Stars-Leave-Infrared-Waves-in-Space**

Bow shocks thought to mark the paths of massive, speeding stars are highlighted in red in this image from NASA's Spitzer Space Telescope. Green shows dust, and blue shows stars. The speeding stars can be seen at the center of each red arc. The massive stars range from 8 to 30 times the mass of our Sun. Image credit: NASA/JPL-Caltech/University of Wyoming

significant overlap between STDT-submitted gaps and those in the EC's list.

The TMB evaluates gaps according to their **Strategic Alignment**, **Benefits and Impacts**, **Scope of Applicability**, and **Urgency**. We expect to use the same criteria in prioritizing STDT-identified gaps and those submitted by others. We will publish this year's priority ranking in our 2016 COR PATR, to be released in October. To increase the likelihood your submission ranks in the highest priority category, and to make accurate prioritization easier, we offer the following guidelines.

• Focus on gaps associated with COR missions prioritized by the **2010 Decadal Survey**, **Astrophysics Implementation Plan**, and **Astrophysics Roadmap**, and other relevant documents or programmatic directives.

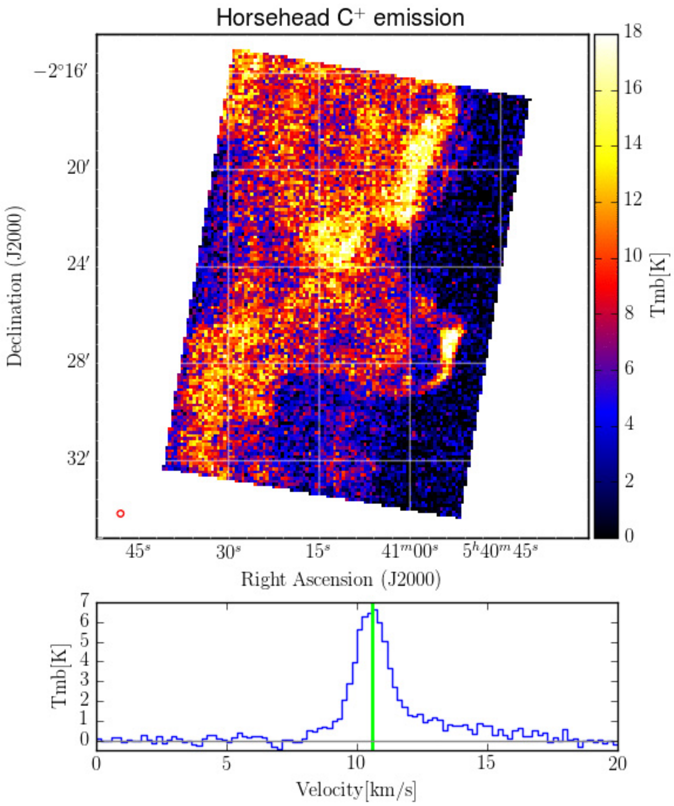
• Submit unique, well-defined gaps, within the COR charter, with a current TRL of 3 to 5 (note that the new gap submission form requests two TRL inputs, one for relevant current state-of-the-art technologies and one for technologies expected to achieve full performance needed—it is the latter that should best be between in the quoted range).

• Submit technology capability gaps separating the current state of the art from what is needed to achieve strategic science objectives, not specific implementations or approaches.

• Present gaps briefly to ease evaluation; with enough detail to make your case; avoiding proprietary details, ITAR-sensitive information, and endorsement or bias for any person, group, or organization.

Refer to the COR PATR or **COR website** for more details on COR science, technology development program and process, recent gap submissions, priority recommendations for this year's SAT solicitation, and status and plans of all current COR SAT projects. All these can inform your consideration of what gaps we should be addressing as we work together now to help realize the COR missions of the coming decades. Each year, we reevaluate all gaps listed in the prior year's PATR. Please resubmit these only if you believe they should be modified. Whether it's a new gap, or a revision of one in last year's list, please submit it by June 1 to **thai.pham@nasa.gov**. Questions or comments on our process or any other aspect of the Program are also welcome.

• • •



One of the SOFIA/upGREAT single channel maps of the Horsehead Nebula in the [CII] line at 158 microns, extracted from the velocity-resolved data cube now available for community access.

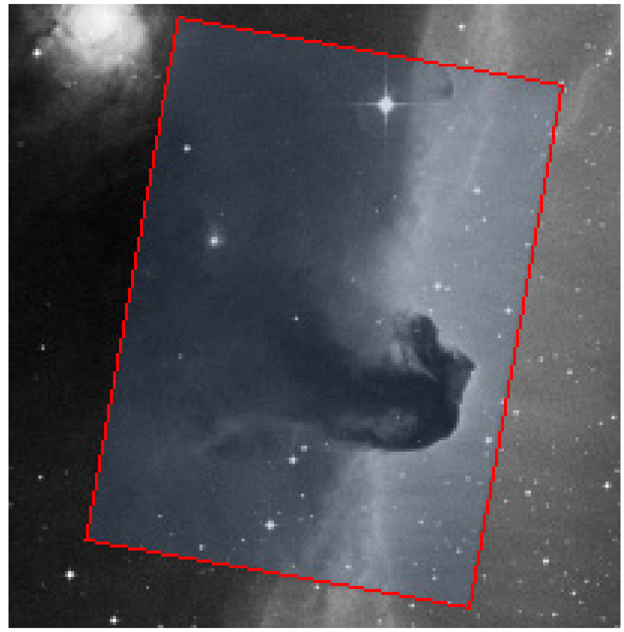
News from SOFIA

Pamela Marcum, *SOFIA Project Scientist*

SOFIA began its current cycle of observations in February 2016, including plans for 101 flights providing more than 550 hours of science observations through January 2017. The research projects span the full gamut of astronomical topics including solar system objects; star and planet formation; the evolution of planetary systems; the interstellar medium and interstellar chemistry; the nucleus of the Milky Way galaxy; and nearby normal and active galaxies. A list of the current *SOFIA* programs is provided at **https://www.sofia.usra.edu/Science/proposals/cycle4/results.html**. Starting in Cycle 4, grant funding for the U.S. Guest Investigator program was substantially increased to $10K per observing hour, on average.

Science highlights from Cycle 3 include the well-planned placement of the *SOFIA* observatory in the middle of the fleeting faint shadow produced by Pluto occulting a star. The occultation fortuitously occurred within weeks of the New Horizons closest approach to Pluto. The New Horizons' comprehensive in situ "snapshot" measurements, taken contemporaneously with the *SOFIA* four-filter (visual and NIR) observations, provided unprecedented ground truth for past and future remote monitoring of Pluto's ever changing atmosphere though occultation data.

SOFIA's Cycle 3 accomplishments also include a successful four-instrument deployment to New Zealand as well as the completion of commissioning for three new science instruments (EXES, FIFI-LS, and upGREAT). For more information on *SOFIA*



Mapped region overlaid on a POSS-red Sky Survey image. See https://www.sofia.usra.edu/Science/proposals/DDT/Horsehead_Nebula.html for additional information. .

instrument capabilities see **https://www.sofia.usra.edu/Science/instruments/index.html**.

Looking ahead, the *SOFIA* 3rd Generation Science Instrument solicitation released in July 2015 resulted in the selection of two instrument proposals for funded concept studies, both of which would expand *SOFIA*'s spectroscopic capability. SHASTA (Stratospheric Heterodyne Array System for Terahertz Astronomy), led by Paul Goldsmith (JPL), covers a frequency band of 1.9 to 2.1 THz (143 to 158 microns) and consists of 64 heterodyne pixels in a closely packed 8x8 configuration, and is designed for investigations of the earliest phases of star formation including the formation of interstellar clouds. HIRMES (High Resolution Mid-InfrarEd Spectrometer), led by Harvey Moseley (NASA/GSFC) features long-slit spectral observing modes with resolving powers ranging from R~600 to R~100,000 between wavelengths of 28 and 112 microns, and is designed to detect protoplanetary disk spectral lines from neutral atomic oxygen, water and deuterated hydrogen molecules. One of these instruments will be selected to begin development by Fall 2016, with a targeted completion date in 2018. Additional information, including a link to the abstracts for both instruments, is here: **https://www.sofia.usra.edu/News/news_2016/01_06_16/index.html**

A project to fully map the Horsehead Nebula in the [CII] 158 micron line using the upGREAT instrument was recently completed using Director's Discretionary Time, resulting in a velocity resolution better than 0.2 km/s across the nebula (see above figure). This data cube was made available to the community with no proprietary restrictions the last week of February. These spectral maps join a growing archive of *SOFIA* science data that may be considered for investigations proposed to the 2016 ADAP (Astrophysics Data Analysis Program) program. The archive can be accessed via the link to the *SOFIA* Data Cycle System: **https://dcs.sofia.usra.edu**.

The *SOFIA* Cycle 5 Call for Proposals will be issued in mid-April 2016, with proposals due at the end of June. The full complement of *SOFIA* instrumentation will be available to all members of the worldwide astronomical community, including the newest *SOFIA* instrument HAWC+. Cycle 5 will also include a deployment to the Southern Hemisphere during the June-July 2017 time frame, and the Science Center anticipates supporting two instruments. Financial support for conducting the investigations will be available as in Cycle 4.

• • •

JWST Status and Progress

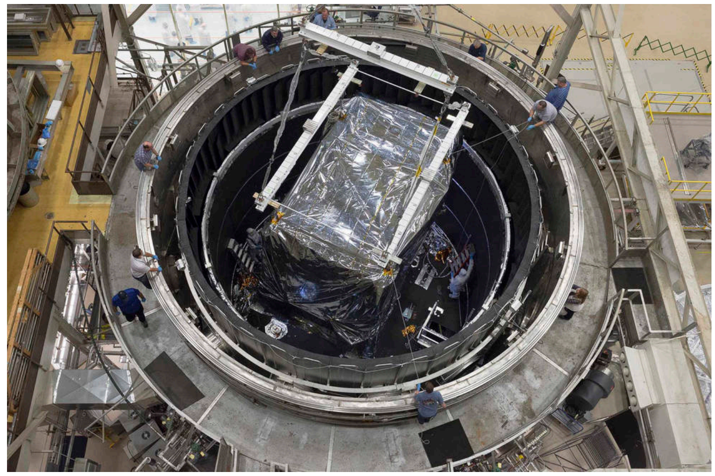
Susan Neff, *COR Program Chief Scientist*

The *James Webb Space Telescope* (*JWST*) is on schedule for launch in 2018. It is expected to transform COR Science, and most other astrophysics fields.

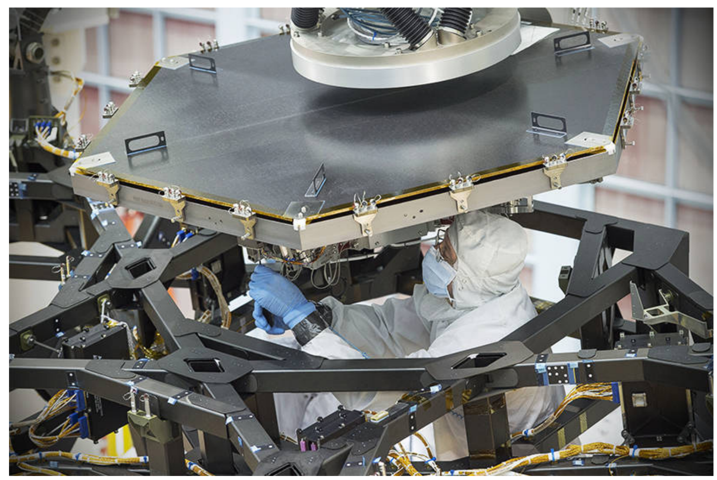
In late August 2015, one of the most crucial pieces of the *JWST*, the flight backplane (the "spine" of the telescope), arrived at Goddard Space Flight Center.

The backplane holds the 18 beryllium primary mirror segments nearly motionless to form the telescope's 6.5m "primary mirror." Between late November and early February, the individual

JWST's 18 mirrors are fully installed on the telescope structure at GSFC. Image credit: NASA / Chris Gunn



JWST's Integrated Science Instrument Module (ISIM) is lowered into the Space Environment Simulator for its final cryogenic testing at GSFC. The test ran from October 28, 2015 to February 12, 2016, and was fully successful. Engineers around the outside of the chamber indicate scale. Image credit: NASA / Chris Gunn



Installation of the first flight mirror onto the JWST backplane structure, November 2015. Image credit: NASA/Chris Gunn

Installation of the last of the telescope's 18 flight mirrors onto the telescope structure. Each of the mirrors has a protective cover. Image credit: NASA/ Chris Gunn mirrors were installed on the backplane. The secondary mirror was installed in early March, and the Aft Optics System (including tertiary and fine steering mirrors) is expected to follow shortly.

The Integrated Science Instrument Module (ISIM) is the heart of the telescope, containing the science instruments. It successfully completed acoustic testing in August, and electromagnetic interference testing in September. In October 2015, the ISIM began a 3+month final cryogenic vacuum test at GSFC, which was completed February 12, 2016. The test was extremely successful, and no new flight hardware issues were identified.

In October 2016, the *JWST* Pathfinder completed its second cryogenic optical test in Chamber A at Johnson Space Flight Center, verifying test processes and equipment that will be used for the flight telescope in 2017.

Major activities in the near future include: integration of the ISIM and the Optical Telescope Element (OTE), and the Thermal Pathfinder test this summer at Johnson.

In the following article, we describe how the *JWST* mirrors were installed.

More information about *JWST* progress and status, including a live camera feed, may be found at the *JWST* web site: **http://jwst.nasa.gov/index.html**

• • •

NASA Webb Telescope Mirrors Installed with Robotic Arm Precision

Laura Betz, *NASA Goddard Space Flight Center*

Inside a massive clean room at NASA's Goddard Space Flight Center in Greenbelt, Maryland the *James Webb Space Telescope* team has installed the segments of the largest space telescope mirror ever. Unlike other space telescope mirrors, this one must be pieced together from segments using a high-precision robotic arm.

The team used a robotic arm called the Primary Mirror Alignment and Integration Fixture to lift and lower each of Webb's 18 primary flight mirror segments to their locations on the telescope structure. Each of the mirrors is made with beryllium, chosen for its properties to withstand the super cold temperatures of space. Each segment also has a thin gold coating to reflect infrared light. These mirror segments will function as one when the telescope is in orbit.

"In order for the combination of mirror segments to function as a single mirror they must be placed within a few millimeters of one another, to fraction-of-a-millimeter accuracy. A human operator cannot place the mirrors that accurately, so we developed a robotic system to do the assembly," said NASA's *James Webb Space Telescope* Program Director Eric Smith, at Headquarters in Washington.

To precisely install the segments, the robotic arm can move in six directions to maneuver over the telescope structure. While one team of engineers maneuvers the robotic arm, another team of engineers simultaneously takes measurements with lasers to ensure each mirror segment is placed, bolted and glued perfectly before moving to the next.

"While the team is installing the mirrors there are references on the structure and the mirrors that allow the team to understand where the final mirror surface is located," said Harris Corporation's James Webb Space Telescope's Assembly Integration and Test Director Gary Matthews Greenbelt, Maryland.

The team uses reference points on the telescope structure called Spherically Mounted Retroreflectors to accomplish this feat. A laser tracker, similar to the ones used by surveyors, looks at those reference points and can determine where the mirror segments go.

"Instead of using a measuring tape, a laser is used to measure distance very precisely," said Matthews. "Based off of those measurements a coordinate system is used to place each of the primary mirror segments. The engineers can move the mirror into its precise location on the telescope structure to within the thickness of a piece of paper."

Harris Corporation engineers are helping build NASA's ultra-powerful James Webb Space Telescope. Harris is responsible for integrating components made by various members of the team to form the optical telescope element, which is the portion of the telescope that will collect light and provide sharp images of deep space.

The *James Webb Space Telescope* is the scientific successor to NASA's *Hubble Space Telescope* and *Spitzer Space Telescope*. It will be the most powerful space telescope ever built. Webb is an international project led by NASA with its partners, the European Space Agency and the Canadian Space Agency.

For more information about NASA's Webb telescope, visit:**www.nasa.gov/webb** or **jwst.nasa.gov**

• • •

Cosmic Origins Program Analysis Group (COPAG) Status

Paul Scowen, ASU, *COPAG Chair*
Susan Neff, GSFC, *COR Program Chief Scientist*

In October 2015, Dr. Paul Scowen (ASU) was appointed the new chair of the Cosmic Origins Program Analysis Group (COPAG). His scientific interests are largely focused on star formation in a variety of environments. He is currently working on a SAT award for high-efficiency robust UV coatings.

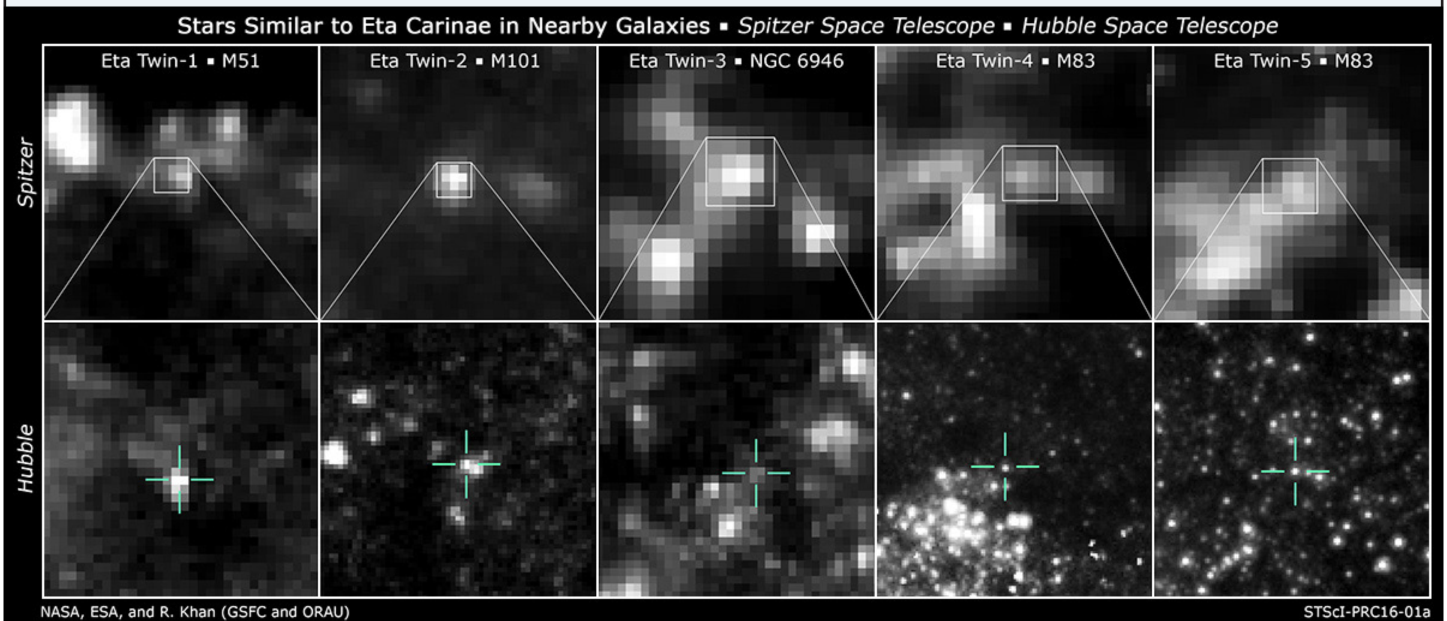
Paul also started the UV/Vis Science Interest Group (UV/Vis SIG).

Dr. Kenneth Sembach stepped down as chair to become the new director of the Space Telescope Science Institute. We thank Ken for his dedicated service to the COR community, and wish him well in his new appointment. Lynne Hillenbrand (Caltech) also rotated off the Executive Committee (EC) in November 2015, while three new members joined the COPAG EC: Lee Armus (Caltech/IPAC), Suvi Gezari (UMd), and Chris Howk (Notre Dame).

In October 2015, the COPAG delivered their report on the question of Flagship-class missions to Astrophysics Division Director Paul Hertz, including an introduction written jointly by all three PAGs. The report laid out the community's support for the four mission concepts originally suggested (Far-IR Surveyor,

NASA Telescopes Find 'Twins' of Superstar Eta Carinae

Eta Carinae, the most luminous and massive stellar system within 10,000 light-years, is best known for an enormous eruption seen in the mid-19th century that hurled an amount of material at least 10 times the sun's mass into space. This expanding veil of gas and dust, which still shrouds Eta Carinae, makes it the only object of its kind known in our galaxy. Now a study using archival data from NASA's *Spitzer* and *Hubble* space telescopes has found five similar objects in other galaxies for the first time.



"The most massive stars are always rare, but they have tremendous impact on the chemical and physical evolution of their host galaxy," said lead scientist Rubab Khan, a postdoctoral researcher at NASA's Goddard Space Flight Center in Greenbelt, Maryland. These stars produce and distribute large amounts of the chemical elements vital to life and eventually explode as supernovae.

Located about 7,500 light-years away in the southern constellation of Carina, Eta Carinae outshines our sun by 5 million times. The binary system consists of two massive stars in a tight 5.5-year orbit. Astronomers estimate that the more massive star has about 90 times the sun's mass, while the smaller companion may exceed 30 solar masses.

As one of the nearest laboratories for studying high-mass stars, Eta Carinae has been a unique, important astronomical touchstone since its eruption in the 1840s. To understand why the eruption occurred and how it relates to the evolution of massive stars, astronomers needed additional examples. Catching rare stars during the short-lived aftermath of a major outburst approaches needle-in-a-haystack levels of difficulty, and nothing matching Eta Carinae had been found prior to Khan's study. Working with Krzysztof Stanek, Scott Adams, and Christopher Kochanek at Ohio State and George Sonneborn at Goddard, Khan developed a kind of optical and infrared fingerprint for identifying possible Eta Carinae twins, or "Eta twins" for short.

Dust forms in gas ejected by a massive star. This dust dims the star's ultraviolet and visible light, but it absorbs and reradiates this energy as heat at longer, mid-infrared wavelengths. "With *Spitzer* we see a steady increase in brightness starting at around 3 microns and peaking between 8 and 24 microns," explained Khan. "By comparing this emission to the dimming we see in *Hubble*'s optical images, we could determine how much dust was present and compare it to the amount we see around Eta Carinae."

In 2015, the team found two candidate Eta twins in the galaxy M83, located 15 million light-years away, and one each in NGC 6946, M101, and M51, located between 18 million and 26 million light-years away. These five objects mimic the optical and infrared properties of Eta Carinae, indicating that each very likely contains a high-mass star buried in five to 10 solar masses of gas and dust. Further study will let astronomers more precisely determine their physical properties. The findings were published in the Dec. 20 edition of The Astrophysical Journal Letters.

NASA's *James Webb Space Telescope* (*JWST*), set to launch in late 2018, carries an instrument ideally suited for further study of these stars. It will take *JWST* observations to confirm the Eta twins as true relatives of Eta Carinae.

Habitable Exoplanet Imaging Mission, Large UV/Optical/Near-IR Surveyor, and X-ray Surveyor) and detailed the large amount of input collected from the community over the last 12 months. The COPAG EC thanks all members of the community who participated in the workshops, white papers, telecon meetings, and other activities. The COPAG report, including the Joint PAG summary, and the other two PAG reports, are available on the COPAG webpage: **http://cor.gsfc.nasa.gov/copag/rfi/**.

The COPAG EC noticed that during the Flagship exercise, the question of smaller missions, the so-called Astrophysics Probes was always part of the discussion. Therefore, the COPAG EC issued a call for 2-page white papers on possible Astrophysics Probe mission concepts. All white papers are posted (unless requested otherwise) at **http://cor.gsfc.nasa.gov/copag/probe-study.php**

The COPAG supported several sessions at the recent 227th meeting of the American Astronomical Society (AAS) in January

Dr. Paul Hertz, Head of Astrophysics Division at NASA HQ, addresses the Joint PAG Session.

2016, in Florida. The three PAGs held a joint session the afternoon of Monday January 4th to hear an address from Paul Hertz on the state of NASA Astrophysics, together with his plans for next steps associated with the Flagship-class mission studies, posted at **http://cor.gsfc.nasa.gov/copag/aas_jan2016/jan2016-meeting.php**

Dr. Hertz also presented his plans to explore the question of Probe-class missions during 2016, and issued a new Charge to all three PAGs to study the question of such missions: **http://cor.gsfc.nasa.gov/copag/probe-study/probes-task.php**. The ECs of the three groups have created a working group to collaborate on the study, and will make an initial presentation to the NAC Astrophysics Subcommittee in March.

During the subsequent COPAG meeting, several COPAG members presented preliminary short descriptions of mission concepts they are developing, that might qualify as Astrophysics Probes: **http://cor.gsfc.nasa.gov/copag/aas_jan2016/AAS2016-agenda-COPAG.php**

All three of the COPAG SIGs (Science Interest Groups, **http://cor.gsfc.nasa.gov/copag/copag.php#groups**) also held face to face meetings. Their reports follow.

Please get involved with the COPAG! All interested members of the scientific and technical communities are members of the COPAG. Sign up for our our mailing list at **http://cor.gsfc.nasa.gov/cornews-mailing-list.php**

We welcome any input from the COPAG community. Please send your thoughts to: **COPAG_Contact@bigbang.gsfc.nasa.gov**.

• • •

COPAG EC members Sally Heap and Joe Lazio both presented Probe concepts at the COPAG meeting.

UV/Visible Astronomy from Space Science Interest Group (COPAG SIG#2)

Paul Scowen, *SIG2 Chair*
Mary Beth Kaiser, *COPAG EC Liaison for SIG2*

Following the workshop last June at NASA GSFC, the organizers have been collating material to produce a summary report to be published as a paper. That article is approaching fruition and will be circulated among contributing authors for comment and correction in the next month. The goal of the SIG is to have the completed report ready for reference by the new STDTs being assembled to consider both the LUVOIR and HabEx Flagship mission concepts over the coming year.

The SIG2 held a face to face meeting at the recent AAS meeting in Kissimmee, FL. The meeting focused on the question of Probe-class missions. In particular, the SIG discussed the impact and opportunities presented by the Probe-class mission scale on the range of compelling science explored at last summer's workshop. Some concerns were expressed about various aspects of what an intermediate mission class could represent and its influence on both budgets and schedules for the development of Explorer-class and Flagship-class missions. The meeting notes were distributed to the SIG membership by email for their information.

The three PAGs were charged by Paul Hertz, the Astrophysics Division director, at the same AAS meeting to study how the community should be best solicited to develop input on Probe-class missions as input to the upcoming 2020 Decadal Survey on Astronomy and Astrophysics. In response to this call, the PAGs have assembled a working group to respond to the charge and to make a report to the next meeting of the NAC Astrophysics Subcommittee in March. As part of this response the COPAG did issue a call for 2-page white papers on the topic and these white papers are available from **http://cor.gsfc.nasa.gov/copag/probe-study.php**.

Looking forward, the SIG membership anticipates being responsive to the LUVOIR and HabEx STDT's and will inform them as appropriate when the SIG's input is solicited. We will remain in active contact via email and seek to develop input and advise the STDTs as they consider what Flagship-class astrophysics science in the UV-Visible passband could and should be done.

• • •

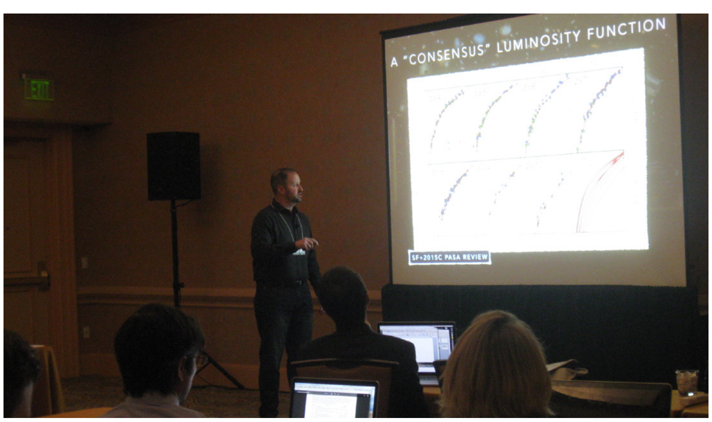
Cosmic Dawn Science Interest Group (COPAG SIG #3)

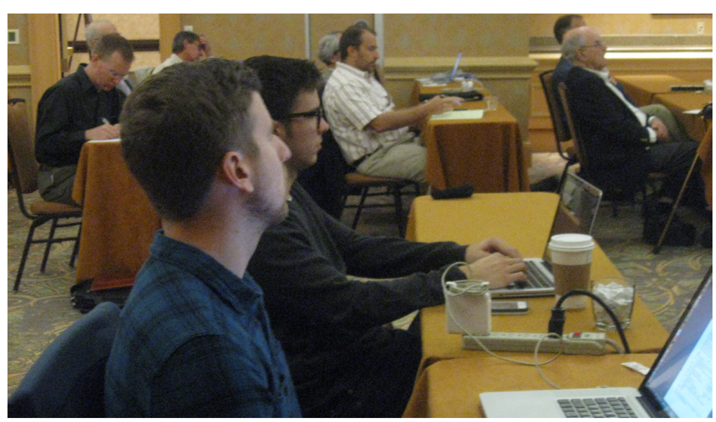
Joseph Lazio, *SIG3 Chair*

This newsletter contains the first report from the Cosmic Dawn Science Interest Group, which is chartered to assess and develop the science cases, observations, and technology development needed to address the "great mystery" of Cosmic Origins, namely how and when did the first luminous sources form? Membership in the SIG is open to all; for more information, visit the Web site (**http://cd-sig.jpl.nasa.gov/**) and contact Joseph Lazio (**Joseph.Lazio@jpl.nasa.gov**) to join the SIG.

The Cosmic Dawn SIG held its "kickoff" meeting on January 4, prior to the start of the 227th AAS meeting (Kissimmee, FL). This initial meeting aimed at providing a broad overview of the potential probes of Cosmic Dawn. Speakers described both how current telescopes are placing limits on the timing and nature of the first luminous sources and what the prospects are for future telescopes. Of recurring interest was the topic of the "escape fraction" of ionizing radiation from the first galaxies—current estimates of the amount of ionizing radiation leaking out of galaxies appears insufficient to maintain an ionized intergalactic medium, even though it is clear that the intergalactic medium is substantially ionized by a redshift $z \approx 6$. The table below lists the speakers and the titles of their talks; presentations are available through the Cosmic Dawn SIG Web site (**http://cd-sig.jpl.nasa.gov/events.html**).

Probing Cosmic Dawn (2016 January 4)	
Title	**Speaker**
Beyond the Horizon: What is Left to Learn After *Hubble* about the First Billion Years?	Steven Finkelstein
Gamma-Ray Bursts as Explosive Probes of Cosmic Dawn	Valerie Connaughton
Molecular Gas at Cosmic Dawn	Jacqueline Hodge
The 21 cm Reionization Power Spectrum	Aaron Parsons
Probing the Cosmic Dawn with the James Webb Space Telescope	Mia Bovill / Massimo Stiavelli
Probing the EoR with Tomographic Intensity Mapping in the Far-IR through Millimeter	C. M. Bradford





Scenes from the Cosmic Dawn SIG meeting in Kissimmee, FL, before the 227th AAS meeting. (Right) Steven Finkelstein reviews the UV luminosity functions and escape fractions of galaxies as a function of redshift.

This initial meeting provided some "cross talk" between the COPAG and the Physics of the Cosmic PAG (PhysPAG). Gamma-ray bursts (GRBs) are typically considered from the nature of the progenitor and the physics of the emission. However, high redshift GRBs have been detected by the *Fermi* Gamma-Ray Telescope, and there was speculation that GRBs might be capable of increasing the escape fraction of early galaxies by a large amount, albeit for a short amount of time, by blasting holes in their interstellar media.

• • •

Cosmic Origins Suborbital Program: BLAST-TNG

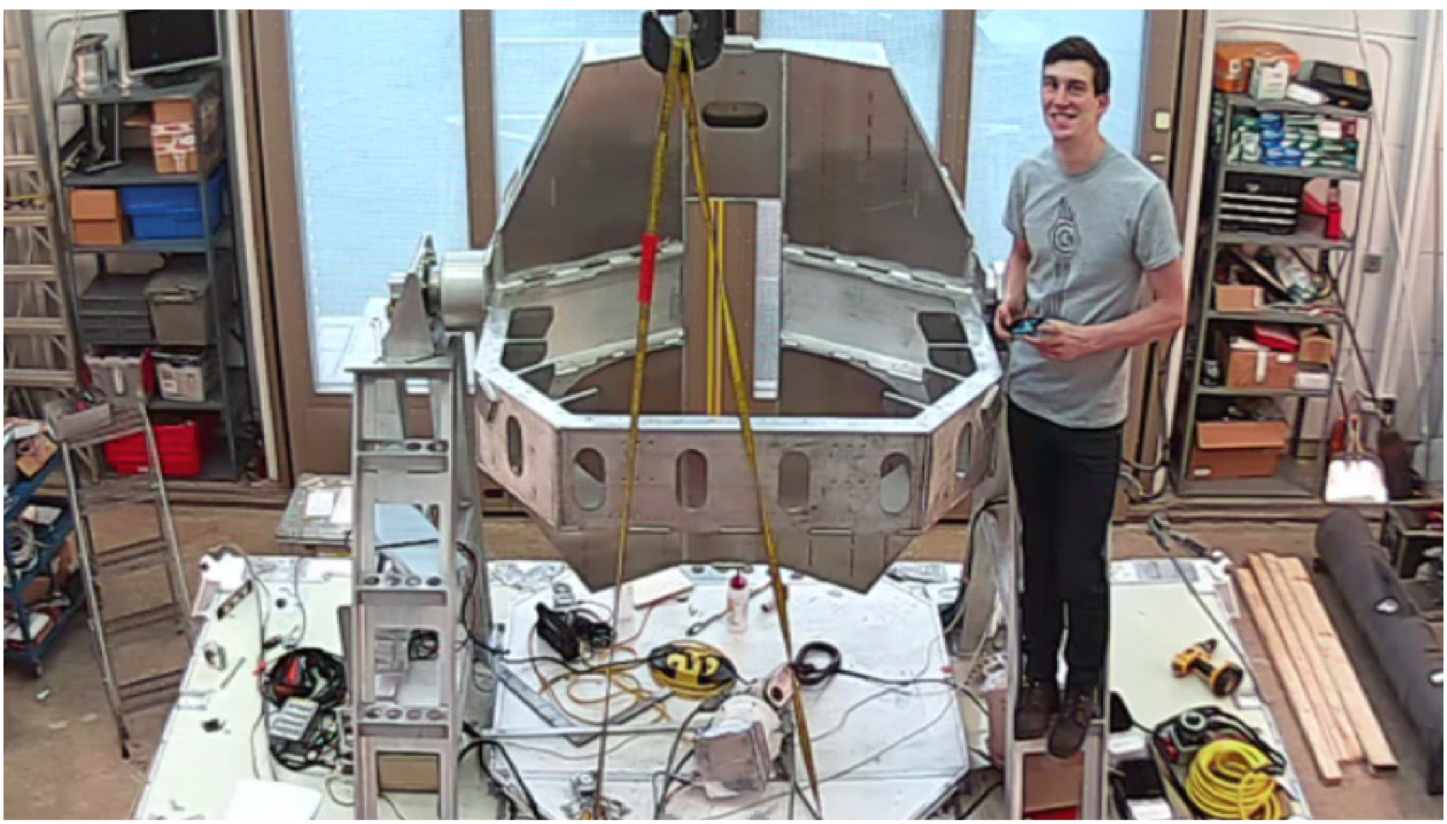
Susan Neff, *COR Program Chief Scientist*

NASA's scientific discoveries depend on access to space (freedom from atmospheric attenuation) and on new observational capabilities. Instruments developed as balloon or sounding rocket payloads have often been precursors to NASA's astrophysics missions. The suborbital program's flexibility, short development timescales, and fast access to space is invaluable in developing instrumentation. Suborbital programs can demonstrate or flight-test new technologies, and are a rigorous training ground for students and postdocs who will become future Principal Investigators. Astrophysics balloon payloads are funded through NASA's Astrophysics Research and Analysis (APRA) program, and are part of NASA's Balloon Program, managed by NASA's Wallops Flight Facility. Currently, there are three funded balloon programs relevant to Cosmic Origins.

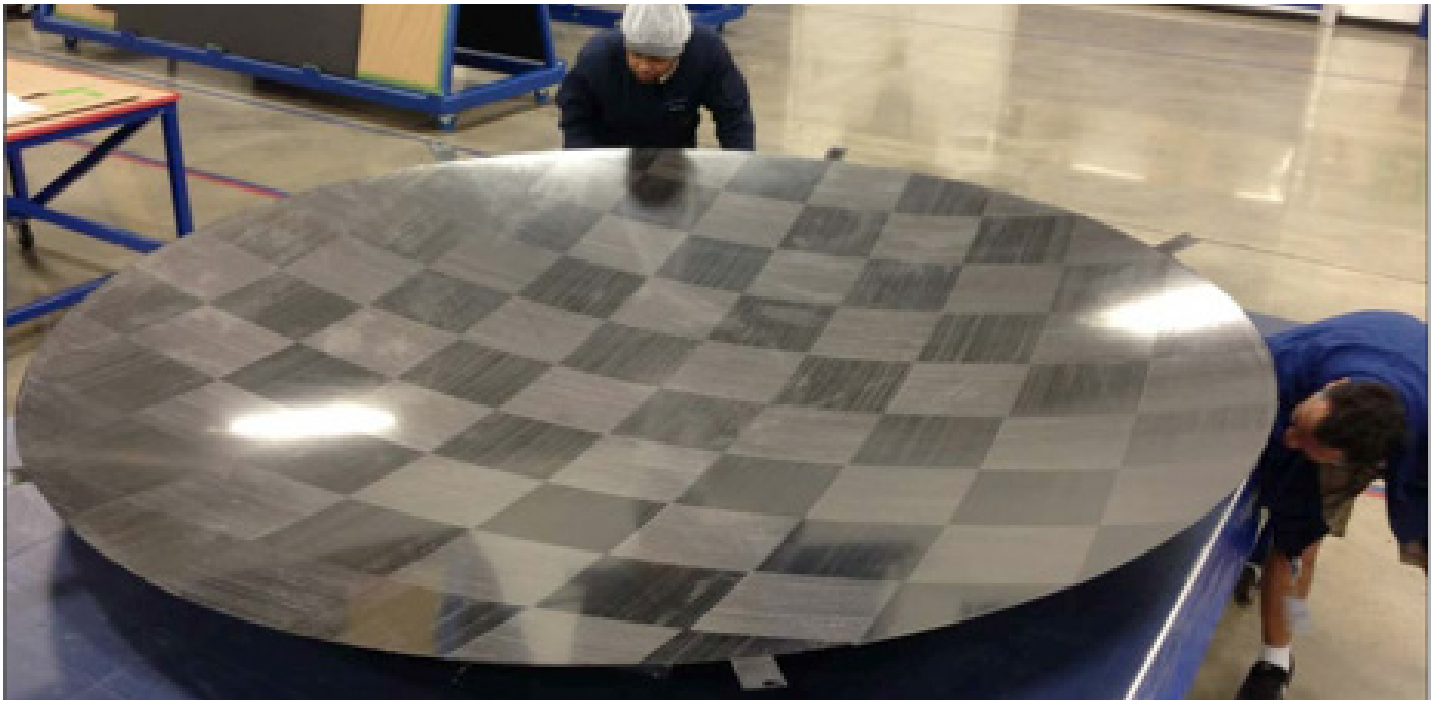
The Balloon-borne Large Aperture Submillimeter Telescope (BLAST) experiment is led by PI Mark Devlin, University of Pennsylvania. The original BLAST flew twice, from Sweden (2005) and from Antarctica (2006). BLAST flew prototype versions of the flight detectors developed by JPL for the *Herschel* mission. The resulting maps at 250, 350, and 500 μm provided insights into the nature of star formation in galaxies when the universe was half its current age. It also peered into the nature of star formation in the Milky Way. In order to probe star formation in our own galaxy in more detail, the payload was adapted for polarization measurements, becoming BLASTPol, and flew again in 2010 and 2012 from Antarctica. The goal was to determine the role magnetic fields play in regulating star formation. BLASTPol used a 1.8 m primary mirror with three arrays of bolometers sensitive to 250, 350, and 500 μm. BLASTPol succeeded in produced degree-scale maps of the magnetic fields in several well-known molecular cloud regions. Results show that the field strength and direction is correlated with molecular cloud structures.

BLAST-TNG (BLAST - The Next Generation) is a cooperative effort between U. Penn, Northwestern, Stanford/SLAC, Arizona State University, National Institute of Standards and Technology (NIST), Cardiff University (Wales), University of British Columbia and University of Toronto (Canada), CEA/IRFU/Sap (France), and Nagoya University (Japan).

Where BLASTPol was an adaptation of the previous unpolarized experiment, BLAST-TNG is specifically designed with polarization in mind. The new payload is designed to map the magnetic field in star-forming regions of our Milky Way galaxy, and to determine how the magnetic field affects the star-formation process throughout the Galaxy. BLAST-TNG will provide the



Penn graduate student Nathan Lourie, shown next to the new gondola for BLAST-TNG.

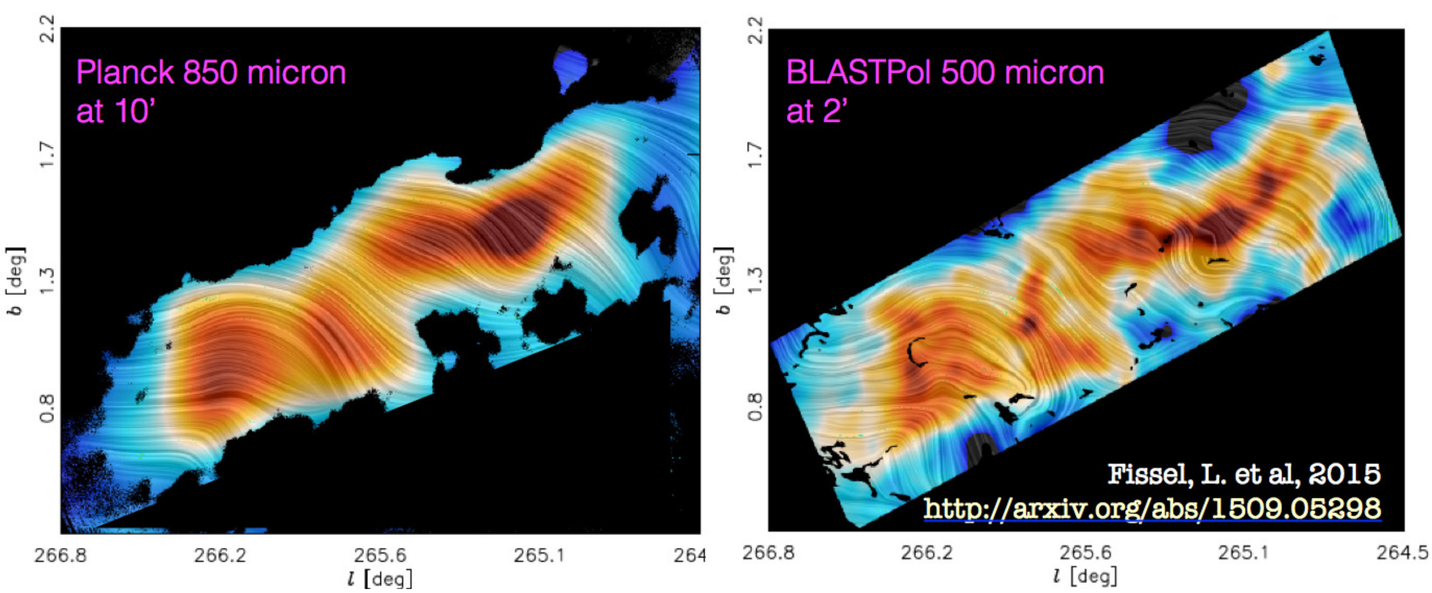


Vanguard technicians inspecting the front surface of the 2.5m primary mirror, which will be coated with aluminum. The squares are carbon fiber tiles, pre-impregnated with epoxy binder, which were laid over a graphite mirror mold and then heat-cured.

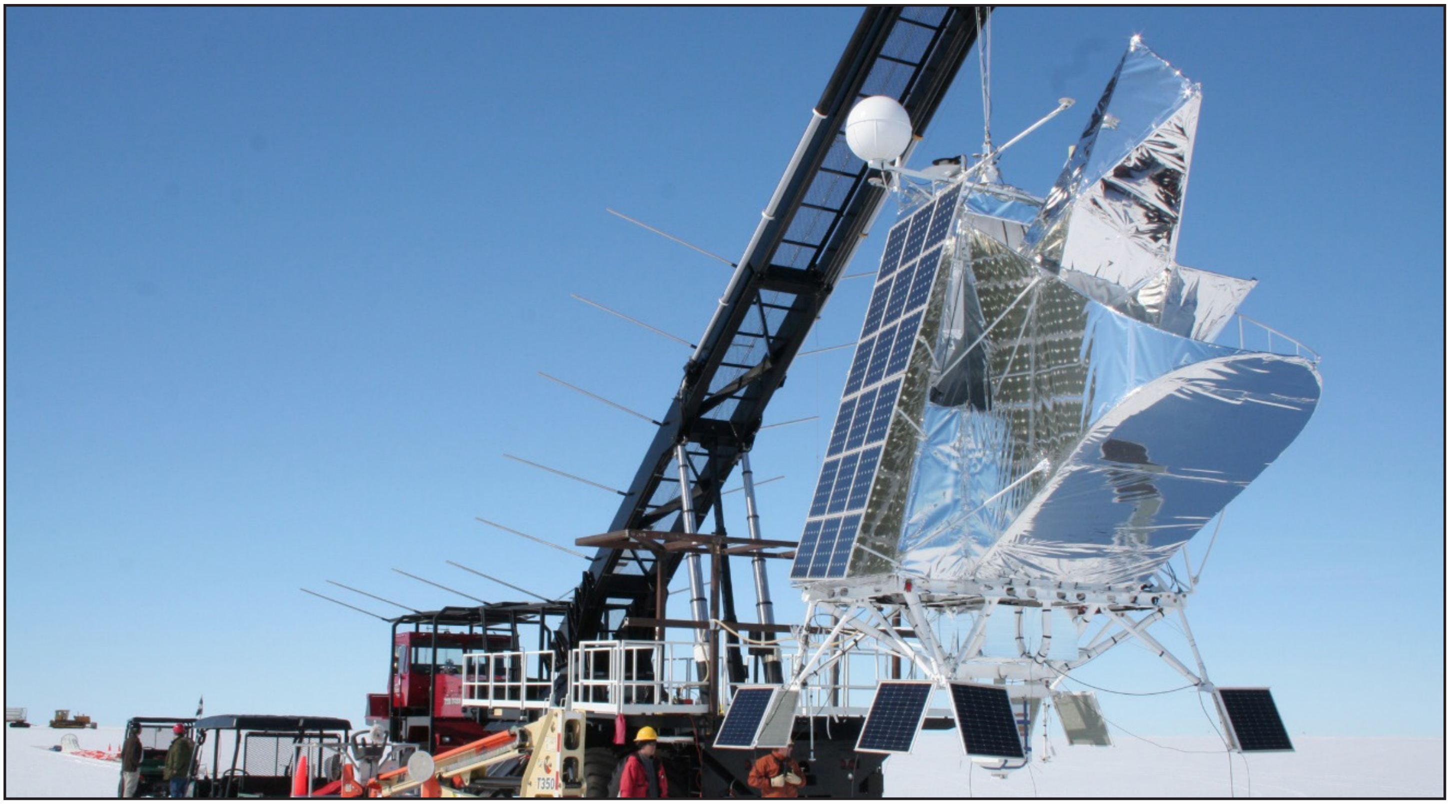
critical link between large-scale magnetic structures (5' resolution, e.g., *Planck*), and super-compact star-formation regions extremely (sub-arcsec, e.g., *ALMA*), by mapping star formation regions with an angular resolution of ~22" over entire cloud complexes. It will measure the magnetic fields in high density filaments and knots identified by *Herschel* and other instruments, and will explore the nature of star formation in these regions.

BLAST-TNG will be able to map the sky 16 times faster than BLASTPol, in the same spectral region. A new lightweight 2.5m Carbon Fiber + Aluminum honeycomb lightweight mirror was developed through an innovative Small Business (SBIR) Phase II grant to Vangard Space Technologies. It will be attached to a Carbon Fiber optical bench. Penn graduate student Nathan Lourie has worked closely with the optical and design engineers at Vanguard to ensure that the telescope system will integrate seamlessly with the BLAST gondola. After construction Lourie will lead the testing and verification of the telescope.

BLAST-TNGs 2.5 meter diameter mirror will result in a resolution of 22 arcseconds in the 250 micron band, a significant increase over BLAST. The detectors are feedhorn-coupled microwave Kinetic Inductance Detectors (MKIDs), developed by NIST, in three arrays sensitive to 250, 350, and 500 µm. Each pixel will provide simultaneous observations of both polarizations, as well as spectral resolution. The MKIDs are read out by new low-power, low-noise cryogenic amplifiers developed at ASU. Graduate students Brad Dober (Penn) and Sam Gordan (ASU) have been

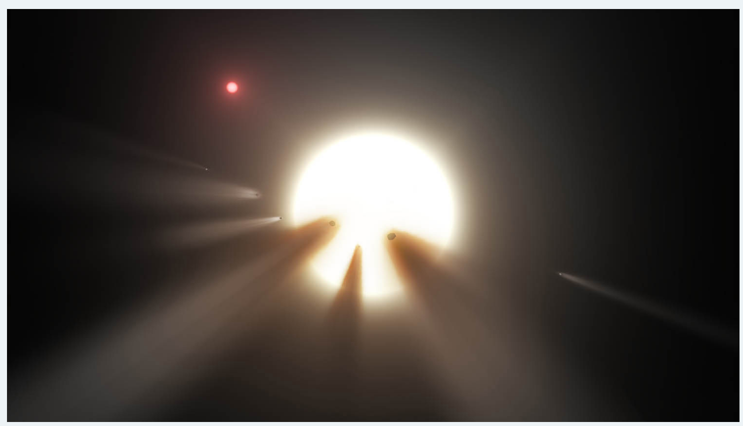


BLASTPol image (right) compared with Planck image (left) of the Vela Molecular Cloud, showing how the magnetic field lines are related to cloud structure. BLAST-TNG will image structures, and field configurations, that are 6 times smaller.



The predecessor BLASTPol payload, preparing for launch in Antarctica in December 2010.

Spitzer Finds Strange Star Likely Swarmed by Comets



A star called KIC 8462852 has been in the news recently for unexplained and bizarre behavior. NASA's *Kepler* mission had monitored the star for four years, observing two unusual incidents, in 2011 and 2013, when the star's light dimmed in dramatic, never-before-seen ways. Something had passed in front of the star and blocked its light, but what?

A new study using data from NASA's *Spitzer Space Telescope* addresses the mystery, finding more evidence for a scenario involving a swarm of comets. The study, led by Massimo Marengo of Iowa State University, Ames, is accepted for publication in the Astrophysical Journal Letters.

One way to learn more about the star is to study it in infrared light. *Kepler* had observed it in visible light. If a planetary impact, or a collision amongst asteroids, were behind the mystery of KIC 8462852, then there should be an excess of infrared light around the star. Dusty, ground-up bits of rock would be at the right temperature to glow at infrared wavelengths.

At first, researchers tried to look for infrared light using NASA's Wide-Field Infrared Survey Explorer, or *WISE*, and found none. But those observations were taken in 2010, before the strange events seen by *Kepler*. To search for infrared light that might have been generated after the oddball events, researchers turned to *Spitzer*, which, like *WISE*, also detects infrared light. *Spitzer* just happened to observe KIC 8462852 more recently in 2015.

"*Spitzer* has observed all of the hundreds of thousands of stars where *Kepler* hunted for planets, in the hope of finding infrared emission from circumstellar dust," said Michael Werner, the *Spitzer* project scientist at NASA's Jet Propulsion Laboratory in Pasadena, California, and the lead investigator of that particular *Spitzer/Kepler* observing program.

But, like *WISE*, *Spitzer* did not find any significant excess of infrared light from warm dust. That makes theories of rocky smashups very unlikely, and favors the idea that cold comets are responsible. It's possible that a family of comets is traveling on a very long, eccentric orbit around the star, the first of which would have blocked the star's light in 2011, as noted by *Kepler*. Later, in 2013, the rest of the comet family would have passed in front of the star and again blocked its light.

By the time *Spitzer* observed the star in 2015, those comets would be farther away, having continued on their long journey around the star. They would not leave any infrared signatures that could be detected.

According to Marengo, more observations are needed to help settle the case of KIC 8462852. "We may not know yet what's going on around this star," Marengo observed. "But that's what makes it so interesting."

involved with the detector design, characterization, and multiplexing readout system.

A new receiver, designed by Penn graduate student Nick Galitzki, with a 250 liter liquid He tank will allow continued operations for approximately 28 days. The gondola and inner frame have been modified to accommodate the larger mirror and cryostat. The payload will also have a new elevation drive, flight computers and data acquisition system, and solar panels. Nathan Lourie and postdocs Laura Fissel (Northwestern), Seth Hillbrand (Penn), and Federico Nati (Penn) have worked to develop the new gondola and pointing system. The instrument will be integrated and tested at Penn this spring and summer.

Current plans are for a December 2016 launch from Antarctica and a 28 day circumpolar flight.

In a major change for the Balloon program, BLAST-TNG plans to offer shared-risk (i.e., with the understanding that the instrument is not fully commissioned for general observers, so its operation is not guaranteed) observing opportunities to scientists. In the summer of 2016, the BLAST-TNG team will work with major astronomical associations to advertise the opportunity and work with potential observers to design the flight plan.

• • •

WFIRST Update

Deborah Padgett, *COR Program Deputy Chief Scientist*

Among the most exciting news for NASA Astrophysics this month is that the *Wide-field Infrared Survey Telescope* (*WFIRST*), a 2.4 meter space telescope with wide-field and coronagraphic imaging and spectroscopic instruments, is now in formulation. *WFIRST* passed its Mission Concept Review (MCR) in December 2015 and KDP (Key Decision Point) A in February 2016. The mission is now considered to be in "Phase A." During this period, the project will create a preliminary design and project plan as a proof of concept.

NASA issued a call in October 2015 for *WFIRST* Science Investigation Teams (SIT) and Adjutant Scientists. The selections were released on Dec. 18. The Wide-field Instrument Adjutant scientist is David Spergel, and the Coronagraph Instrument Adjutant Scientist is Jeremy Kasdin. Science Investigation Teams were selected on the topics of weak lensing (PI: Doré), supernova cosmology (PIs: Perlmutter, Foley), microlensing (PI: Gaudi), exoplanet coronagraphy (PIs: Macintosh, Turnbull), and five General Observer and Archival Science investigations (PIs: Kalirai, Rhoads, Robertson, Williams, Szalay). Members of these teams have become part of the *WFIRST* Formulation Science Working Group (FSWG), which will advise the *WFIRST* project on mission decisions as they affect the scientific objectives. There was a meeting of the FSWG on February 2–4 at which all the SITs presented plans for their analysis and product delivery. The plans for *WFIRST* were presented for the mid-Decadal Review of Astronomy and Astrophysics in October 2015. *WFIRST* is currently planned for launch in the mid-2020s.

• • •

Meet *Hubble* Fellow Katherine Alatalo

"Galaxy archeology" describes the research of 2015 *Hubble* Fellow Katherine "Katey" Alatalo, currently at the Carnegie Observatories in Pasadena, CA. Katey's work probes "red and dead" giant elliptical galaxies, looking for evidence of remaining star-forming fuel, molecular gas and dust, using CARMA and *ALMA*. Many of these galaxies have the right star-forming fuel but no evidence of star formation. She spends much of her time thinking about how galaxies transform from blue spirals to red early-type galaxies, and specifically how the interstellar medium of the transitioning galaxy interplays with the quenching of star formation. As a *Hubble* Fellow, Katey is searching for new galaxies in transition and is studying evidence of core activity in post-starburst galaxies. She has used *WISE*, *Spitzer*, and *HST* to look at the internal structure of NGC 1266, the first galaxy known to be a shocked post-starburst galaxy with inefficient star formation, to determine how shocks were affecting the nucleus of the galaxy. Her catalog of candidate shocked post-starburst galaxies was submitted to Astrophysical Journal Supplements in January 2016.

Katey obtained dual undergraduate degrees in Physics and Astronomy at the University of Michigan, where she did her first research on Gamma-Ray Bursts. Her Ph.D. on galaxy transition and death was obtained under the tutelage of Prof. Carl Heiles at UC Berkeley, who gave her the "freedom to pursue about her own ideas". After receiving her Ph.D., Katey spent three years at Caltech/IPAC studying star formation suppression in compact group galaxies with Phil Appleton. Katey has always been a scientist, with strong early interests in how insects, tornadoes, and earthquakes work. She was inspired by COSMOS and, thanks to supportive teachers, discovered that she was good at calculus and physics. Thus, astronomy was a natural career choice for her.

Katey is an enthusiastic frequenter of the US National Park system. Lassen Volcanic National Park is one of her favorite places.

Cosmic Origins Organization

Program Office

Program Manager: Mansoor Ahmed
mansoor.ahmed-1@nasa.gov

Deputy Program Manager: Thomas Griffin
thomas.j.griffin@nasa.gov

Chief Scientist: Susan Neff
susan.g.neff@nasa.gov

Deputy Chief Scientist: Deborah Padgett
deborah.l.padgett@nasa.gov

Chief Technologist: Bernard Seery
bernard.d.seery@nasa.gov

Technology Development Manager: Thai Pham
thai.pham@nasa.gov

Headquarters

Program Executive: Shahid Habib
Shahid.Habib-1@nasa.gov

Program Scientist: Mario Perez
mario.perez@nasa.gov

Deputy Program Scientist: Kartik Sheth
Kartik.Sheth@nasa.gov

Upcoming Events

March 15-16, 2016	Astrophysics Subcommittee Meeting, Washington, DC
March 18, 2016	NASA's Astrophysics Research and Analysis (APRA) and Strategic Astrophysics Technology (SAT) proposals due
March 24, 2016	*Spitzer* Cycle 13 Exploration Science and Frontier Legacy Letters of Intent due
April 8, 2016	*Hubble* Cycle 24 proposals due
April 2016	NASA Large Mission Concept Studies STDT Kickoff
April 25-28, 2016	"What Shapes Galaxies," STScI, Baltimore, MD
May 23-25, 2016	"The Mysterious Connection Between Superluminous Supernovae and Gamma-Ray Bursts, STScI, Baltimore, MD
June 1, 2016	**Technology Gaps Submission** due for prioritization and results published in 2016 Program Annual Technology Report (PATR) in October.
June 8, 2016	*Spitzer* Cycle 13 Proposals due
June 11, 2016	COPAG Meetings at the AAS, San Diego, CA
June 26 – July 1, 2016	SPIE Telescopes and Instrumentation, Edinburgh, UK
July 1, 2016	NASA Postdoctoral Program (NPP) proposals due
August 7-11, 2016	"The Hidden Monsters: Obscured AGN and Connections to Galaxy Evolution in the Era of NuStar and WISE," Dartmouth College, NH
Fall 2016	SOFIA Third Generation Science Instrument selection announced
September 12-14, 2016	"Linking Exoplanet and Disk Compositions," STScI, Baltimore, MD
September 26-28, 2016	"Mastering the Science Instruments and Observing Modes of JWST," ESAC, Madrid, Spain
October 16-20, 2016	"The Local Truth: Galactic Star Formation and Feedback in the SOFIA Era – Celebrating 50 Years of Airborne Astronomy," Asilomar, CA

Visit our
Cosmic Origins
Web site at
http://cor.gsfc.nasa.gov