National Aeronautics and Space Administration

Cosmic Origins Newsletter

September 2016 Volume 5 Number 2

Summer 2016 Cosmic Origins Program Update

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

Welcome to the September 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.

In January 2016, Paul Hertz (Director, NASA Astrophysics) presented his plans for **four large mission concept studies**, in preparation for the 2020 Decadal Study of Astronomy and Astrophysics, and invited all interested members of the community to consider nominating themselves for one (or more) of the teams. Two studies, for a Large UV-Optical-near IR mission (LUVOIR) and for a Far-Infrared Surveyor, support COR interests. The study teams' memberships were announced in March, and the teams are off and working hard. The articles by **Paul Hertz** and by the Community Chairs of the **Far-IR Surveyor** and **LUVOIR** studies, summarize expectations, plans, and activities of these study teams.

All four large mission study teams have been careful to include significant numbers of people at early stages of their careers, as they will be the primary users of the future observatories. We introduce a ***Hubble* fellow, Dr. Jon Trump**, who is currently working on the connection between galaxy growth, supermassive Black Hole formation, and feedback in the early universe.

In March 2016, the three Astrophysics Program Analysis Groups (PAGs) recommended that the Astrophysics Division sponsor several studies of possible Astrophysics Probe-class mission concepts to determine feasibility of requesting a new budget line for a program of astrophysics missions larger than a MIDEX (but costing less than ~$1B). In July, Dr Hertz announced his intent to support several concept studies, and in mid August a **call for Astrophysics Probe Studies** was released (proposals due November 15, 2016). **Dr. Hertz's article** presents his thoughts on Astrophysics Probes. An announcement of the next MIDEX call is expected in September. The article by **Paul Scowen** presents the recommendations of the Cosmic Origins Program Analysis Group (COPAG) on Probes, and reports on other COPAG activities.

Inside this Issue

Hubble continues to make scientific breakthroughs seem routine, and to collect stunning images of the Universe. Demand for *Hubble* observations remains very strong; the 25th call for proposals received over 1000 responses, with the number of orbits requested increasing significantly over last year. *Spitzer* recently announced selections from its 13th call for proposals, which had the most time ever requested in a call. A third of the proposals were to prepare for *JWST* follow-up. **SOFIA is operating well** and is moving ahead with its third generation instrument selection and fifth cycle of observing requests (results to be announced in October). We include highlights of a few recent science results from operating COR missions, in boxes throughout the newsletter.

The *James Webb Space Telescope* (*JWST*) continues towards its planned 2018 launch on time and on budget. Preparations are underway for observation planning tools and proposal workshops, starting this fall. We provide a **quick status of JWST**, as well as an article about the **complex manufacture of the five-layer sunshield**.

The *Wide-Field-Infrared Survey Telescope* (*WFIRST*) has started Phase A development and Science Integration Teams are hard at work. 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. We provide an update on **selections for the SAT program**. We also present a summary of combined NASA and NSF **funding opportunities for technology development**.

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 the **BETTII balloon payload**. BETTII is a Far-Infrared interferometer, scheduled to fly for the first time in September 2016 that will study deeply buried star-formation regions.

We have had several changes in the Cosmic Origins Program Office. Tom Griffin has moved to the *WFIRST* project office; the new Deputy Program Manager is Azita Valina. Harley Thronson is replacing Bernie Seery as Chief Technologist. We welcome them to the Program Office.

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

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Message from the Astrophysics Division Director

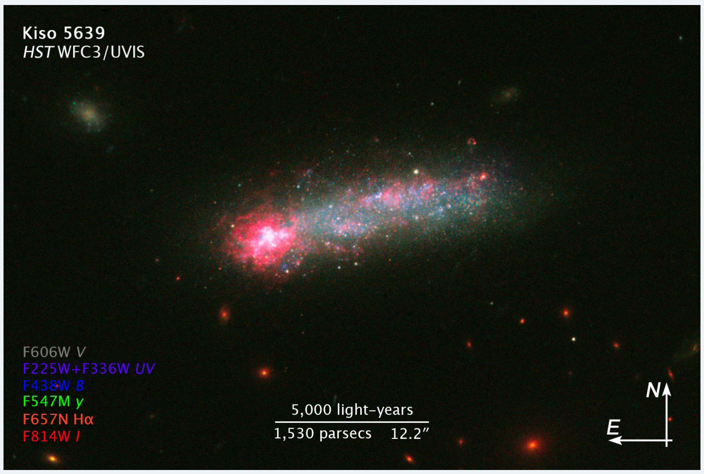
Paul Hertz, *Director, Astrophysics Division, Science Mission Directorate, NASA Headquarters*

The NASA Science Mission Directorate (SMD) saw a major leadership change with the departure of Associate Administrator for SMD, John Grunsfeld, in May 2016. Geoffrey Yoder, formerly the Deputy Associate Administrator for SMD, has been appointed the Acting Associate Administrator for SMD. Mr. Yoder is committed to continuing to advance all SMD missions in formulation, development, and operations; integrating strategic planning across all Divisions to further advance NASA objectives and Decadal Surveys; making NASA's technical and capability management more efficient to free up resources for more missions and science; and continuing to base NASA's decisions firmly on community input and peer review.

As I described during the NASA Town Hall at the 228th meeting of the American Astronomical Society in San Diego, CA, and at the July meeting of the Astrophysics Subcommittee, the Astrophysics Division continues to execute a portfolio that can be broadly divided into Strategic Missions, Explorer Missions, Research and Analysis (R&A), and other cross-cutting activities. We rely on our advisory committees and expert community groups

Hubble Reveals Stellar Fireworks in 'Skyrocket' Galaxy

Hubble has captured spectacular star formation in a small, nearby galaxy called Kiso 5639. The dwarf galaxy is a flattened disk, but because it is tilted edge-on, it resembles a skyrocket, with a brilliant head and a long starry tail. The intense star-formation apparent at one "end" is thought to be triggered by intergalactic gas falling onto one edge of the galaxy as it moves through space.



Hubble image of the "tadpole" galaxy Kiso 5639. The edge-on nearby dwarf galaxy is undergoing a burst of star formation on one edge, where primordial gas is falling onto the disk. In this image, the pink filamentary emission indicates ionized hydrogen gas . A burst of new stars, in a region 2700 light years across, makes the hydrogen glow. Image credit: NASA, ESA, and D. Elmegreen (Vassar)

Kiso 5369 is a rare nearby example of what occurs frequently at larger distances (where we observe the universe when it was young). Observations of the early Universe, such as *Hubble*'s Ultra Deep Field reveal that about 10 percent of all galaxies have these elongated shapes, dubbed "tadpoles." Lead researcher Debra Elmegreen (Vassar College) explains: "The current thinking is that galaxies in the early universe grow [by] accreting gas from the surrounding neighborhood. It's a stage that galaxies, including our Milky Way, must go through as they are growing up."

Studies of the nearby universe have turned up only a few of these apparently elongated systems. The development of nearby tadpole galaxies has lagged behind that of their peers, which typically take billions of years to build up to a typical spiral galaxy seen today.

Elmegreen's team finds that the gas in the galaxy's bright "head" contains fewer heavy elements than the rest of the galaxy. "[This] suggests that there has to be rather pure gas … coming into the star-forming part of the galaxy…" explains Elemegeen. "Otherwise the starburst region should be as rich in heavy elements as the rest of the galaxy." *Hubble* observations allowed the team to find several dozen star clusters, typically less than 1 million years old and with masses three to six times larger than those in the rest of Kiso 5639. Star clusters elsewhere in the galaxy are older, and star formation is occurring much more leisurely. *Hubble* also identified giant holes in the starburst region, excavated by supernova explosions.

The team suggests that for most of its lifetime, Kiso5639 was drifting through a "desert", devoid of much gas. About a million years ago, its leading edge encountered a filament of denser gas, and the sudden gas infusion initiated a burst of star formation.

Full story at: **http://hubblesite.org/newscenter/archive/releases/2016/23/full/**

to provide NASA guidance in strategic planning and in the smooth execution of our programs. The fiscal year (FY) 2017 President's budget request, which was submitted to Congress in February 2016 and is the subject of discussion by the Congressional appropriations committees this summer, would provide funding for NASA astrophysics to continue its planned programs, missions, projects, and supporting research and technology; for the operating missions continue to generate important and compelling science results; for the new missions under development for the future; and for continuing progress toward implementing the recommendations of the 2010 Decadal Survey (**http://www.nasa.gov/news/budget/**).

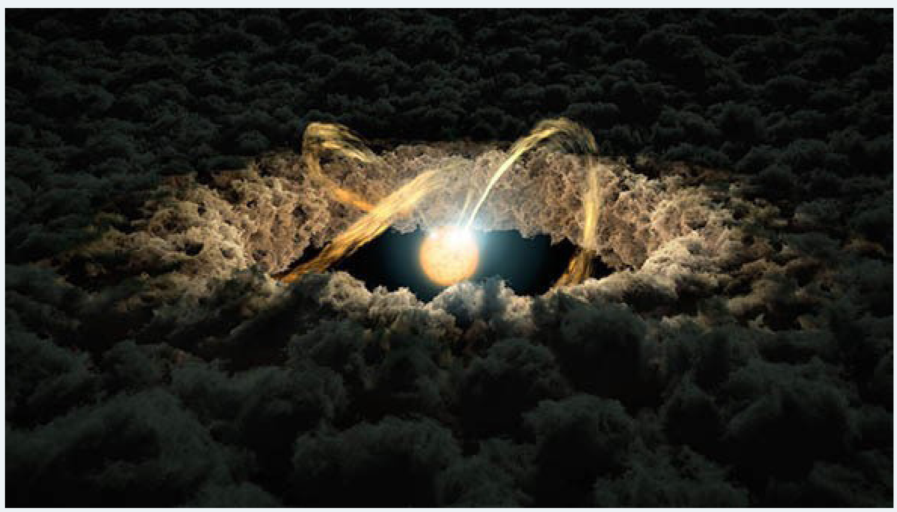
Conditional on Congressional appropriations that support the President's budget request, a modest funding growth in the R&A program will continue in FY2017. In addition to R&A, NASA also funds the community through the mission Guest Observer (GO) programs. The selection rate for proposals in 2015-2016 was 23% for R&A proposals and 28% for GO proposals. 100% of the 2015 selections were announced within 150 days of 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 through the mission GO programs, a late summer/fall 2016 release date is targeted for Medium-class Explorer (MIDEX) and Explorers Mission of Opportunity solicitations (**http://explorers.larc.nasa.gov/APMIDEX2016/**).

The NASA 2016 Astrophysics Senior Review was held during February and March 2016. Eight missions (*Chandra*, *Fermi*, *Hubble*, *Kepler*/K2, *NuSTAR*, *Spitzer*, *Swift*, and *XMM-Newton*) were evaluated in three review panels. The *Hubble Space Telescope* and the *Chandra* X-Ray Observatory were reviewed in standalone panels, as these are core facilities for the community, mature and stable missions with no operational changes. The Senior Review panels found no scientific reason to discontinue or significantly reduce any of the missions under review and that the scientific

Light Echoes Give Clues to Protoplanetary Disk

Imagine you want to measure the size of a room, but it's completely dark. If you shout, you can tell if the space you're in is relatively big or small, depending on how long it takes to hear the echo after it bounces off the wall. Astronomers have used this principle to calculate how far young stars are from the inner edge of their surrounding disks.

"Understanding protoplanetary disks can help us understand some of the mysteries about exoplanets," said Huan Meng, postdoctoral research associate at the University of Arizona, Tucson. "We want to know how planets form and why we find large planets called 'hot Jupiters' close to their stars." Meng is the first author on a new study using data from NASA's *Spitzer Space Telescope*.



Artist's conception of a star surrounded by a protoplanetary disk. Material from the thick disk flows along the stars magnetic field lines and is deposited onto the stars surface. When material hits the star, it lights up brightly. By comparing arrival times of the brightening from the star, with the "light echo" from the disk, astronomers can measure the gap between the disk and the star. Image credit: NASA/JPL

This measurement cannot be done directly—doing so would be like using a satellite photo of your computer screen to measure the period at the end of this sentence. Instead, researchers used a method called "photo-reverberation," or "light echoes." When the central star brightens, some of the light hits the surrounding disk, causing a delayed "echo." Scientists measure the time it took for light coming directly from the star to reach Earth, then wait for its echo to arrive.

Young stars, which have variable emission, are the best candidates. The star used in this study is called YLW 16B. It has about the same mass as our sun, but at one million years old it's just a baby compared to our 4.6 billion-year-old Sun.

Astronomers combined *Spitzer* data with observations from ground-based telescopes. During two nights of observation, researchers saw consistent time lags between brightness changes by the star (shorter wavelengths, ground telescopes), and their echoes in the surrounding disk (longer wavelengths, *Spitzer*). They then calculated how far this light must have traveled during that time lag: about 8 percent of the distance between Earth and its sun, or one-quarter the diameter of Mercury's orbit—a mere 74 seconds.

The *Spitzer* study marks the first time the light echo method was used in the context of protoplanetary disks. "This new approach can be used for other young stars with planets in the process of forming in a disk around them," said Peter Plavchan, co-author of the study (Missouri State University).

NASA's Jet Propulsion Laboratory in Pasadena, California, manages the *Spitzer* mission for NASA's Science Mission Directorate in Washington.

Full story at **http://www.spitzer.caltech.edu/news/1876-feature16-07-Light-Echoes-Give-Clues-to-Protoplanetary-Disk** value of the complete operating mission portfolio is greater than the sum of its parts. The panels encouraged NASA to continue all of these missions. Based on the report of the 2016 Astrophysics Senior Review, and conditional on Congressional appropriations that support the President's budget request, NASA approved all eight missions for continued operations through FY2017 and FY2018. The full reports of the 2016 Astrophysics Senior Review panels and NASA's response can be found at **http://science.nasa.gov/astrophysics/2016-senior-review-operating-missions/**.

With the spring 2016 New Zealand Super Pressure Balloon (SPB) campaign completed, NASA has demonstrated a new capability for ultra-long duration balloon (ULDB) missions at mid-latitudes. Launched on May 11, 2016, from Wanaka, New Zealand, the SPB circumnavigated the globe for ~46 days, terminating in a remote area of Peru on July 2, 2016. Aside from the technology test of the balloon itself, the SPB carried the Compton Spectrometer and Imager (COSI) gamma ray telescope (PI: Steven Boggs, U.C. Berkeley) as a science payload-of-opportunity. Information on the SPB campaign, including the round-the-world flight track of the mission and a link to the COSI team's home page, is available at **http://www.csbf.nasa.gov/newzealand/wanaka.htm**. Additional balloon campaigns are planned this year from Palestine, Texas, Ft. Sumner, New Mexico, and McMurdo Station, Antarctica.

Operating mission news includes:

• The LISA Pathfinder mission began science operations on March 1, 2016, with a successful performance of the ESA test package. Commissioning of the NASA experiment, the Disturbance Reduction System (DRS), started at the end of June.

• Following successful activation of the observatory and instruments, *Hitomi* (*ASTRO-H*) suffered a mission-ending spacecraft anomaly on March 26, 2016. Prior to mission failure, the NASA-provided Soft X-ray Spectrometer (SXS) demonstrated a spectral resolution of ~4.7 eV, significantly exceeding the science requirement. The SXS completed several science observations, including a scientifically important observation of the Perseus Cluster, before the anomaly. The Japanese Aerospace Exploration Agency (JAXA) has invited NASA to join a recovery mission, and NASA is considering such a mission at this time.

• The Stratospheric Observatory for Infrared Astronomy (*SOFIA*) started conducting Cycle 4 observations in February 2016, and conducted a successful deployment in New Zealand through mid-July 2016 for southern hemisphere observations. The German second generation instrument, upGREAT, a multi-pixel heterodyne spectrometer, has been commissioned, and the testing and commissioning of the U.S. second generation instrument, HAWC+, a far infrared imager & polarimeter, is under way. The downselect for a third generation instrument will be made in September 2016.

Missions in development news includes:

• The Neutron star Interior Composition Explorer (*NICER*) and Cosmic Ray Energy and Mass (CREAM) payloads are in storage at Kennedy Space Center awaiting launches to the International Space Station in 2017; the launch on the SpaceX CRS-11 mission is planned for February 2017.

• The Transiting Exoplanet Survey Satellite (TESS) project has begun fabrication and integration of all flight systems; TESS is planning a December 2017 launch.

• The *James Webb Space Telescope* has achieved major milestones during the past year, including installation of all 18 telescope mirrors into the telescope backplane and integration of all four science instruments into the telescope at Goddard Space Flight Center, completion of the cryocooler for the Mid-Infrared Instrument (MIRI) at Jet Propulsion Laboratory, first powering of the spacecraft bus at Northrup Grumman, and completion of the second test of the pathfinder telescope and ground support equipment at Johnson Space Center. Planning has begun for early release observations and the Cycle 1 GO call in late 2017. More information on Webb is at **http://jwst.nasa.gov/** and **https://jwst.stsci.edu/**. Webb remains on track for its October 2018 launch.

• The *Wide-Field Infrared Survey Telescope* (*WFIRST*), the highest large mission priority of the 2010 Decadal Survey, became a new NASA project when it entered the formulation phase (Phase A) in February 2016. The Formulation Science Working Group has begun meeting under the leadership of Neil Gehrels (Goddard Space Flight Center), David Spergel (Princeton U.), and Jeremy Kasdin (Princeton U.). The next milestones for *WFIRST* are the System Requirements Review (SRR) in June 2017 and starting Phase B (KDP-B) in October 2017. More information on *WFIRST* is at **http://wfirst.gsfc.nasa.gov/**.

NASA has initiated large mission concept studies to serve as input to the 2020 Decadal Survey. NASA has appointed Science and Technology Development Teams (STDT) and initiated four large mission concept studies: Far Infrared Surveyor, Habitable Exoplanet Imaging Mission, Large Ultraviolet/Optical/Infrared Surveyor, and X-ray Surveyor. The STDTs have a significant role and responsibility to develop a science case, flow the science case into mission parameters, vet the technology gap list, and direct trades of science versus cost/capability for the missions. NASA has issued a solicitation (#NNH16ZDA001N-APROBES) for medium-size mission concept studies (Astrophysics Probes). Full information on NASA's planning for the 2020 Decadal Survey is at **http://science.nasa.gov/astrophysics/2020-decadal-survey-planning/**.

On August 15, 2016, the National Research Council released a report on the review of the progress towards the Decadal Survey vision in New Worlds, New Horizons. (**http://www.nap.edu/catalog/23560/new-worlds-new-horizons-a-midterm-assessment**). NASA will take the recommendations from that report into consideration as it continues to implement the Decadal Survey priorities.

NASA is proposing that the NASA Advisory Council (NAC) Science Committee's four subcommittees associated with SMD divisions become stand-alone Federal Advisory Committee Act (FACA) committees, which will advise the respective Division Directors within SMD. NASA has decided to apply for FACA charters for the four science advisory subcommittees, including the Astrophysics Subcommittee. Once chartered, the Astrophysics Subcommittee will be replaced by the Astrophysics Advisory Committee (APAC), which will report to the Director of the

Astrophysics Division. Once the APAC is chartered, NASA will establish subordinate groups, which include the three Program Analysis Groups (PAGs), the four STDT's for large mission studies, and the L3 Study Team.

My entire Town Hall Presentation from the June 2016 AAS meeting is available at **http://science.nasa.gov/astrophysics/documents/**, and my entire presentation at the July 2016 meeting of the Astrophysics Subcommittee is available at **http://science.nasa.gov/science-committee/subcommittees/nac-astrophysics-subcommittee/**.

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Far-IR Surveyor Study Status

Lee Armus, *Caltech*

The second face-to-face meeting of the Far-Infrared Surveyor STDT was held at the Goddard Space Flight Center in Greenbelt, Maryland on 16–17 August 2016. The STDT made significant progress in outlining the science and the architecture of the FIR Surveyor.

More than 32 community-driven science proposals were reviewed in five STDT science working groups covering (1) Solar System, (2) Planet Formation and Exoplanets, (3) Milky Way, ISM and Nearby Galaxies, (4) Galaxy and Black Hole Evolution over Cosmic Time, and (5) Early Universe and Cosmology. The scientific requirements of the 14 top-ranked proposals were used to select a baseline architecture to study for the FIR Surveyor: an actively-cooled, filled-aperture telescope with effective diameter between 8 and 15 meters. Imaging spectrometers and wide-field, broad-band imagers will cover the 10 micron to 1 mm range; coverage below 10 microns is under study. During the full course of the study, the STDT will continue to develop the scientific requirements and detailed design of the FIR Surveyor. The STDT encourages all members of the scientific community to participate in future discussions. Members of the community interested in contributing to the science case for the FIR Surveyor should contact any member of the STDT (see below).

The third face-to-face meeting of the FIR Surveyor STDT is scheduled for 2–3 November 2016 in Boulder, Colorado. Among the goals for this meeting are further work on defining the scope and requirements for the FIR Surveyor instrument suite. In addition to the regular face-to-face meetings of the STDT, there will be a discussion of the study at the FIR Science Interest Group meeting at the upcoming January 2017 AAS meeting in Grapevine, Texas, where there will also be a special session on Decadal Missions (Jan. 7). Representatives of the STDT may be found at the Cosmic Origins table in the NASA booth during the AAS meeting.

The Far-IR Surveyor Team. Image credit: Kartik Sheth

The FIR Surveyor STDT is comprised of 19 voting members of the US scientific community, and an additional 11 Ex-Officio members drawn from international scientific community and NASA. In addition, there is a 12 member Science and Technology Advisory Group consisting of US scientists and representatives from a number of aerospace industrial partners. The chairs of the FIRS STDT are Asantha Cooray (UC Irvine) and Margaret Meixner (STScI). The full listing of the FIR Surveyor membership, along with the goals for the study, can be found on the team website (**http://asd.gsfc.nasa.gov/firs/**). All meetings are open to the public and are posted on the website.

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LUVOIR Study Status

Brad Peterson, *Ohio State and STScI*

The Large Ultraviolet Optical Infrared Surveyor (LUVOIR) was identified in the 2013 NASA Astrophysics study "*Enduring Quests, Daring Visions*: Thirty-Year Roadmap for NASA Astrophysics" as a future flagship-class mission to dramatically advance Cosmic Origins science as well as to characterize potential Earth-like planets in the habitable zones of nearby stars. LUVOIR is envisioned as an 8–16 m class telescope with broad imaging and spectroscopic capabilities over the range 100 nm to 2 µm, with possible extension to 90 nm and 5 µm as stretch goals. The preferred location of LUVOIR will be L2, and the telescope and spacecraft will be designed for serviceability (either human crew or robots) and a long lifetime.

LUVOIR is one of four potential future missions that the NASA Astrophysics Division is funding for three-year developmental studies; the others are the Habitable Exoplanets Imaging Mission (HabEx), the Far-IR Surveyor, and the X-ray Surveyor. The LUVOIR science and technology definition team (STDT) is chaired by Debra Fischer (Yale) and Brad Peterson (Ohio State and Space Telescope Science Institute). The team has

spent much of the summer refining the science goals for LUVOIR, building on the Astrophysics Roadmap as well as the ATLAST and High-Definition Space Telescope concept studies, with input from discipline-specific science working groups (SWGs) and technology working groups (TWGs). The STDT solicited input from the cosmic origins and exoplanet communities to identify the highest priority science that can be accomplished with LUVOIR and to determine what additional capabilities are necessary to achieve the most compelling science goals of the community. At the second team meeting (August 18 and 19, GSFC) the STDT used these science cases to establish an initial, notional preliminary design and suite of instruments. As the study moves forward, the team will encourage additional input from the science communities.

There will be a special public session at the upcoming AAS meeting on January 7, 2017, at 10:30 A.M. This will be an opportunity to learn more about all four mission studies and we are eager to hear your questions and ideas for the critical science that could be achieved with a large, serviceable telescope that will operate for decades at L2.

All LUVOIR team meetings are open to the public. More information may be found at **http://asd.gsfc.nasa.gov/luvoir/**.

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Strategic Astrophysics Technology (SAT) Selections for ROSES-2015

Mario Perez, *Astrophysics Division, Cosmic Origins Program Scientist*

As part of the continuous efforts of supporting the maturation of key technologies to the point at which they are feasible for implementation in space flight missions, the Astrophysics Division solicited a new cycle of Strategic Astrophysics Technology (SAT) proposals for the Cosmic Origins theme. The solicitation was part of the ROSES-2015 research announcement.

Proposals were due on March 18, 2016. A total of 12 new COR-related investigations were submitted, out of a total of 29 proposals submitted to the three themes of the SAT program.

After a peer review of these technology proposals and the consideration of programmatic considerations, the selecting official, Paul Hertz, Astrophysics Division Director, on August 15, 2016, signed the decision document. The selection decision was communicated to all 12 proposing teams, and the information was made public for the selected proposals. Two highly-rated investigations, listed below, were selected with partial funding, both for a three-years period of performance. A third meritorious investigation was deferred until funding and programmatic issues are resolved.

Title	PI	Institution
Predictive Thermal Control Technology for potential HabEx Mission	P. Stahl	MSFC
High-Efficiency Continuous Cooling for Cryogenic Instruments and sub-Kelvin Detectors	J. Tuttle	GSFC

All three investigations belong to the critical areas of interest explicitly requested in the SAT Cosmic Origins solicitation, namely Precision Large Optics and Next Generation Detectors. The key technologies are identified and prioritized every year by the Cosmic Origins community, as reported in the **Program Annual Technology Report** (PATR, latest version October 2015).

Planned revisions of the updated Cosmic Origins PATR (to be issued in October 2016) are important for the next cycle of SAT proposals (part of the ROSES-2016), for which the Notice of Intent (NOIs) are due on January 20, 2017 and the full proposals are due on March 17, 2017.

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Technology Solicitations to Enable Astrophysics Discoveries

Mario R. Perez, *Astrophysics, NASA Headquarters*
James E. Neff, *Division of Astronomical Sciences, NSF*
Denise A. Podolski, *Space Technology Mission Directorate, NASA Headquarters*

Federal funding agencies have been the main sponsors of efforts to understand, define, and identify the technology needs for upcoming astrophysical missions, projects, and observatories. As always, federal resources are limited, and the need to maximize the impact of funded investigations is important. We seek to promote innovative concepts and support balanced portfolios.

The science drivers or the scientific problems that can be addressed by new technologies are central and should be explicit in building a case to justify these technology investments. Often technologists come up with a solution and then try to find a problem that they could solve with it. This may not be the best path to success in securing federal funding.

Vital components in the areas of detectors, optics, optical coatings, electronics, and other supporting hardware have a low level of technological readiness. Fundamental advances in experimental astrophysics will only be achieved when the proper technologies and quality components are matured and ready to be part of instruments, observatories, or flight missions.

The overall strategic guidelines for technology solicitations are the recommendations provided by the 2010 Decadal Survey – New Worlds, New Horizons in Astronomy and Astrophysics. Tactical implementations within NASA could point the community to specific components or immediate needs in a particular year or solicitation announcement. Potential proposers should examine in detail each year's solicitation to understand the new emphasis and priorities described in these announcements. NSF's ATI program does not have a solicitation that spells out strategic goals from year to year but rather welcomes a broad range of proposals. The NSF MRI program has specific goals that could include some component of limited technology development.

Upcoming Solicitations for Astrophysics

Agency/Title of Solicitation	Funding Amounts (first year awards)	Submissions (annual cycle)
NASA		
Astrophysics Research and Analysis (APRA) (APD solicitation)	$15-20M	March - 2017
Strategic Astrophysics Technologies (SAT) APD solicitation- all themes)	~$4-6M	March – 2017
Space Technology Research Grants - Early Stage Innovation (STMD solicitation)	8-10 new annually (2-3 year awards, up to $500K total each)	May release July due date
Space Technology Research Grants - Early Career Faculty (STMD solicitation)	6-8 new annually (3 year awards, up to $600K total each)	Feb/March release April due date
Space Technology Research Grants - NASA Space Technology Research Fellowships (STMD solicitation)	50-55 new awards annually (up to 4 years and $74K/year)	Early/mid Sep release November due date
NASA Innovative Advanced Concepts (NIAC) (STMD solicitation)	~$1.5M new Phase I awards/$125K each ~$5M Phase II awards/$500K each	August release/mid-Sep due date (Phase I) Mid-Dec release/Feb due date (Phase II)
NSF		
Advanced Technology Instrumentation (ATI) (AST announcement)	~$8M	November - 2016
Major Research Instrumentation (MRI) (NSF-wide solicitation)	~$1 – 2.5 M (AST share)	January 2017 Two </= 3 proposals maximum per institution; $4M maximum

Below, we present here a list of the upcoming solicitations issued by NASA's Astrophysics Division (APD), the Space Technology Missions Directorate (STMD) at NASA Headquarters, and the Division of Astronomical Sciences (AST) at the National Science Foundation (NSF). These solicitations are of high interest to the technology community, which works to solve the critical challenges that will enable the next level of detection in astrophysics.

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Cosmic Origins Suborbital Program: Balloon Program – BETTII

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 frequently been precursors to NASA astrophysics missions. The suborbital program's flexibility, short development cycles, and low cost are 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 four funded balloon programs relevant to Cosmic Origins.

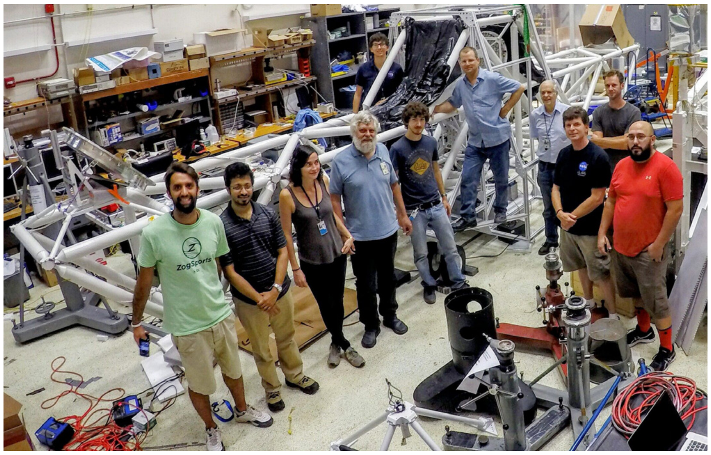
The Far-Infrared (FIR) is the spectral region where many astrophysical sources are brightest; these include very young stars in actively star-forming regions.

The atmosphere both radiates strongly in the FIR and absorbs FIR light from space; therefore to make astrophysical observations in the FIR, we must get above the majority of the atmosphere. The angular resolution of current FIR telescopes is insufficient to resolve the detailed structures of these regions in our galaxy, to separate star-forming regions in most galaxies beyond our own, or to tell one distant galaxy from its neighbors. Higher resolution requires much larger single telescopes, which are currently difficult to build and expensive to launch. Interferometry provides a way to obtain spatial resolution with very modest sized telescopes.

The Balloon Experimental Twin Telescope for Infrared Interferometry (BETTII) is a new concept: a balloon-borne far-infrared (FIR) interferometer. Initially, it will explore the structures and spectral properties of warm dust, in nearby active star-formation regions or in active galaxies. BETTII is led by PI Stephen Rinehart, at Goddard Space Flight Center. His Goddard team works with colleagues at Cardiff University (Wales) and University College London (United Kingdom).

BETTII serves as an excellent pathfinder for future space-based interferometers, both for a system-level proof of an interferometer in space, as well as a testbed for individual components (e.g., mechanisms, structures). Ground-based interferometers (at radio, visible, or near-IR wavelengths) often have variable baselines, and/or many elements, which allow them to reconstruct complex fields. For this initial demonstration, BETTII is built with a fixed baseline. Thus, it is not intended to produce detailed images, but rather to allow spatially resolved spectroscopy with an angular resolution of ~1 arcsecond and a spectral resolution R~20 at wavelengths 30–90 µm. It will fly at ~120,000 feet, approximating space environments.

The BETTII experiment has 2 identical siderostats separated by 8m, each with an effective diameter of 50 cm. They are mounted on a carbon-fiber truss which also serves as the optical bench. Each



BETTII payload and team, just before shipment to Fort Sumner, NM for the first flight. From left to right: Jordi Vila (former M.S. student), Arnab Dhabal (UMD grad student), Roser Juanola-Parramon (NPP), Dale Fixsen (UMD), Julien Jolles (Master's student from France), Stephen Rinehart, Bob Silverberg, Steve Maher (contractor), Elmer Sharp (contractor), Todd Veach (postdoc)

siderostat sends light through a telescope assembly, producing a compressed collimated beam. Light from one arm passes through a (warm) delay line, while light from the other arm passes through a beam rotater, before both beams enter the cryogenic instrument.

The heart of the BETTI interferometer operates inside a cryostat, and includes: 1) a 4 K volume with an innovative cold delay line (CDL), a beam combiner, and FIR optics; 2) a Helium-3 refrigerator to keep the Far-IR detectors at a temperature of 300 mK; 3) a warmer 77 K volume for the tracking system; and 4) tanks for the liquid Helium and Nitrogen. The CDL produces a controlled optical path difference between the two arms of the interferometer (up to ~10 mm), with positional knowledge of tens of nanometers. The four detectors are 9 × 9 arrays of multiplexed superconducting transition edge sensor (TES) bolometers, with higher saturation levels and faster readout speed (400 Hz) than earlier versions (both needed for BETTII). The detectors are read out by advanced SQUID multiplexers with greatly reduced sensitivity to magnetic fields. The beam combiner was fully characterized at Cardiff University, and detectors were built at Goddard.

The pointing control system for BETTII is one of the key features. The control system operates in two stages; the gondola pointing is controlled to within a few arcseconds, while the fine control system aligns the two arms to within ~0.1 arcseconds. Development of this system has been extremely challenging, and the effort was led by UMD graduate student Maxime Rizzo.

BETTII will obtain spatially resolved spectroscopy in two bands, 30–60 μm and 60–90 μm with a spatial resolution of ~0.5 arcsec at 40 μm (~1 arcsec at 80 μm), over a field of ~ 2 arcmin, with a spectral resolution R~20. The first flight will observe calibration sources and a few bright astrophysical sources, with an emphasis on understanding and characterizing the performance of the system. It is expected to fly from Fort Sumner (NM) in September 2016.

A live TV feed is often available at **www.ustream.tv/channel/nasa-educationa**

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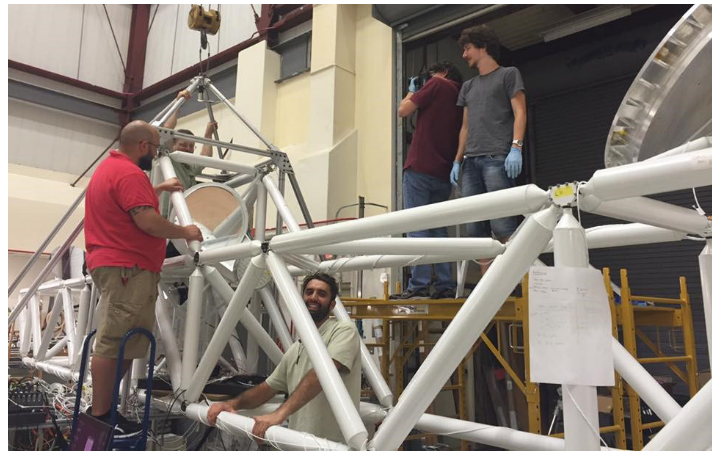


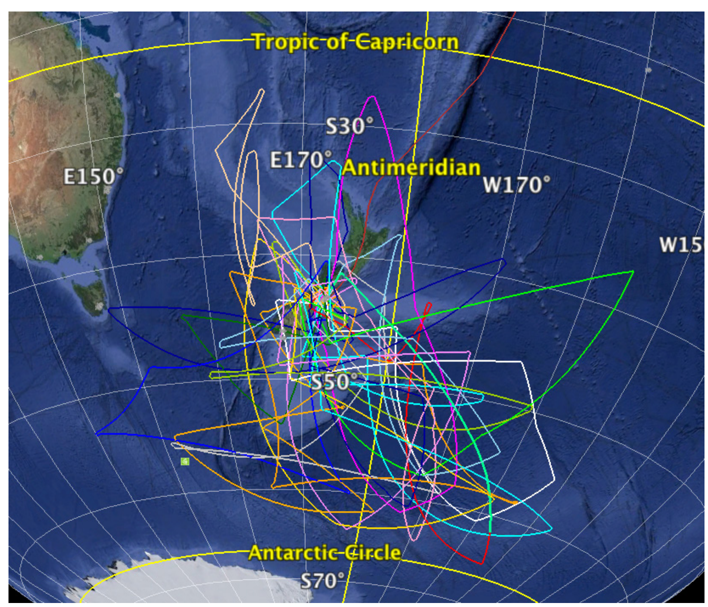
BETTI payload and team after installing second telescope on metering truss. From left to right: NPP Postdoc Todd Veach, PI Stephen Rinehart (behind the mirror), former graduate student Jordi Vila, graduate student Maxime Rizzo, and visiting graduate student (from France) Julien Jolles

News from SOFIA

Pamela Marcum, *SOFIA Project Scientist*

The *SOFIA* mission has had a busy and productive summer conducting Cycle 4 observations, with more than 75% of the planned observations now complete. The flight plans for all science targets associated with Cycle 4 investigations can be found, along with links to the related proposal abstracts, at **https://sofia.usra.edu/science/proposing-and-observing/proposal-calls/cycle-4/cycle-4-flight-plans**.

From June through July, the observatory conducted operations from New Zealand (See figure below). Three science instruments (upGREAT, FIFI-LS, and FORCAST) were used to conduct science investigations of southern hemisphere targets, providing high spectral resolution and integral-field spectroscopy in the far-IR, and imaging with moderate spectral resolution in the mid-IR. Aside from the obvious advantage of gaining access to targets of



A composite of all of the science flight plans conducted during the 2016 Southern Hemisphere deployment in Christchurch, New Zealand.

GALEX Uncovers 'Frankenstein' Galaxy

The galaxy UGC 1382 was thought to be a typical, old, small galaxy. However, when Mark Seibert (Carnegie) and Lea Hagen (PSU) looked at GALEX images of the system, they found that it was 10 times larger than previously thought. Further, the outer reaches of the galaxy were found to form a rotating disk of low-density cold gas, threaded with a few spiral arms of very recent star formation. It now appears to be one of the three largest isolated disk galaxies known, according to the researchers. Although there is a great deal of material available, stars form slowly because the gas is so diffuse.

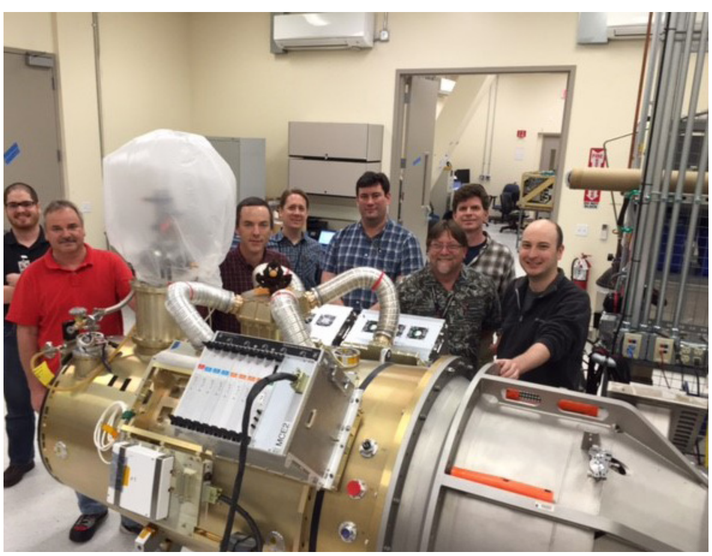
By combining data from several different telescopes, Seibert and Hagen find that the inner regions of the galaxy appear to be younger than the outer regions—the reverse of most galaxies—as if the galaxy has been assembled from spare parts. "This is like finding a tree whose inner growth rings are younger than the outer rings," said Seibert. The researchers suggest that the current galaxy started as a group of small galaxies, dominated by cold gas and dark matter. Later, a disk galaxy formed nearby, eventually absorbing and destroying the individual small galaxies, which settled into the larger disk.

The galaxy UGC 1382 a) as seen in visible light (from the Sloan Digital Sky Survey (SDSS)), b) in ultraviolet light (from GALEX, shown in blue) and deeper visible SDSS imaging, and c) with radio emission from cold hydrogen gas (HI, shown in green). Image credit: NASA/JPL/Caltech / SDSS/NRAO

Although the GALEX mission ended in 2013, the rich data set from the 10-year survey mission is still a valuable source for exploring galaxy evolution. Calibrated GALEX data is archived in the Milkuski Archive at Space Telescope (MAST), at the Space Telescope Science Institute (STScI).

Full story at **http://www.galex.caltech.edu/newsroom/glx2016-01f.html**

high interest such as the Small and Large Magellanic Clouds and the Galactic Center region, the southern hemisphere deployments during local winter provide at-altitude observing conditions that are at least 50% drier on average than those in the northern hemisphere, greatly benefiting IR observations. For observations of strong interstellar medium (ISM) cooling lines such as [CII] 158 µm, such observing conditions can be comparable to those of a space-based facility.



SOFIA's newest science instrument, HAWC+, in the lab with the science/development team.

The state-of-the-art high-speed FIR mapping capabilities of both upGREAT and FIFI-LS further optimized the data quality and production. The velocity-resolved maps produced by upGREAT played a critical role in several investigations requiring kinematic separation of emission sources from molecular and atomic components in the same line of sight, such as the evolution of dominant species (OI, OH, water, CO) during the formation of massive stars, the interaction of spiral arms with highly ionized interarm gas that results in gas compression and star formation, the role of non-dissociative shocks on water production in young stellar object outflows, the characterization of "CO-faint" molecular hydrogen, and velocity field mapping across protoplanetary disks.

SOFIA's newest instrument, HAWC+ (High-Resolution Airborne Wideband Camera), experienced some vibrational issues to its ADR (Adiabatic Demagnetization Refrigeration) during its Phase 1 commissioning earlier this year. Recent lab tests following the implementation of stiffening agents suggest that the instrument will be ready to finalize its commissioning this fall (see figure at left).

In addition to the commissioning and beginning of science operations for HAWC+, there are several other noteworthy *SOFIA*-related events occurring this fall: Cycle 5 proposal selections will soon be announced (for proposal statistics, see **https://sofia.usra.edu/science/proposing-and-observing**); Readers are reminded that successful U.S. proposals are eligible for Guest Observer funding. The down-select and development phase for

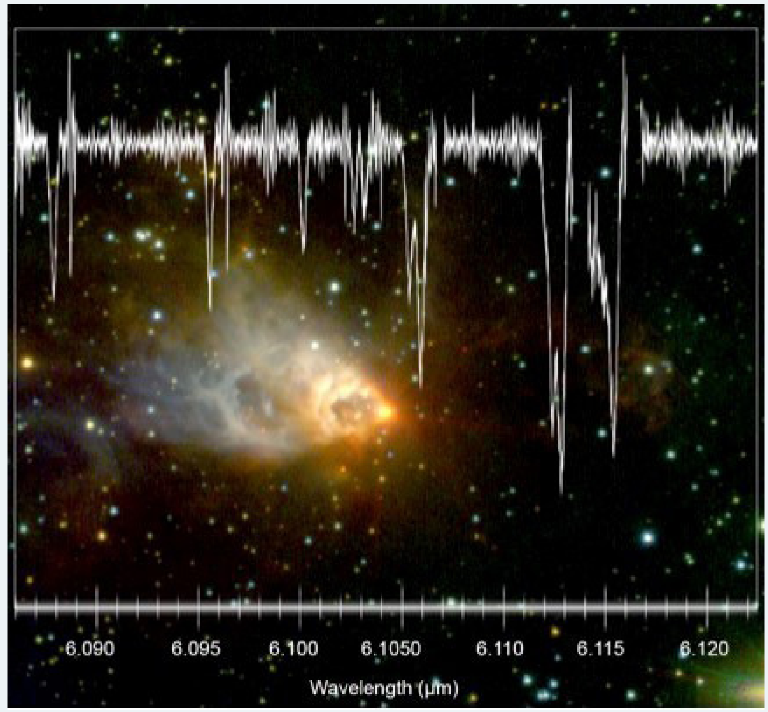
SOFIA Pinpoints Water Vapor in Young Star

A team of scientists using the Stratospheric Observatory for Infrared Astronomy (*SOFIA*) has pinpointed the amount and location of water vapor around a newly forming star with groundbreaking precision.

Using data collected aboard *SOFIA*, the team determined that most of this young star's water vapor is located in material flowing away from the star, rather than within the disk of matter orbiting around it. This location is unexpected, indicating that if planets formed around this star, they might receive only a small fraction of the water in the system.

These observations were made possible by using *SOFIA*'s airborne vantage point in the Stratosphere—at an altitude above 99% of Earth's water vapor, which prevents this type of measurement from the ground—as well as the precision and sensitivity of the EXES (Echelon-Cross-Echelle Spectrograph) instrument aboard *SOFIA*. The instrument spreads infrared light into its component colors with very high detail, providing scientists with more information about this light than was previously possible.

"This detection of water vapor would have been impossible for any ground-based observatory, and there are currently no space-borne telescopes providing this capability," said *SOFIA* project scientist Pamela Marcum. "These mid-infrared observations allow us to directly measure the amount of water vapor in this young star, expanding our understanding of the distribution of water in the universe and its eventual incorporation into planets."



Infrared spectrum of the protostar AFGL 2591 made by the EXES instrument on SOFIA, superimposed on an infrared image of the protostar and the nebula that surrounds it, made by the Gemini Observatory. Credits: Spectrum Image: NASA/DLR/USRA/DSI/EXES Team/N. Indrolio (U. Michigan & JHU); Credit Background Image: C. Aspin et al. / NIRI / Gemini Observatory / NSF

These findings were published in Astrophysical Journal Letters in 2015 by a team of scientists at the University of Michigan, Johns Hopkins University, and the University of California at Davis.

Full article at **http://www.nasa.gov/feature/sofia-pinpoints-water-vapor-in-young-star**

SOFIA's 3rd Generation Science Instrument will begin (**https://www.sofia.usra.edu/public/news-updates/nasa-sofia-third-generation-science-instrument-selection-enters-final-phase**), and a *SOFIA* conference will be held October 17–20 focusing on the current understanding of star-formation and the impact of feedback processes in Galactic molecular clouds and nearby galaxies (see **https://www.sofia.usra.edu/conference/local-truth-star-formation-and-feedback-sofia-era-celebrating-50-years-airborne-astronomy** for additional information and registration).

Finally, the team gratefully acknowledges Dr. Erick Young, who will soon be retiring from his position as Director of *SOFIA* Science Missions. Erick has provided valuable leadership and guidance to *SOFIA* during his seven years of service, laying the strong foundation upon which *SOFIA*'s legacy is being built. As we wish Erick an enjoyable and well-deserved retirement, we welcome Dr. Hal Yorke to the team. Hal, who was previously at the Jet Propulsion Laboratory where he held numerous management and science leadership positions, will be taking the position of SMO Director effective October 15 (for more info, see **www.usra.edu/news/pr/2016/sofialeadership**).

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WFIRST Update

Deborah Padgett, *COR Program Deputy Chief Scientist*

After beginning formulation in February, the *Wide-Field Infrared Survey Telescope* (*WFIRST*) is proceeding through Phase A. Shortly after passing this threshold, *WFIRST* announced the selection of Ball Aerospace (Boulder, CO) and Lockheed Martin Advance Technology Center (Palo Alto, CA) for early Phase A studies to examine their potential contributions to the wide field instrument (WFI).

On Feb. 29–March 2, the Community Astrophysics with *WFIRST* conference was held in Pasadena. Talks covered the

Community Astrophysics with WFIRST *conference, Spring 2016.*

activities of the Science Investigation Teams selected in December 2015, ideas for novel General Observer observations, and a project update from Project Scientist Neil Gehrels.

A Science Investigation Team led by Margaret Turnbull issued a challenge to the astronomical community to participate in an exercise to retrieve exoplanet spectra from simulated *WFIRST* coronagraphic observations. Their Challenge will run from August 15th to November 15th, and it will consist of a blind spectral retrieval exercise using simulated extracted spectra for several “known RV” and/or hypothetical “discovery” exoplanets. The challenge can be viewed at **https://wfirst.ipac.caltech.edu/sims/CGI_Data_Challenges.html**. In August 2016, the *WFIRST* project successfully held its Acquisition Strategy Meeting to decide on approaches for future activities and procurement. *WFIRST* information and news can be found at **http://wfirst.gsfc.nasa.gov/**.

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JWST Status and Progress

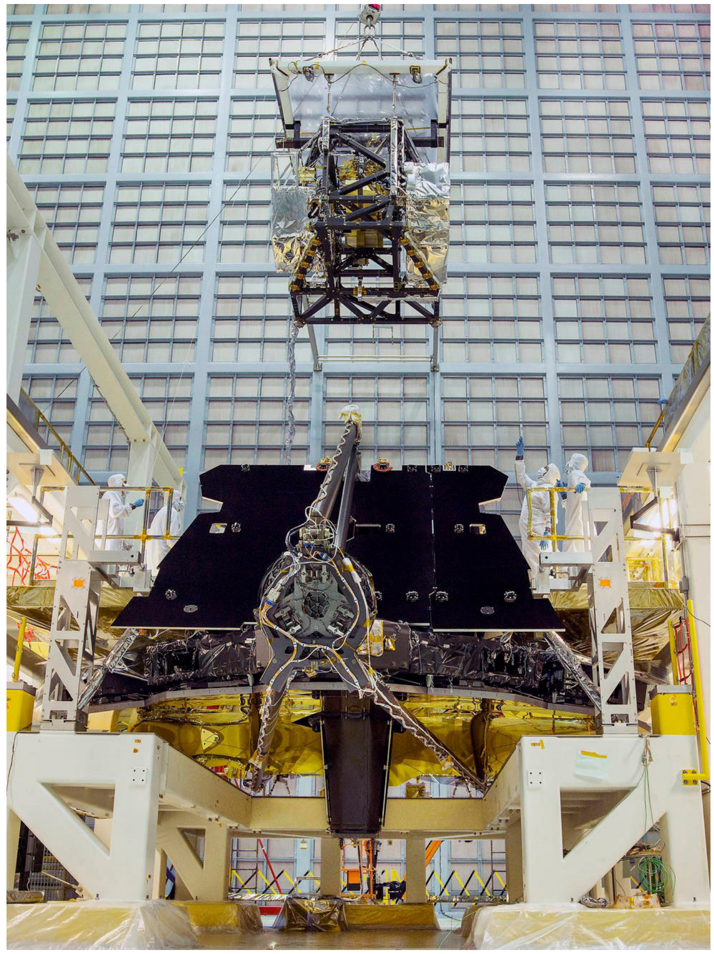
Susan Neff, *COR Program Chief Scientist*

The *James Webb Space Telescope* (*JWST*) is on schedule for launch in 2018. Observations made by *JWST* are expected to advance all aspects of astrophysics, particularly COR science.

Installation of the 18 flight mirrors and cryovac testing was completed in February 2016 and installation of the secondary mirror, and the Aft Optics System (including tertiary and fine steering mirrors) was accomplished in March 2016, The Integrated Science Instrument Module (ISIM) is the heart of the telescope, containing the science instruments. It was installed in the telescope structure in 2016. The installation of over 900 pieces of thermal blanketing is largely finished, and integration and installation of the ISIM Electronics Compartment (IEC, on cold side of spacecraft) and the instrument harness radiators is in progress.

In September, the surface figure of the 18 primary mirror segments will be measured with a custom-built interferometer. After acoustic and vibration testing of the Optical Telescope

John Mather, JWST Project Scientist, and the completed JWST primary mirror regard one another in late April, 2016. Image credit: NASA/Goddard/David Friedlander



The Integrated Science Instrument Module (ISIM) is carefully lowered into place in the JWST telescope structure in late May 2016. Engineers above the telescope indicate the scale. Image credit: NASA/Chris Gunn A video of the installation may be found at: ***https://www.youtube.com/watch?v=AfzVEZGrMMw***

element and Integrated Science instrument module (OTIS = Optical Telescope Element + ISIM) (planned for fall 2016), the mirror segments will be remeasured to check for any changes. The flight telescope assembly is expected to be shipped to Johnson Spaceflight Center (JSC) early in 2017.

At JPL, acceptance testing of the cryocooler for the Mid Infrared Instrument (MIRI) finished in in late May, and the cooler was delivered for spacecraft integration. Preparations continue at JSC for the final test of the pathfinder telescope, starting in September and running for 52 days. In 2017, JSC will be testing the flight telescope before it goes to Northrup Grumman in California, for integration with the spacecraft and sunshield.

Layer 5 of the sunshield (closest to telescope) was delivered to Northrup Grumman in June, Layer 1 (sunfacing) in August and Layer 2 is in the final phase of manufacturing. (Layers 3 and 4 were delivered in 2015). Cryovac deployment of the sunshield Core was successfully tested in June; the sunshield layers will be attached to the Core over the next year.

In the following article, we describe the complex engineering of *JWST*’s sunshield.

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**

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The Complex Material Engineering of NASA's Webb Telescope Sunshield

Rob Gutro, *NASA Goddard Space Flight Center*

The shiny silver material of the five-layer sunshield that will fly aboard NASA's *James Webb Space Telescope* is a complex and innovative feat of material science and engineering. Each layer is made from a unique composite material, each has a specific thickness and size, and they must be precisely separated in space. There are even special seams and reinforcements to limit meteorite damage.

NASA and its industry partners developed a lightweight, robust way to protect the telescope and mirrors from the sun's infrared radiation in the material that makes up the sunshield. Some of the things that make the sunshield unique are its strong yet ultra-thin material, special kite-like shape, and the special role of its layers.

Material Make-up

The sunshield consists of five layers of a material called Kapton. Each layer is coated with aluminum, while sun-facing side of the two hottest layers (designated Layer 1 and Layer 2) also have a "doped-silicon" (or treated silicon) coating to reflect the sun's heat back into space. The sunshield is a critical part of the Webb telescope because the infrared cameras and instruments aboard must be kept very cold and out of the sun's heat and light to function properly.

Kapton is a polyimide film that was developed by DuPont in the late 1960s. It has high heat-resistance and remains stable across a wide range of temperatures from minus 269 to plus 400 Celsius (minus 452 to plus 752 degrees Fahrenheit). It does not melt or burn at the highest of these temperatures. On Earth, Kapton polyimide film can be used in a variety of electrical and electronic insulation applications.

The sunshield layers are also coated with aluminum and doped-silicon for their optical properties and longevity in the space environment. Doping is a process where a small amount of another material is mixed in during the Silicon coating process so that the coating is electrically conductive. The coating needs to be electrically conductive so that the Membranes can be electrically grounded to the rest of *JWST* and will not build up a static electric charge across their surface. Silicon has a high emissivity, which means it emits the most heat and light and acts to block the sun's heat from reaching the infrared instruments that will be located underneath it. The highly-reflective aluminum surfaces also bounce the remaining energy out of the gaps at the sunshield layer's edges.

Kite-Like Shape and Layers

The kite-like shape and the number of layers of sunshield both play an important role on the Webb telescope. Each of the different layers are positioned and separated with precision to accomplish their function.

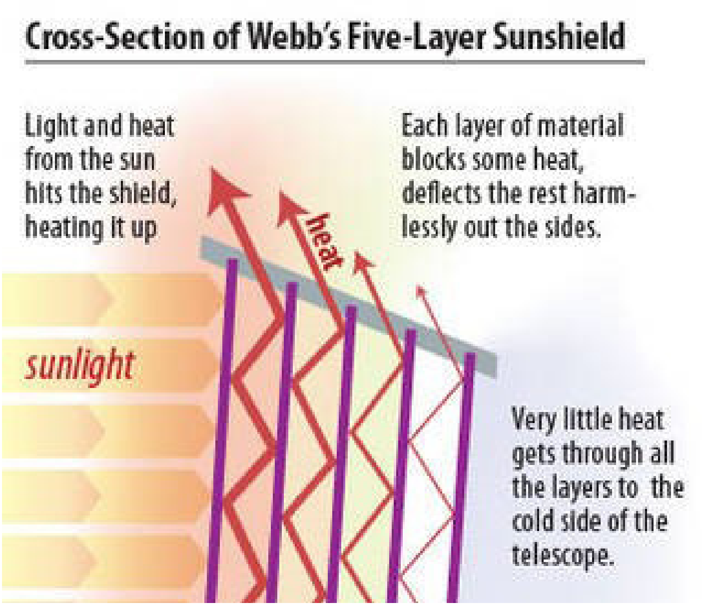
"The shape and design also direct heat out the sides, around the perimeter, between the layers," said James Cooper, Webb telescope Sunshield Manager at NASA's Goddard Space Flight Center, Greenbelt, Maryland. "Heat generated by the Spacecraft bus at the "core," or center, is forced out between the membrane layers so that it cannot heat up the optics."

"The five layers are needed to block and re-direct enough heat to get the telescope down to required temperatures, with margin," Cooper said. "The fifth layer is mostly for margin against imperfections, micro-meteoroids holes, etc." The gap between the layers provides an additional insulating effect.

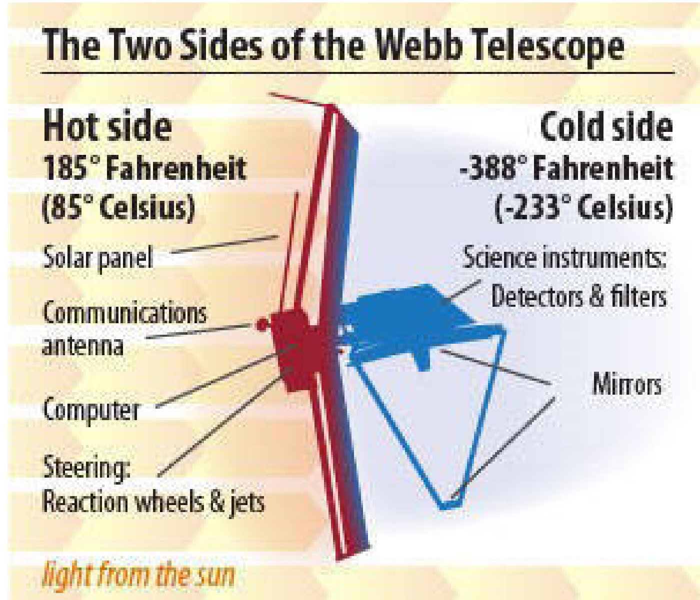
Each layer of the sunshield is incredibly thin. Layer 1 will face the sun and is only 0.05 millimeters (0.002 inches) thick, while the other four layers are 0.025 mm (0.001 inches). The thickness of the aluminum and silicon coatings are even smaller. The silicon coating is ~50 nanometers (nm) (1.9 microinches) thick, while the aluminum coating is ~100 nm (3.93 microinches) thick.

An engineer in a cleanroom looks at one of the sunshield layers that shows a grid pattern of "rip-stops." Credits: Nexvolve

Deployment of a full-sized test sunshield. Image credit: Northrup Grumman



Cross-section of Webb's five layer sunshield. Credits: STScI



The two sides of the Webb telescope. Credits: STScI

The layers are slightly different sizes and different shapes. Layer 5 (just under the primary mirror) is smallest and Layer 1 is largest. Layer 1 is relatively flat and layer 5 is more curved. The layers are closer together at center and further apart at the edges to direct heat from center to the outside of the layers.

The Webb telescope optics (like the infrared camera and mirrors) must always be protected from direct exposure to any hot objects. So the membranes are sized and positioned such that the mirrors only have a direct line of sight to the cold layer 5, while the sun only directly shines on layer 1 no matter which way the observatory is pointed.

Special Seaming

The membrane material is tough, but if it gets a small tear or hole, the hole could become much larger. So, there is a special process called a Thermal Spot Bond (TSB)— areas where each layer are melted together. In addition, reinforcing strips of membrane material are Thermal Spot Bonded to the parent membrane about every 6 feet or so, forming a grid pattern of "rip-stops."

"This has been shown through testing to arrest a tear and keep it from extending outside of a given grid area," said Cooper. So, if a hole occurs in a layer of the sunshield from a meteoroid, or small meteor, the size of the damage is limited. These are not intended to stop a meteoroid, but rather to contain the area of damage.

Extreme Temperatures and the Sunshield

The material of the sunshield does shrink as it gets colder, and the hot layers expand. Cooper said, "The Kapton variety minimizes this compared to some other material choices. We have tested the material so we know how much it shrinks. We account for this in both our manufacturing and in our analysis predictions of the shape we will get in space. We have also tested a one-third-scale five-layer sunshield at temperature and vacuum to verify our predictions."

Credits: NASA/STScI

For more information about the James Webb Space Telescope, visit: **www.nasa.gov/webb** or **jwst.nasa.gov**

For more information and images about the sunshield, visit: **jwst.nasa.gov/sunshield.html**

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COPAG Status

Paul Scowen, *COPAG Chair*

Since the last newsletter in March, the Cosmic Origins Program Analysis Group (COPAG) has been active on a variety of fronts. We continue to solicit input from our membership about concerns they may have about the programs of the Cosmic Origins office and the science NASA is seeking to support through the many missions we have in operation.

Probe-class missions: in the first quarter of CY 2016 the COPAG delivered both a joint statement with the other two PAGs and an individual report on the desires of the COR community to define a possible Probe mission class to fill the gap between Explorers and Large missions. This report is available at **http://cor.gsfc.nasa.gov/copag/probe-study/COPAG_Probe_Response.pdf**.

In response to this input, NASA SMD issued a call for proposals to further study specific mission concepts. The call was released in August with proposals being due in November 2016. The details of the call are available at **https://nspires.nasaprs.com/external/solicitations/summary.do?method=init&solId=%7B96D40385-EB0D-6F64-9195-CE8B5555F9BD%7D&path=open**. We encourage our members to be responsive to this call—the outcome of these studies will be submitted to the 2020 Decadal Survey with the specific goal of demonstrating whether a mission class of this size has merit and that there is compelling science that the community would like to do inside this price point ($400M–$1B FY17).

Meet *Hubble* Fellow Jon Trump

Hubble Fellow Jon Trump investigates the "fossil record" of supermassive black holes (SMBH) in dwarf galaxies. His field of interest is the connection between galaxy growth and SMBH formation and feedback in the early universe. The fraction of "light seeds from supernovae versus "massive seeds," mysterious quasi-stars with masses up to a million times solar, in the formation of SBH is particularly intriguing to him. To study these objects, Jon has used the *Hubble* Cosmological Evolution Survey (COSMOS) and Cosmic Assembly Near-Infrared Deep Extragalactic Legacy Survey (CANDELS), as well as *Chandra*, *Spitzer*, and ground-based optical and radio observatories. In a recent paper, he analyzed the spectra of 317,000 galaxies from the Sloan Digital Sky Survey (SDSS) to determine the fossil record of SMBH seed formation and to investigate the impact of feedback—energetic jets from active galactic nuclei—on the disruption of star formation in galaxies. As a frequent user of the *HST* WFC3 grism, Jon looks forward to the commissioning of the NIRISS slitless spectrograph on *JWST*. This instrument will open a whole new frontier on dwarf galaxies by observing signatures of accretion onto the very first SBH and galaxies. Jon also eagerly anticipates the multi-object spectroscopic capabilities of *WFIRST* and Euclid.

Jon was a graduate of Penn State University, where he performed a Senior Project on SDSS quasars. He received his Ph.D. at the University of Arizona working with Chris Impey on "Supermassive Black Hole Activity in the Cosmic Evolution Survey." After a postdoctoral appointment at University of California, Santa Cruz, Jon has returned to Penn State for his *Hubble* Fellowship research. Jon has a long-standing love of math and physics and originally thought he would study particle physics. However, a fascinating seminar convinced him to try astrophysics. Although intrigued by theory, his love of working "from the mountaintop" made him an observer. An explorer by nature, Jon would like to be an astronaut. He was inspired by an early professor who answered the question "why astrophysics?" by saying, "we are humans, and this is what we do—think about our universe and our place in the natural order."

Jon enjoys being a father and has just welcomed his second child. He also loves hiking in the southwest and black powder/muzzle-loader hunting.

Since March, the COPAG Executive Committee (EC) has discussed two possible new SAGs—one to study the synergies between the upcoming operation of *JWST* and existing facilities in space and on the ground, and another to possibly reopen the study by SAG8 on the *WFIRST* archive now that *WFIRST* has entered Phase A. In both cases it was found that the existing communities are already engaged in extensive community interaction and definition towards both ends, and that any COPAG activities towards the same goals would be redundant. We did agree to revisit the *JWST* issue periodically to ensure that the needs of the Cosmic Origins community continue to be met.

As many of you are aware, NASA has now convened Science and Technology Definition Teams (STDTs) to study four possible large mission concepts as direct input to the 2020 Decadal Survey. The COPAG EC has reached out to all four groups to extend an offer of help and support as needed in their efforts to define the best missions possible. In addition, the EC has direct membership on three of the four, with SWG membership in the fourth. The EC continues to monitor the activities of all four teams to ensure the best interests of Cosmic Origins science are represented.

All four of the STDTs are now actively soliciting input from the community and in some cases membership in their various Science Working Groups (SWGs). We strongly encourage our members to investigate the areas of study these Teams are taking and to get involved and give your input where appropriate—it is only through our joint participation (where appropriate) that these studies will achieve the best solutions possible.

In late May and into June, the COPAG contributed input to the Annual Technology Report exercise that seeks to identify technology gaps in our capabilities as a community—this map is then used to shape funding opportunities to close those gaps looking into the next fiscal year. Our final input to the COR office was given in late June. However, the EC is currently studying the establishment of a new Technology Interest Group to help shape that input and its subsequent review each year to ensure an accurate and visionary product that will guarantee the implementation of our most innovative technologies to the compelling science we wish to achieve as a community. Stay tuned for more information on this new group.

We continue to have three active Science Interest Groups (SIGs). All of them will meet in January 2017 at the AAS meeting.

The COPAG EC will have several members rotating off at the end of the year, so please look for a new Dear Colleague letter from the COR office soon to solicit applications for membership. We welcome any interested members to step up and help us with our efforts to ensure the most compelling science is both fostered and enabled.

More information on the COPAG is available on the **website**.

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Cosmic Origins Organization

Program Office

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

Deputy Program Manager: Azita Valinia
azita.valinia-1@nasa.gov

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

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

Chief Technologist: Harley Thronson
harley.a.thronson@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

September 2016	SOFIA Third Generation Science Instrument selection announced
September 12–14, 2016	Linking Exoplanet and Disk Compositions, STScI Baltimore, Maryland
September 26–28, 2016	Mastering the Science Instruments and Observing Modes of JWST, ESAC, Madrid, Spain
October 17–20, 2016	The Local Truth: Galactic Star Formation and Feedback in the SOFIA Era – Celebrating 50 Years of Airborne Astronomy, Asilomar, California
October 24–26, 2016	Exploring the Universe with JWST meeting Montreal, Canada
November 3, 2016	*Hubble* Fellow proposals due
November 1–3, 2016	Mirror Technology Days, Greenbelt, Maryland
November 14–16, 2016	High Contrast Imaging in Space Workshop Baltimore, Maryland
November 15, 2016	Astrophysics Probe Concept Study proposals due
November 8–11, 2016	JWST Data Analysis Workshop, Baltimore, Maryland
November 9–11, 2016	LUVOIR / HabEx STDT meeting, New Haven, Connecticut
November 2–3, 2016	Far-IR Surveyor STDT meeting, Boulder, Colorado
December 2016	Explorers (MIDEX/SALMON) proposals due
January 3, 2017	COPAG meetings at AAS, Grapevine, Texas
January 20, 2017	SAT and APRA Notices of Intent due
March 17, 2017	SAT and APRA proposals due
April 2017	*Hubble* Proposals due
May 2017	JWST Proposal Planning Workshop, Baltimore, Maryland
June 2017	*Spitzer* proposals due
July 2017	SOFIA proposals due

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