National Aeronautics and Space Administration

Cosmic Origins Newsletter

September 2015 Volume 4 Number 2

Summer 2015 Cosmic Origins Program Update

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Welcome to the September 2015 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 2015, Paul Hertz (Director, NASA Astrophysics) asked the Program Analysis Groups (PAGs) for help as he begins planning for the 2020 Decadal Survey of Astrophysics and deciding which large missions should be studied in depth by NASA prior to the next Decadal Survey. The **article by Ken Sembach**, Cosmic Origins PAG (COPAG) chair, explains how the COPAG has involved the community, what they have learned, and how they are working with other PAGs in responding to this request. We strongly encourage all astronomers and astro-technologists to participate in this process, which will help shape the future of space astrophysics.

As part of the COPAG response to Dr. Hertz's request, the COR program has sponsored two community workshops, organized by two of the COPAG's Science Interest Groups (SIGs). The far-IR SIG sponsored a **Community Workshop on the Far IR Surveyor** possible large mission, and the UV/Vis SIG sponsored a community workshop on **Finding the UV/Visible Path Forward**, both in June 2015.

The COPAG has been busy in other areas as well. A new **SIG for Cosmic Dawn Science** was approved in April 2015. Two Science Analysis Group (SAGs) have completed their analysis and have produced very thoughtful reports, one on how **Spitzer observations now can enable future *James Webb Space Telescope* science** and one on **optimizing COR science using the WFIRST archive**.

We particularly encourage young researchers to participate in these community SIGs and SAGs, as they will be the primary users of many of the future observatories. We introduce **a *Hubble* fellow**, Dr. Jacqueline Faherty, who is currently working on studies of Brown Dwarfs, low mass objects that cannot sustain fusion and may be similar to giant exoplanets.

NASA's *Hubble Space Telescope* celebrated the 25th anniversary of its launch this past April. It continues to make scientific breakthroughs seem routine, and to collect stunning images of the Universe. In June, *Hubble* announced selections for its 23rd observing cycle. *Spitzer* has issued its 12th call for proposals, while SOFIA is evaluating responses to its 4th call for observing proposals. Further, SOFIA is requesting proposals for third generation instruments. We include highlights of a few recent science results in boxes throughout the newsletter.

Missions and studies not formally part of the COR program are also making good progress. 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 the possibility of **cleaning JWST mirrors with CO_2 snow**, should

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cleaning be needed. The *Wide-Field-Infrared Survey Telescope* (WFIRST) is soliciting members for Science Investigation teams; these teams will work with the study office over the next several years to refine the science requirements and technology drivers. Proposals (through NASA Solicitation and Proposal Integrated Review and Evaluation System (NSPIRES)) are due in October.

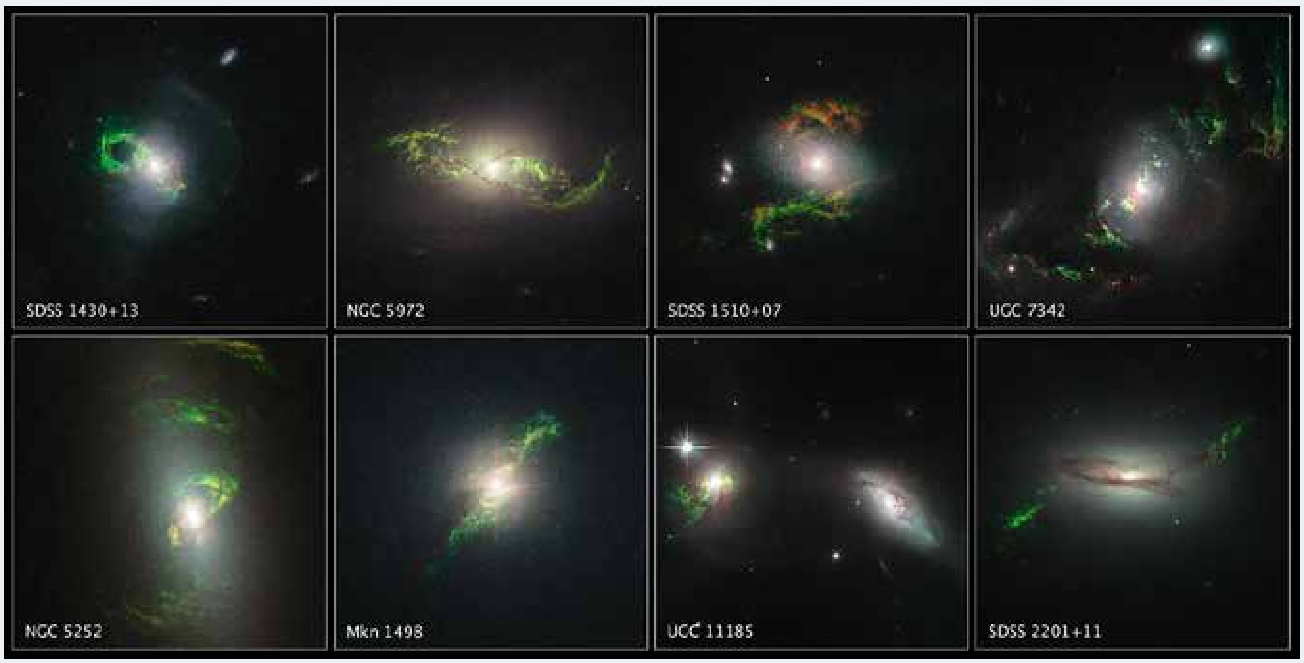
A key part of the COR Program is managing development of the technologies required for future COR discoveries. The Strategic Astrophysics Technology (SAT) program is designed to bring important technologies from proof-of-concept to a level of development that can be infused into flight missions. The community's input regarding the important technology gaps is extremely helpful in identifying the relevant technologies. We provide an **overview of this year's SAT selection process and results**, and the recommended technology priorities for next year's call. We also review **how Technology Readiness Levels are determined**.

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** flying an innovative multiplexing ultraviolet spectrograph that already has set new limits for the brightness of the intergalactic medium.

The COR program office has had several personnel changes in the past six months. In June, we welcomed Shahid Habib as the new COR Program Executive; he replaces Jeanne Davis. Dr. Habib

Hubble Sees Ghosts of Quasar Outbursts

Hubble has photographed a set of wispy, goblin-green objects: the ephemeral ghosts of quasars that flickered to life and then faded. The glowing structures have looping, helical, and braided shapes. "They don't fit a single pattern," said Bill Keel of the University of Alabama, Tuscaloosa, who initiated the *Hubble* survey.



Hubble images reveal greenish, photoionized oxygen emission around eight active galaxies. The ethereal wisps outside the host galaxies were blasted briefly by powerful ultraviolet radiation from a supermassive black hole at the core of each galaxy, tens of thousands of years ago. Image Credit: NASA, ESA, and W. Keel (Univ. of Alabama, Tuscaloosa)

The ethereal wisps outside the host galaxy were illuminated by powerful ultraviolet radiation from a supermassive black hole at the core of the host galaxy, which for now has faded. In the most active of these galaxies, quasars, infalling material is heated to a point where a brilliant searchlight shines into deep space.

The quasar beam causes once invisible filaments in deep space to glow, in green light, through a process called photoionization. Oxygen atoms in the filaments absorb light from the quasar and slowly re-emit it over many thousands of years.

The ghostly green structures are so far outside the galaxy that they do not light up until tens of thousands of years after the quasar outburst, and will likewise fade tens of thousands of years after the quasar fades. That's the amount of time it takes for the quasar light to reach them. "The quasars are not bright enough now to account for what we're seeing; this is a record of something that happened in the past," Keel said. The host quasars currently produce a fraction of the brightness needed to photoionize the gas.

The green filaments are long tails of gas pulled apart like taffy during a merger of two galaxies. Rather than being blasted out of the quasar's black hole, these immense structures, tens of thousands of light-years long, are slowly orbiting their host galaxy long after the merger was completed. Galaxy mergers can trigger quasar activity by pouring material into the central supermassive black hole. Variable infall rates result in quasar brightness changes; or pairs of co-orbiting black holes could power the quasars and lead to brightness variations.

Read the full story at **http://hubblesite.org/newscenter/archive/releases/2015/13/full/**

has extensive background managing Earth Science missions and related technologies. Kartik Sheth became Deputy Program Scientist in July, replacing Michael Garcia; his background is in optical, infrared, sub-mm, and radio astronomy, with an interest in galaxy evolution and star formation. Also in July, Steve Horowitz joined the COR Program as study manager for future large missions, with initial emphasis on ESA's L2 and L3 missions; he replaces Gerry Daelemans. Steve has been a Program Executive at HQ, and a mission manager in the Explorer Program. Tracy Parlate is now the COR Program Business Manager; she replaces Kevin Miller.

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Message from the Astrophysics Division Director

Paul Hertz, *Astrophysics Division Director*, NASA Headquarters

As fiscal year (FY) 2015 comes to a close, I would like to highlight some of our recent achievements and outline our plans ahead. As I described during the NASA Astrophysics Subcommittee meeting on July 21–22, 2015, NASA is making progress toward achieving the goals set by the National Academy of Sciences in its 2010 Decadal Survey, *New Worlds, New Horizons in Astronomy and Astrophysics*.

• Our operating missions continue to take critical observations that lead to compelling scientific discoveries. For example, in the area of exoplanets alone, the *Kepler* mission, which re-invented its science program in 2014 under the name K2, observed Neptune continuously for 75 days with sufficient photometric precision to probe its internal structure through global surface oscillations; the *Spitzer Space Telescope* observed a microlensing event of a star-plus-planet that was also observed from the ground by the OGLE consortium, the observed parallax between *Spitzer* and the Earth allowed both the mass and the distance of the lensing planet to be determined; *Kepler* mission data has yielded a mass measurement of a Mars-size exoplanet that is about one tenth the mass of the Earth.

• SOFIA completed its second southern hemisphere deployment, and the first one to involve multiple instruments, after successfully executing scientific observations including a stellar occultation by Pluto that yielded atmospheric data supporting the New Horizons flyby.

• Three new Small Explorer missions, SPHEREx (PI James Bock, Caltech), IXPE (PI Martin Weisskopf, MSFC), and PRAXYs (PI Keith Jahoda, GSFC), and two Missions of Opportunity, the ultralong duration balloon payload GUSTO (PI Christopher Walker, U. Arizona) and U.S. Participation in the LiteBIRD Cosmic Microwave Background Polarization Survey (PI Adrian Lee, U.C. Berkeley), were selected in July 2015 for Phase A mission concept studies.

• The Senior Review of the NASA Astrophysics Archives, held in May 2015, gave a strong endorsement to all the archives and provided a thoughtful evaluation to guide their forward planning. The report of the Astrophysics Archives Senior Review is available at **http://science.nasa.gov/astrophysics/documents/**.

• JWST continues to make technical progress during its integration and test phase according to its plan. The start of the primary mirror assembly is on track; the telescope backplane arrived at Goddard Space Flight Center in August 2015. The daily progress on integrating the mirror segments into the flight telescope backplane can be observed on the WebbCam at **http://jwst.nasa.gov/**. JWST remains on cost and on schedule for an October 2018 launch.

• Proposals submitted to the Science Education Cooperative Agreement Notice solicitation have been reviewed and a decision on the re-organized Science Mission Directorate education program is expected by the end of September 2015.

• NASA funded scientists continue to be internationally recognized for their achievements through prestigious awards such as the 2015 Shaw Prize awarded to Dr. William Borucki (NASA Ames Research Center) for leading the *Kepler* mission and his contribution to Exoplanet science, and the Astronomical Society of the Pacific's 2015 Klumpke-Roberts Award to Robert Nemiroff (Michigan Tech) to Jerry Bonnell (NASA Goddard Space Flight Center) for outstanding contributions to public understanding and appreciation of astronomy for their work on the Astronomy Picture of the Day.

• On the personnel front, during 2015 we bade farewell to visiting scientists Drs. Larry Petro, Glenn Wahlgren Debra Wallace, and Eric Tollestrup, who completed their assignments under the Intergovernmental Personnel Act (IPA). We welcomed two new civil servant hires, Drs. Kartik Sheth and Daniel Evans, who joined the Astrophysics Division at NASA Headquarters this summer.

Our next major challenge is supporting the review of progress toward the Decadal Survey Vision in *New Worlds, New Horizons in Astronomy and Astrophysics* being conducted by the National Academy of Sciences. The committee has been appointed and is chaired by Jacqueline Hewitt (MIT); the Committee's membership and meeting schedule will be available at **http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_161177**.

In preparation for the 2020 Decadal Survey, our Program Analysis Groups (PAGs) have been busy gathering community input for potential large mission concept studies. They have held a series of workshops through the year including one at the International Astronomical Union General Assembly, Honolulu HI, in August 2015. We expect to announce a path towards mission concept studies in support of the 2020 Decadal Survey at the NASA Town Hall during the January 2016 American Astronomical Society meeting in Kissimmee, FL. The presentations and white papers from all of these workshops, including my presentation at the IUA General Assembly, may be found at **http://cor.gsfc.nasa.gov/copag/rfi/**.

My entire Astrophysics Subcommittee presentation from the July 2015 meeting is available at **http://science.nasa.gov/science-committee/subcommittees/nac-astrophysics-subcommittee/**

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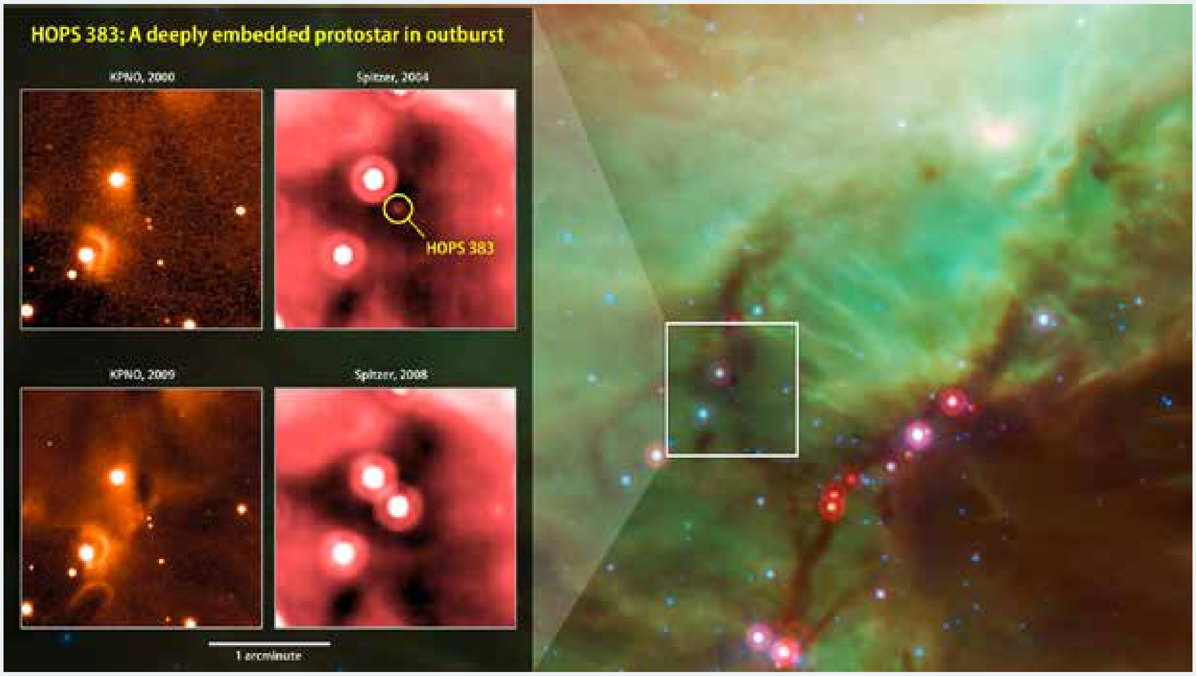
Spitzer Catches a 'Growth Spurt' from Newborn Protostar

With data from *Spitzer*, WISE, *Herschel*, and ground-based facilities, astronomers have discovered the sudden, unprecedented brightening of HOPS 383, an exceptionally young protostar.

Stars form within protostellar envelopes embedded in collapsing fragments of cold gas clouds. As an envelope contracts under its own gravity, the infalling material feeds a dusty circumstellar dusk, which then accretes onto the newly forming central protostar. At the earliest times, when the star has yet to accumulate half of its expected final mass, astronomers call the system a Class 0 object. Outbursts like the one seen in HOPS 383, a Class 0 object, are likely due to instabilities in the circumstellar disk that generate clumpy structures. When a clump falls into the star, gravitational energy is converted into luminosity, and the system brightens dramatically. The HOPS 383 event will help astronomers understand planet-forming disks at their earliest stages of evolution.



Infrared images from instruments at Kitt Peak National Observatory (left) and NASA's Spitzer Space Telescope document the outburst of HOPS 383, a young protostar in the Orion star-formation complex. Credit: E. Safron et al.; background: NASA/JPL-Caltech/Univ. of Toledo

"HOPS 383 is the first outburst detected in a Class 0 object, suggesting it is the youngest protostellar eruption ever recorded," said Will Fischer, a NASA Postdoctoral Program Fellow at GSFC and member of the discovery team.

Infant suns are thickly swaddled in gas and dust so their visible light cannot escape, but the light warms circumstellar dust that reradiates the energy at infrared wavelengths.

Undergraduate researcher Emily Safron first recognized the eruption of HOPS 383 in 2014. Her senior thesis at the University of Toledo compared 2004–2008 *Spitzer* observations of Orion to 2010 observations from WISE, obtained at similar wavelengths, to search for protostellar variability. For HOPS 383, the first hint of brightening appeared in 2006 *Spitzer* images. By 2008, HOPS 383's brightness at 24 microns had increased by a factor of 35. According to the most recent data available, from 2012, the eruption shows no sign of abating.

Read the full story at **http://www.spitzer.caltech.edu/news/1736-feature15-02-NASA-Satellites-Catch-a-Growth-Spurt-from-a-Newborn-Protostar**

Cosmic Origins Program Analysis Group (COPAG) Update

Kenneth Sembach, STScI, *COPAG Chair*

The COPAG's main focus for the past six months has been to respond to NASA Astrophysics Division Director **Paul Hertz's January 2015 charge**.

Dr. Hertz presented plans to study a small set of large mission (>$1B) concepts in preparation for the 2020 Decadal Study of Astronomy and Astrophysics.

Three of the four missions on Dr. Hertz's short list are drawn from the **2014 Astrophysics Visionary Roadmap** and the fourth from the 2010 Decadal Survey recommendations. These are: 1) a Far-Infrared Surveyor, 2) a Habitable Exoplanet Imaging mission, 3) a UV/Optical/IR Surveyor, and 4) an X-ray Surveyor. Note that in this context the word "Surveyor" does not necessarily imply that the observatory works in survey mode, rather this is the term for future missions adopted in the Astrophysics Visionary Roadmap. As a first step, Dr. Hertz asked the PAGs to canvass their communities to concur (or not) with his short list of possible mission studies. A second phase of activities will develop the science cases and a mission concept for each of the possible missions.

The COPAG has been hard at work on the first step—soliciting and reporting on the community's response to the initial list of missions. In March, the COPAG Executive Committee (EC) sponsored a joint meeting of the COPAG, PhysPAG, and ExoPAG Executive Committees to discuss areas where the PAGs were in agreement and areas specific to each individual community. The COPAG EC **solicited short white papers from the community** describing key science questions and requisite technical capabilities for future "flagship" missions. The COPAG EC has sponsored two Virtual Town Halls, first to introduce the COPAG's plans (March) and sec-

Seeking new COPAG
Executive Committee nominations!
Due September 4th.
Please see announcement on
http://cor.gsfc.nasa.gov/news/ec-nominations.php
for more details.
Self nominations encouraged!

ond to report their findings (August). Two of the COPAG's Science Interest Groups (SIGs) held community face-to-face workshops to discuss the charge and draft responses to it (reports below). All three PAGs reported on their findings at the August meeting of the International Astronomical Union (**IAU Joint PAG agenda and talks**). COPAG EC members participated in workshops sponsored by the other PAGs to better understand those communities' responses to the charge, and to identify common ground between the PAGs. The report from the COPAG is being written now, and will be posted on the COPAG website for public comment in September. The final report will be submitted to the Astrophysics Subcommittee in early October.

The COPAG has found that the cosmic origins community generally supports the four missions proposed by Dr. Hertz for study. The community does not favor studying other missions or dropping any of the four suggested missions. It appears that the other PAGs have found the same result. The community has expressed a wide range of opinions on what these missions might look like, and a strong interest in making sure that the Science and Technology Development Teams (STDTs) assembled in the second phase of this process are composed of technical and scientific experts competitively selected through a free and open selection process.

The COPAG has also found that the community believes cosmic origins science will require access to flagship-class space missions to make major advancements over present or planned facilities. Flagship-class space missions will be required for NASA space science to remain scientifically competitive with, and complementary to, ground-based Extremely Large Telescopes (ELTs) at optical/IR wavelengths in the 2020s and 2030s.

In other COPAG news, a **Science Interest Group for Cosmic Dawn Science and Technology** has been started—it will be chaired by Joe Lazio. For further information, or to join the SIG, contact Joe Lazio. Two of the COPAGs Science Analysis Groups have completed their work and submitted their reports to the APS, as described below.

The COPAG will have a community meeting at the January 2016 AAS in Kissimmee, Florida. All interested members of the community are, by definition, members of the COPAG. Please plan to join us there, on Monday, January 4, where we will discuss future plans and learn about the next step in planning for the 2020 Decadal Study.

More information about COPAG activities can be found on the COPAG website at **http://cor.gsfc.nasa.gov/copag/**

You can send us your thoughts at **COPAG_Contact@bigbang.gsfc.nasa.gov**

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UV/Vis SIG Community Workshop: Finding the UV-Visible Path Forward

Paul A. Scowen, Arizona State University, *SIG#2 Chair*

The UV/Vis SIG held its first face to face workshop to consider a variety of discussion topics that had been developing since our opening meeting in Seattle in January. The workshop was attended by nearly 100 scientists and technologists both in person and online as we continued work performed in the run-up to the meeting. Breakout sessions were held for the four subcommittees in the SIG:

- Next generation UV-visible science
- Enabling technologies for the UV-visible from space
- The range of mission sizes that could enable UV-visible science
- Understanding how Flagship-class missions could benefit UV-visible science

The session chairs reported back to the workshop attendees on the second day to summarize what had been discussed. The workshop also took time on the second day to discuss the question of Flagship-class missions identified by NASA SMD for further analysis, and whether there was support for those mission concepts. The particular missions that were relevant to our discussions were the UVOIR Surveyor and the Habitable Exoplanet Imaging Mission—both were supported by the SIG for additional study using STDTs and that recommendation was subsequently sent up to the COPAG for submission to NASA.

The SIG membership will be continuing the work reported at the workshop with a report on the findings and discussions to be published in the near future, and the possibility of a second workshop next year. Our goal is to define a vision for the future development of this passband from space to be input to the 2020 Decadal Survey. We welcome your involvement.

Workshop presentations and reports are available online at **http://asd.gsfc.nasa.gov/conferences/uvvis/**

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Far-IR SIG Community Workshop: The Far-IR Surveyor

Lee Armus, Caltech/IPAC, for SIG#1

A community workshop was held from 3 to 5 June 2015 in Pasadena, California to help define key science drivers and leading architecture for a FIR Surveyor. Approximately 150 members of the far-infrared community, from over 40 institutions worldwide, attended the workshop either in person or via WebEx.

The workshop consisted of invited science presentations covering Galactic star formation, protostellar disks, debris disks, astrochemistry, planet formation, nearby galaxies, AGN and starburst galaxies, the early universe, and large-scale structure. In addition, there were presentations describing the two leading FIR Surveyor architectures (described below), synergies with other space-borne and ground-based facilities that would be operating in the 2020s, and key far-infrared detector, cryocooler, and telescope technologies. Science breakout groups (solar system and planetary formation, nearby galaxies, the Milky Way, and the early Universe) discussed key science questions and themes that will drive the requirements for the FIR Surveyor. The summaries from these groups were discussed in plenary sessions at the end of each day. Breakout group summaries and general discussions became integral parts of the workshop report. The workshop overview, as well as presentations and supporting documentation are available online at: **http://conference.ipac.caltech.edu/firsurveyor/**

Two leading architectures for the FIR Surveyor were identified before the workshop: a direct detection, cryo-cooled double-Fourier interferometer; and a large, wide-field cryo-cooled single-aperture telescope. Both platforms provide the capability for sensitive imaging and spectroscopy in the far-infrared. During the second day of the workshop, a straw poll was conducted of the participating US scientists. The clear outcome strongly favored a large, filled-aperture telescope as the architecture best suited to addressing the key science questions of the 2020s and 2030s. Parameters envisioned for the FIR Surveyor mission include:

- telescope temperature of < 4K, actively cooled
- telescope diameter ~ 5m, potentially off-axis
- telescope field of view ~1 degree at 500 microns
- total number of detectors is 1–5 × 10^5
- wavelength coverage of 25–400 microns, with possible extension to ~800 microns.
- instruments include wide field, broad-band R~500 imaging spectrometers, high-resolution (R~300,000) spectrometers, and continuum cameras potentially with polarization capability.

Please join us at future meetings.

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COR Science Enabled by the WFIRST Archive

Sally Heap, GSFC, for Science Analysis Group 8

The WFIRST-AFTA mission concept is designed to address all three questions in all three of NASA's astrophysics themes: Physics of the Cosmos, Cosmic Origins, and Exoplanet Exploration. This report responds to a charter from Cosmic Origins Program Analysis Group (COPAG) directing COPAG Science Analysis Group (SAG) #8 to analyze how the WFIRST archive is to be used and to scope the data requirements necessary to conduct science investigations related to the Cosmic Origins theme. It is to describe what data, high-level science data products, and catalogs will be available in the WFIRST-AFTA archive; what data processing is required to produce these data products; and how scientists can identify and access the data of interest.

The report is divided into four sections:

- Section 1 provides an introduction to the report.
- Section 2 comprises excerpts from the WFIRST-AFTA 2015 Report describing Cosmic Origins science (a.k.a. General Astrophysics) that can be accomplished with data obtained from WFIRST's High-Latitude Surveys (HLS) and the Galactic Bulge Field.

The section also highlights Cosmic Origins science as described by potential Guest Investigators (GIs) using WFIRST-AFTA data and Guest Observers (GOs) who will make new observations of specific targets.

- Section 3 briefly describes the data that will be obtained in each of the three High Latitude Surveys (Wide-Area Imaging for Weak Lensing, Wide-Area Spectroscopy for the Galaxy Redshift Survey and Galaxy clustering, the Supernova Field) and Wide-area imaging of the Galactic Bulge. It then goes on to describe the data processing of each of these types of observing programs and to give a (incomplete) list of online "catalogues" that will be produced.

• Section 4 then describes how WFIRST-AFTA data, high-level science products, and catalogues can be found and accessed through querying the WFIRST-AFTA archive.

This report is posted at **http://cor.gsfc.nasa.gov/sags/CO-PAG_SAG8_Report_16Jul2015.pdf**

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COR Science Enabled by Spitzer Observations Prior to JWST Launch

Daniela Calzetti, UMASS, for Science Analysis Group 9

The SAG9 was tasked with identifying compelling science cases for JWST that would benefit from large blocks of observing time with the *Spitzer* Space Telescope prior to the JWST launch. The SAG9 has produced a number of science cases, listed in the Report, which take into account inputs from the broader astronomical community, and attempt to not duplicate the vast holdings already present in the *Spitzer* Heritage Archive. Three main findings have emerged from this analysis:

(1) dedicated *Spitzer* observations would significantly reduce the current uncertainty in the zodiacal dust contribution to the Cosmic Infrared Background and improve the stray light model for JWST;

(2) *Spitzer* still offers unique capabilities in a number of science areas, including, but not limited to, the ability to produce priority lists of newly discovered extra-solar planets for JWST follow-up; enabling unique science to come to fruition may require extending the *Spitzer* mission; and

(3) an ad-hoc committee may be required to evaluate whether observationally- and resource-demanding programs (e.g., requiring multiple years of *Spitzer* observing time) may provide a lasting Legacy for the community for future JWST science.

The full report can be found at **http://cor.gsfc.nasa.gov/sags/SAG9_Report_v5.pdf**

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JWST Status and Progress

Susan Neff, *COR Chief Scientist*

The *James Webb Space Telescope* (JWST) is on schedule for launch during 2018. Once launched, it will be a key component of the Cosmic Origins (COR) portfolio. JWST will enable transformational capability for COR Science, and fundamental to the continued advance of many other astrophysics fields of study. JWST development is going well, and is on time and on budget.

During March, detectors and new microshutter arrays were installed in the Near Infrared Spectograph (NIRSpec), and new IR detectors were installed in the Near Infrared Camera (NIRCam). Both instruments were reinstalled in the Integrated Science Instrument Module (ISIM) in April. During June, vibration testing of the ISIM was successfully finished. In July, the flight cryocooler. a crucial assembly for the Mid-Infrared Instrument (MIRI), was delivered to JPL for acceptance testing.

On the telescope side, during March the Primary Mirror Backplane Support Structure was integrated with the Secondary Mirror Support. In May, the JWST Pathfinder completed testing of the Optical Ground Support Equipment (OSGE) in Chamber A at Johnson Space Center; a second OGSE test is planned for October. During June, the telescope backplane structure was completed, including connection to the deployable tower assembly (connects the telescope structure to the spacecraft, and separates the telescope from the sunshield). In July, flight mirror metrology tests were conducted, to enable calculation of the shim size for mounting each mirror onto the mirror backplane. In late August, the flight backplane structure arrived at GSFC.

Major activities in the near future include the October cryo-vacuum test of the ISIM, the installation of flight mirrors onto the backplane, and the next test of the OSGE in Chamber A at JSC.

Below, we describe an investigation into cleaning JWST mirrors with CO_2 "snow," which will allow cleaning the mirrors, should any dust or other contamination affect the optics during integration and testing.

(Left and center) The JWST Pathfinder prepares for a fit-check in Johnson Space Flight Center's Chamber A, in April 2015. It cleared the chamber door by 8 inches. Image credit: Chris Gunn, (Right) The JWST Pathfinder backplane test model is prepared for its cryogenic test in Chamber A at Johnson Space Center in Houston. This was the first time two mirror segments were aligned together, as part of a larger optical surface. The test was successfully completed in May.

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**, and in the "Webb Update" (newsletter): **http://jwst.nasa.gov/newsletters.html**

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Can the JWST Primary Mirror be Cleaned Prior to Launch?

Eve Wooldridge, GSFC, *JWST Contamination Systems Lead*

This is the burning question for a mirror that is made up of 18 hexagonal, 1.1 m mirror segments. Rarely do optics get cleaned after they are integrated on an observatory, however, because such a large portion of work is done with the mirrors exposed, it is important to have a cleaning procedure in place. CO_2 "snow" is the method of choice because it is a non-contact method that is used frequently at ground-based large observatories. However, unlike observatories where the large monolithic optics can be removed for cleaning, JWST's primary mirror is made up of 18 segments with gaps between them and an instrument module behind it. They are aligned and tested and cannot be removed. CO_2 snow cleaning will need to be tested for best performance on the mirrors themselves, but also to understand condensation or other effects on the back side. As the picture shows, the spray disperses widely. Unfortunately, for this reason, it is unlikely that snow cleaning can be used on the pick-off mirrors because they are in a confined space with the instruments surrounding them, aligned and ready for their final cryo-vac test.

Jim Collins of Harris, the company that calibrates and integrates the JWST Optical Telescope Element, developed the protocol for JWST. He focused on the unknown variables for the primary mirror configuration: condensation, coating degradation, particle redistribution, electrostatic discharge (ESD), and cleaning effectiveness. The photo shows a demonstration on the Subscale Beryllium Mirror Demonstrator (SBMD), which has the same coating as the flight primary mirror segments. The next test planned will be on the Engineering Development Unit mirror segment, which is a flight back-up segment for the primary mirror mounted to the Pathfinder backplane. This testing will demonstrate whether CO_2 snow cleaning can be safely used in the primary mirror's final configuration: mounted to the backplane. This test is expected to take place in late 2016, after Pathfinder testing at Johnson Space Center is completed. If that test is successful, JWST would be ready to clean the primary mirror, if needed, within a few months of launch.

Test of the cleaning on the SBMD mirror on January 22, 2015. Bill Ryan of Harris performs the procedure with Jim Collins and Matt Magsamen looking on.

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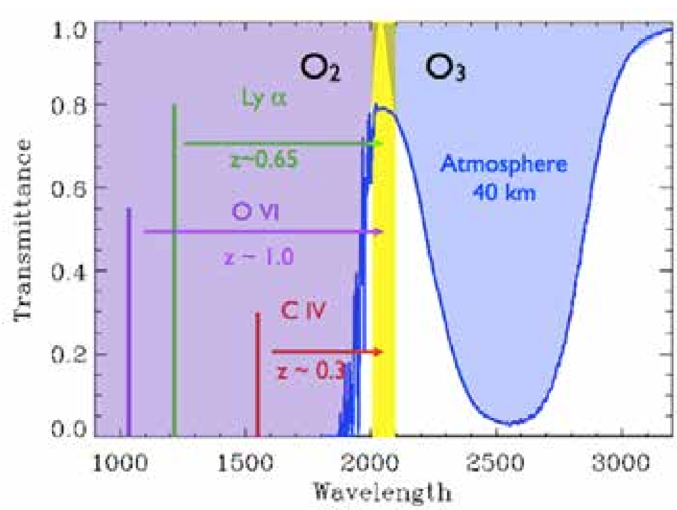
Cosmic Origins Suborbital Program: Balloons—FIREBall

Susan Neff, *COR Program Scientist*

NASA's scientific discoveries result from access to space (freedom from atmospheric attenuation) and new observational capabilities. Instruments developed as balloon or sounding rocket payloads have been precursors to most of NASA's astrophysics missions. The suborbital program allows flexibility, short development timescales, and fast access to space. Suborbital programs provide an opportunity to demonstrate and 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 projects relevant to Cosmic Origins.

The Faint Intergalactic medium Red-shifted Emission Balloon (FIREBall) experiment (PI Chris Martin, Caltech; Institutional PI David Schiminovich, Columbia University; Project Scientist Erika Hamden, Caltech) is a cooperative effort with France's Laboratoire Astronomie Marseille/CNES (Lead Investigators: Bruno Milliard/ Robert Grange). The mission was designed to discover and map faint emission from the Intergalactic Medium (IGM). Most previous work on the IGM has used absorption against background bright point sources. FIREBall uses strong resonance *emission* lines of HI Lyα (1216Å), OVI (1033Å), and CIV (1549Å), which have been redshifted into the stratospheric window between 1950–2260Å.



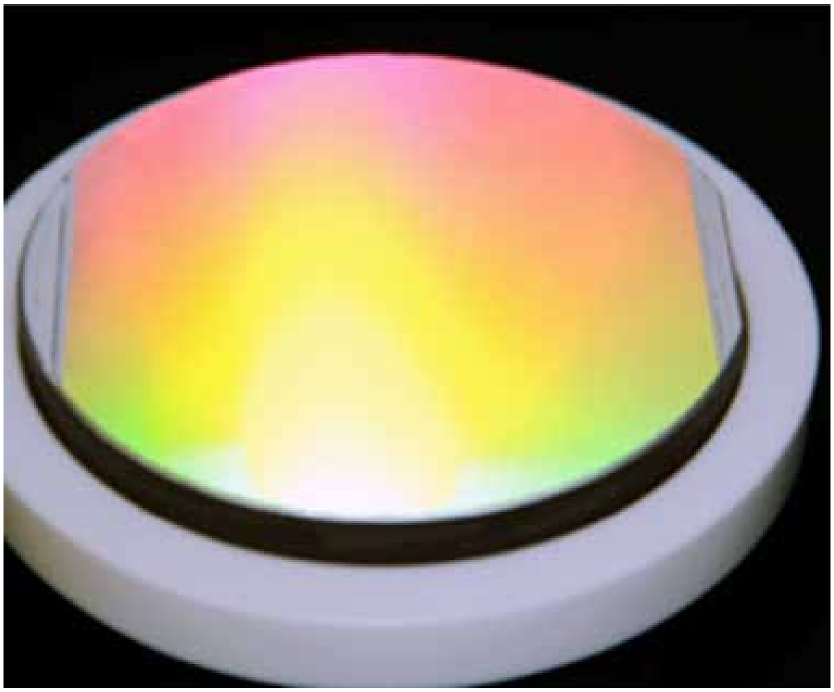
*FIREBall observes redshifted emission lines in a narrow Near-UV atmospheric window at 1950–2260*Å.

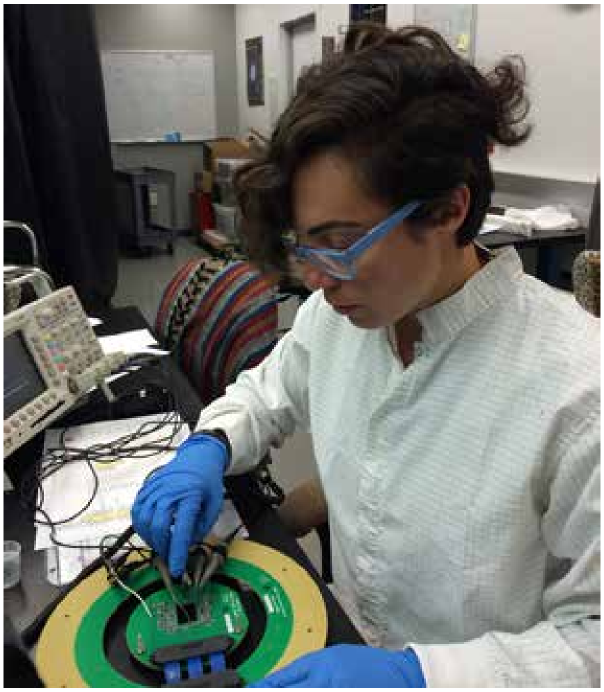
FIREBall-1 used a 1m primary mirror with an innovative mounting system to feed an ultraviolet Integral Field Unit (IFU) spectrograph. The spectrograph used 281 fused silica fibers to cover a hexagonal 2.3 arcmin field of view. For the first FIREBall flight, the detector was a GALEX spare microchannel plate (MCP) Near-UV device. Graduate students Sarah Tuttle, Matt Matuszewski, and Shahinur Rahman fabricated and integrated the spectrograph and the fiber bundle, designed and built the fine guidance system, and developed the flight electronics and software. Several Columbia undergrads were involved in the fiber bundle and spectrograph development.

FIREBall-1 initially observed known regions of large-scale structure to maximize chances of detection both directly and through statistical stacking. FIREBall-1 made a successful engineering flight in July 2007, from Palestine, Texas. The first scientific flight was in June 2009, from Fort Sumner, New Mexico, in suboptimal conditions. Although the balloon flew at a lower than desired altitude due to poor weather conditions, thus reducing the atmospheric transparency during flight, the payload performed flawlessly. Science observations were able to place meaningful new limits on the physical conditions in circumgalactic gas and in intergalactic filaments, as well as constraining gravitational energy dissipation and mechanical energy deposition in the IGM.

The team is now working on an improved FIREBall-2 payload. FIREBall-2 uses the same gondola and large optics as FIREBall-1, but has completely redesigned the spectrograph to increase overall throughput significantly. FIREBall-2 will use a low-noise, high QE, UV-optimized, electron-multiplying (photon counting) CCD as a detector (S. Nikzad, JPL), increasing UV throughput by a factor of 10. Red-blocking coatings on the spectrograph optics will minimize out of band light. FIREBall-2 will also use an Integral Field Unit with slit masks capable of observing up to 50 targets per field, rather than a fiber bundle. A new grating (designed and manufactured in France) acts as a Schmidt corrector for the wide-field telescope. Graduate students Nicole Lingner, Jose Manuel Zorrilla, and Lauren Corlies have been involved in building detector electronics, guider electronics, spectrograph mask design and testing, and flight and science analysis software. Postdocs Erika Hamden, Gillian Kyne, and April Jewell (JPL) have worked on detector performance testing, detector fabrication optical coatings, and vacuum test systems. The spectrograph will be integrated and tested in Marseilles France this fall. Final integration and testing of the full

Preparing to launch FIREBall-1 from Fort Sumner, NM





(Left) FIREBall-2 imaging grating with coating serves as an image corrector for the wide field telescope. (Right) Project Scientist Erika Hamden checking FIREBall-2 flight electronics before vacuum testing.

payload will occur in the field, and the payload is expected to fly in early/mid-2016 from Texas or New Mexico.

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COR Strategic Astrophysics Technology (SAT) Update and 2015 Selections

Mario R. Perez, *COR Program Scientist*, NASA HQ
Kartik J. Sheth, *COR Deputy Program Scientist*, NASA HQ

In the rest of the decade, the Astrophysics Division expects to conduct several mission concept studies that will explore the nature of the universe at its largest scales, its earliest moments, and its most extreme conditions. These missions will study how clusters of galaxies, active galactic nuclei, stars and planets orbiting other stars are formed and evolved to shape the universe we experience nowadays. The mission concept studies will mature technology components, architectures and science cases that will be prioritized by the upcoming 2020 Decadal Survey.

However, as compelling as these future missions may be, implementing them presents daunting technological challenges. The main obstacles to reaching the next level of astrophysics measurements are technological in nature; proper investments in these engineering areas could provide significant advancements. The continuous funding of the SAT program, which supports the maturation of key technologies (3 ≤ Technology Readiness Level < 6) to the point at which they are feasible for implementation in space flight missions, is a positive step towards achieving mature components, retiring technological risks and paving the way to more ambitious missions.

Given the limited funds available for SAT maturation, the scope of this program is focused on the advancement of those technologies judged to be most critical to making substantive near-term progress on the recommendations of the 2010 Decadal Survey and the Astrophysics Implementation Plan (AIP, December 2014).

For the COR component of SAT, recently announced selections represent the fourth full cycle of this program. Eleven investigations have selected recently (3 in 2011, 5 in 2012, 3 in 2013, and none in 2014). In 2015 we have added four more selections, listed below:

Title	PI	Institution
Building a Better ALD—Use of Plasma Enhanced ALD to Construct Efficient Interference Filters for the FUV	P. Scowen	ASU
Development of Large Area (100 × 100 mm) photon counting UV detectors	J. Vallerga	UCB
Advanced FUVUV/Visible Photon Counting and Ultralow Noise Detectors	S. Nikzad	JPL
Raising the Technology Readiness Level of 4.7-THz local oscillators	Q. Hu	MIT

The four investigations represent two of the three areas explicitly requested in the NRA for Cosmic Origins: Next Generation Detectors and Optical Coatings. The new selections will be actively managed by the COR Program's Technologists, who closely monitor progress, evaluate milestones and validate TRL advancements.

All the proposals submitted this year presented innovative solutions and promised substantial advancements. Unfortunately, due to limited funding, only a few proposals could be selected. Members of the community are strongly encouraged to keep applying to the COR SAT solicitations, as we are optimistic that additional funding may become available toward the end of the decade. For the next SAT proposal opportunity, Notices of Intent to propose (NOIs) will be due on 22 January 2016, and proposals will be due on 18 March 2016.

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TRL Vetting by the COR Program Office

Thai Pham, *COR Program Technology Manager*
Opher Ganel, *COR Program Technologist*

The Cosmic Origins (COR) and Physics of the Cosmos (PCOS) Program Offices (POs) manage the strategic technology development process for these NASA Astrophysics Division programs. Through the Strategic Astrophysics Technology (SAT) program, the Astrophysics Division invests in maturing technologies expected to enable and/or significantly enhance future strategic astrophysics missions. These technologies typically enter the SAT program at Technology Readiness Levels (TRLs) of 3–4, and are intended to progress toward higher TRLs, typically up through 5, after which they would be supported by a flight project if selected for flight insertion.

Why review TRLs?

TRLs are used throughout the agency to help assess the maturity of technologies. The PO's charge includes a requirement that it monitor the progress of the Astrophysics Division's investments in technology maturation through SAT projects, relative to the TRL plan and milestones submitted by the principal investigator (PI) in the SAT proposal. A key indicator of such progress is TRL advancement as vetted by the PO, providing a consistent method of assessing progress across our full portfolio of projects.

What does our vetting mean?

When the Program's Technology Management Board (TMB) approves or vets a new, higher TRL asserted by the PI, this provides an independent assessment and verification that the project has achieved that TRL. The TMB consists of scientists, technologists and system engineers from the Program, and subject matter experts from the community and Aerospace Corporation, who provide an objective and informed assessment. The primary purpose for issuing this assessment is to inform the PO of significant progress in preparing the technology for possible inclusion in strategic missions. It also informs the PI and the science community of the improved state of readiness.

What is expected?

The TRL vetting process is initiated when a PI notifies the PO that the milestones necessary for TRL advancement have been met. The PI then presents the progress to a TMB convened by the PO, which considers the TRL assertion as guided by TRL definitions in NASA Systems Engineering Processes and Requirements, also known as NASA Procedural Requirements (NPR) 7123.1B. Recognizing that PI teams are busy and must concentrate their efforts on the actual work of maturing their technology, the PO is satisfied to rely on a cogent exposition of the same reports, graphs, and test results the PI team captures for its own records.

The PI team should prepare a brief but compelling presentation, making the case for the higher TRL. The PO has tools to help PIs assess their progress and is available to provide information on the TRL process. Finally, if the project is still ongoing, we recommend the PI present a plan for further TRL advances, if any, allowing the TMB to offer feedback and make recommendations.

What are the benefits for the PI and the Program?

The same presentation materials and supporting evidence provided to the TMB by the PI team could help make the TRL case to flight projects or proposal teams considering adding the technology to their mission. Another leveraging opportunity might be in collaboration opportunities.

The PO's TRL vetting process serves as an opportunity to collect and capture the needed documentary evidence and present it to a group of experts. This can strengthen a potential future presentation, whether in person or in writing, to flight projects and/or proposal reviewers.

As alluded to above, the TMB can help the PI team fine-tune their plan for future work needed for achieving the claimed TRL if the current claim was not vetted, or for the next TRL if it was.

Finally, TRLs are NASA's technology development assessment language, and TRL advancement is one of the key success criteria for SAT projects and the entrance gate for adoption into flight projects. Our TRL vetting is an objective process, rendering an independent verification of achievement, increasing the credibility of the technology's maturity and its potential for continued funding or injection into a flight mission.

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"Beyond JWST" Study—AURA

Jason Tumlinson, STScI, for the HDST Team

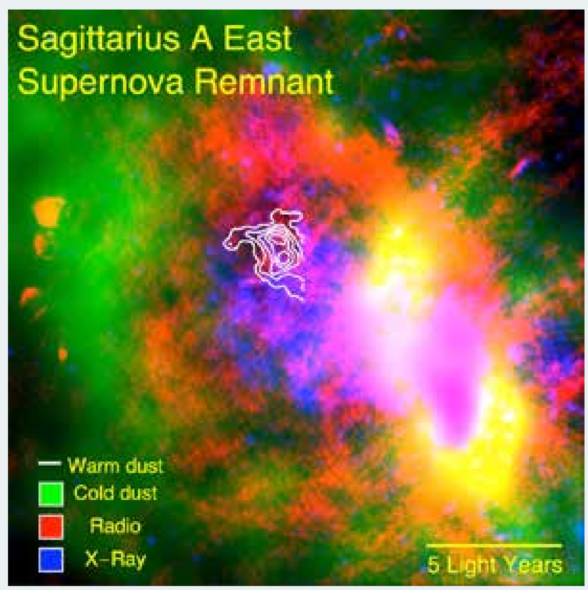
Editor's note: We believe this study is highly relevant to future COR science, and therefore of interest to the COR community. However, it is not part of NASA's COR program, nor is it endorsed by the COR program.

The Associated Universities for Research in Astronomy (AURA) recently published its report "From Cosmic Birth to Living Earths: The Future of UVOIR Space Astronomy." The report envisions a "High-Definition Space Telescope" (HDST) for the decade of the 2030s. The study, co-chaired by Julianne Dalcanton (Uniersity of

SOFIA Reveals Supernova Dust Factory at Galactic Center

What is the origin of large quantities of dust in early galaxies? The answer to this question is key to understanding galaxy evolution in the young universe. Using the Faint Object InfraRed Camera for the SOFIA Telescope (FORCAST) instrument on SOFIA, an international scientific team has shown that supernovae are capable of producing, and retaining, a substantial amount of the material from which planets like Earth can form.

"A … cloud produced by a supernova explosion 10,000 years ago contains enough dust to make 7,000 Earths," said Ryan Lau of Cornell University in Ithaca, New York. The research team, headed by Lau, obtained detailed infrared images of an interstellar dust cloud known as Supernova Remnant Sagittarius A East, or SNR Sgr A East. The total mass of dust in the cloud was estimated from the intensity of its infrared emission. Measurements at long infrared wavelengths were required to peer through intervening interstellar clouds and detect the radiation emitted by the supernova dust.

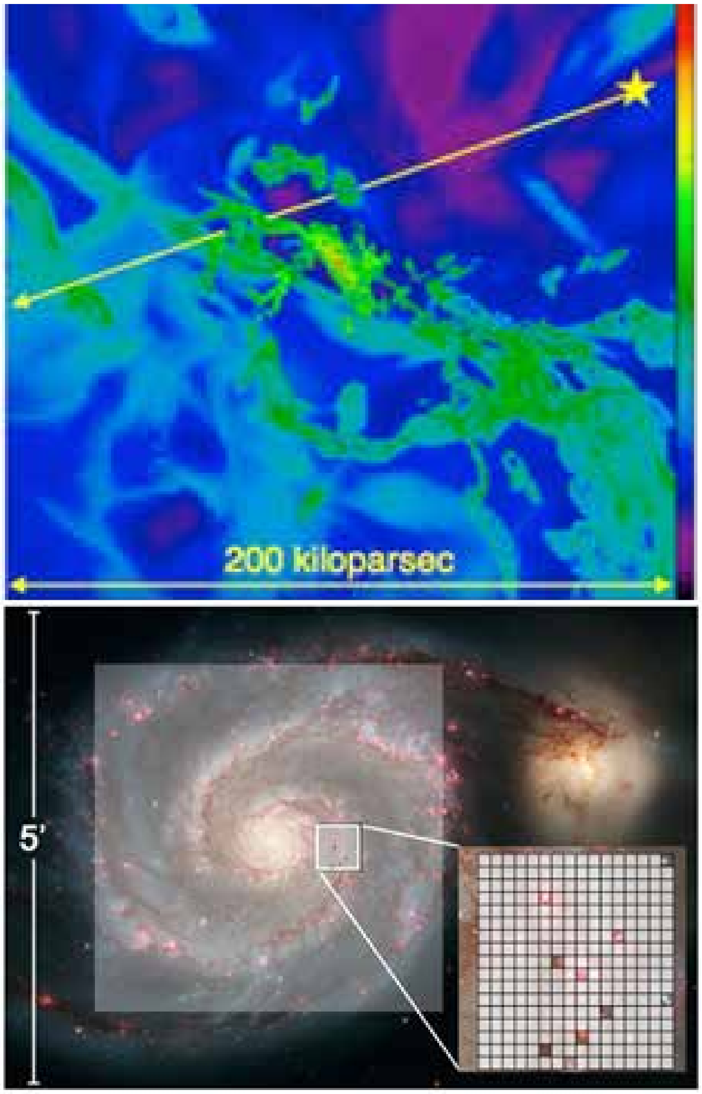


SOFIA 31μ measurements (white contours) reveal warm dust that has survived within the supernova remnant (SNR) Sgr A East. Blue indicates the hot X-ray gas and red indicates non-thermal radio emission inside the SNR. Green, to the upper left, indicates the surrounding cold interstellar cloud, into which the SNR is expanding. Image credit NASA/CXO/Herschel/VLA/SOFIA-FORCAST and R. Lau

Astronomers already had evidence that a supernova's outward-moving shock wave can produce significant amounts of dust. Until now, a key question was whether newly-formed soot- and sand-like dust particles would survive the subsequent inward "rebound" shock wave generated when the first, outward-moving shock wave collides with surrounding interstellar gas and dust. "The dust survived the later onslaught of shock waves from the supernova explosion, and is now flowing into the interstellar medium where it can become part of the 'seed material' for new stars and planets," Lau explained.

These results also suggest that vast amount of dust observed in distant young galaxies may have been made by supernova explosions of early massive stars, as no other known mechanism could have produced nearly as much dust. "This discovery … demonstrates how observations made within our own Milky Way galaxy can bear directly on our understanding of the evolution of galaxies billions of light years away," said Pamela Marcum, SOFIA project scientist at Ames Research Center in Moffett Field, California

Read the full story at **https://www.sofia.usra.edu/News/news_2015/03_19_15/index.html**

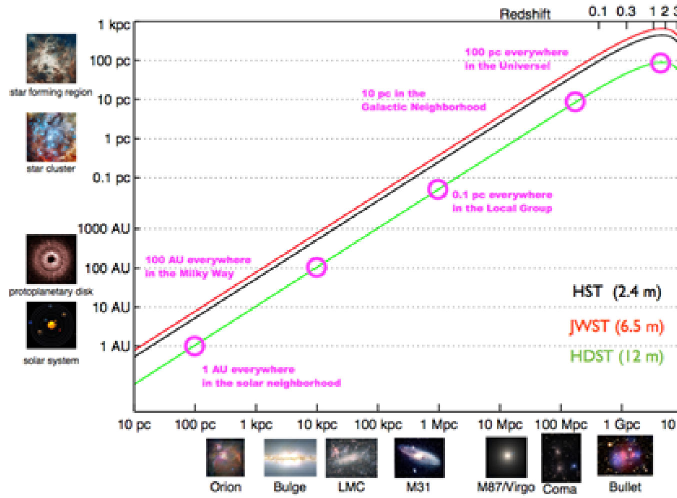


(Top) A simulated map of a galaxy and its CGM in the emission of C IV 1550, such as might be obtained by HDST's UV MOS capability. (Bottom) This same UV MOS is used to observe galactic feedback from star-forming regions source by source. Both processes are critical yet poorly understood ingredients in galaxy formation that HDST will address with unprecedented resolution and sensitivity.

Washington) and Sara Seager (MIT), defines HDST as a 12-m general purpose flagship observatory with broadband (0.1–3 micron) sensitivity, several novel modes of instrumentation such as far-UV Multi Object Spectrograph (MOS), and unprecedented stability in support of high-precision astrometry, spectroscopy, and exoplanet coronagraphy.

HDST's headline science goals are to (1) detect and characterize dozens of Earth-like planets in the habitable zones of nearby stars, looking for biosigature gases in their optical/NIR spectra, and (2) to advance studies of stars, galaxies, and the ultimate ingredients of life in the "Cosmic Origins" theme.

COR science will be enabled by HDST's dramatically advanced capabilities: it will have 25x the pixel density per area as HST in the optical, 4x better resolution than JWST in the NIR, up to 100x the point-source UV spectroscopic sensitivity, UV MOS coverage for up to 100 sources in a ~3 arcmin FOV, and extremely stable wavefronts to provide precise PSFs over long timelines.



The physical size of HDST's diffraction-limited spatial resolution element, as a function of distance / redshift. Note that the HDST resolution element is < 100 AU anywhere in the Milky Way and < 100 pc anywhere in the observable Universe.

HDST's optical-band spatial resolution corresponds to ~100 pc or less physical scales at all redshifts, which will reveal the internal structure of high-z galaxies that even JWST will not resolve. HDST will also have the UV sensitivity to map the weak emission from metals in the circumgalactic medium of galaxies at z < 2, where gas flows drive galaxy fueling and transformation. This same UV MOS capability will enable detailed dissection of star-formation and AGN-driven feedback source-by-source in nearby galaxies. These new UVOIR capabilities promise to transform our understanding of galaxies, stars, and the origins of the chemical elements.

The AURA study also carefully examined the technology requirements for HDST and concluded that, with the proper investments this decade, HDST will be feasible and affordable for a new start in the next decade and launch in the 2030s. For COR science, the greatest technology needs are for large-format and high-QE UV and optical detectors and UV coatings that support sensitivity down to 0.1 micron (1000Å). The high degree of starlight suppression required for HDST's exoplanet science is the greatest technology challenge, but new designs for coronagaphy are advancing rapidly. The report makes specific recommendations on these points that we hope will feed into priorities for tech development funding in the next few years.

More details and contact information are at **http://www.hdstvision.org**

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ATLAST Update

Harley Thronson, GSFC, for the ATLAST Team

Editor's note: We believe this study is highly relevant to future COR science, and therefore of interest to the COR community. However, it is not part of NASA's COR program, nor is it endorsed by the COR program.

The Advanced Technology Large-Aperture Space Telescope (ATLAST) is a 10 m-class reference design manifestation of LUVOIR and HDST. Our joint GSFC/JPL/MSFC/STScI team has been assessing this scalable design to show that it can achieve priority science objectives and which engineering and technology requirements are the most demanding. We have thus been able to identify high priority technology investments.

Now near the beginning of its third year of increasingly sophisticated engineering modeling, the segmented reference design includes a tertiary mirror, as well as several folds and a surrogate focal plane array. These new elements interface with the existing conceptual designs for the primary mirror and secondary mirror and will be used in the process of developing conceptual instrument interfaces. The current version of the design has an aperture of 9.2 m and stows inside a 5 m diameter launch vehicle fairing, an industry standard. The aperture can be increased, if necessary, in response to refinements of the mission science requirements.

Early design work for the segmented telescope is making progress in developing the demanding mechanical stability that will be necessary to support exoplanet observations with a coronagraph. Initial integrated modeling analysis of telescope jitter is showing encouraging initial results. Early thermal analysis on a representative mirror segment has examined the ability to control wave front error with a high-precision active heater control, which appears feasible.

The ATLAST team has carried out engineer-to-engineer design meetings to develop the interfaces between the ATLAST observatory and the SLS launch vehicle. Our reference design compatible with any of the proposed SLS launch vehicle fairings is 5, 8.4, and 10 m.

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Herschel Detects the Skeleton of our Milky Way Galaxy

Stars are born in the densest pockets of the interstellar medium, a diffuse mixture of gas and dust that pervades galaxies. We do not understand how this tenuous material creates the dense concentrations in which stars are born. Astronomers use far-infrared light to observe the cosmic incubators where gas and dust are transformed into stars, since the interstellar material shines brightly at long wavelengths.

The *Herschel* space observatory, which observed far-infrared radiation during its four year mission, has detected a filamentary network which appears to be everywhere in our Galaxy's interstellar medium. *Herschel* observations have found that our Galaxy is threaded with filamentary structures on every length scale. From nearby clouds hosting tangles of filaments a few light-years long to gigantic structures stretching hundreds of light-years across the Milky Way's spiral arms, the filaments fill the galaxy.

Prior to *Herschel*, astronomers had already identified several filaments in interstellar clouds and had recognized their potential importance for star formation. However, only with *Herschel*'s sensitivity and spatial resolution did they learn the full extent of filamentary patterns in the Milky Way.

"The greatest surprise was the ubiquity of filaments in these nearby clouds and their intimate connection with star formation," explains Philippe Andre from CEA/IRFU, France, Principal Investigator for the *Herschel* Gould Belt Survey.

The filamentary structure of the Galactic Plane. Credit: ESA/PACS & SPIRE Consortium, S. Molinari, Hi-GAL Project

Most of the filaments are dotted with compact cores, suggesting that stars are readily taking shape in these dense 'fibres' of the interstellar medium. However, there are filamentary regions that show no signs of on-going star formation. Astronomers think that filaments must somehow precede the onset of star formation. In at least one region, material flows through a network of smaller filaments towards the more prominent structures.

Star formation does not occur only in filaments, and it appears that filaments and non-filament regions produce different types of stars. Star formation along filaments tends to produce typical solar-type stars, possibly due to the greater availability of raw material within the dense filament environment. In contrast, stars born elsewhere generally have lower masses.

The filaments are not limited to our immediate neighborhood in the Galaxy, but appear everywhere surveyed in the Milky Way's huge disk—about 100 000 light-years across - where most of the Milky Way's stars form and reside. "We detected a wealth of huge filaments, with lengths ranging from a few to a hundred light-years, revealing what seems to be the 'skeleton' of our Galaxy," explains Sergio Molinari from IAPS/INAF, Italy, Principal Investigator for the Hi-GAL Project. "The intricate distribution of filaments in the interstellar medium revealed by *Herschel* has definitely revolutionised our view of how stars form in the Milky Way and, presumably, also in other similar galaxies," comments Goran Pilbratt, ESA *Herschel* Project Scientist.

Herschel was launched on 14 May 2009 and completed science observations on 29 April 2013. It is an ESA space observatory with science instruments provided by European-led Principal Investigator consortia and with important participation from NASA.

The full press release can be viewed at **http://sci.esa.int/herschel/55942-herschels-hunt-for-filaments-in-the-milky-way/**

Meet *Hubble* Fellow Jacqueline Faherty

Sub-stellar objects known as "brown dwarfs", intermediate in mass between the lowest mass stars and giant planets, are the focus of research for *Hubble* Fellow Jacqueline Faherty, currently in residence at the Carnegie Department of Terrestrial Magnetism in Washington, DC. Jacqueline studies the coldest known brown dwarfs, the "Y-dwarfs" revealed by NASA's Wide-field Infrared Survey Explorer mission, isolated warm young brown dwarfs. Her *Hubble* Fellow research seeks to compare brown dwarf atmospheres with those of giant exoplanets. Y dwarfs like WISE J085510.83−071442.5, only 2 parsecs from our solar system, have temperatures of ~250 K—similar to Jupiter at ~120 K, so their atmospheric constituents and dynamics may be similar. Near infrared photometry of this source in particular suggests that it may have water ice clouds. These field objects can be studied without extremely high contrast, making them interesting proxies for future NASA mission studies of their "siblings"—giant exoplanets. Young brown dwarfs have extremely cloudy atmospheres, which may include high hazes or thick clouds of exotic materials such as corundum—the building block of rubies and sapphires. By studying the atmospheres of brown dwarfs, she hopes to determine whether they have significantly different formation mechanisms from stars and planets.

Jacqueline obtained her undergraduate degree in Physics at the University of Notre Dame after being inspired by the strong female lead in the movie "Contact" to change her major after more than a year studying economics. In spite of the late start and discouragement from her first physics professor, she won an award for best undergraduate physics research. The negative professor apologized! Jacqueline spent the next three years at the American Museum of Natural History working in an astrophysics education program. While there, she was able to custom design her PhD dissertation research on brown dwarf kinematics performed under the tutelage of Prof. Fred Walter (SUNY, Stony Brook), Dr. Mike Shara (AMNH), and especially Prof. Adam Burgasser (MIT, now UCSD). After graduation, Jacqueline was awarded an NSF International Research Award that enabled her to do research at the Universidad de Chile. During a long hiking trip in Patagonia in 2013, she found out about receiving her *Hubble* Fellowship when she checked her email after many days offline. The picture shows the resulting celebration.

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Upcoming Events

September 4, 2015	Nancy Grace Roman Technology Fellowship Notices of Intent due
September 11, 2015	*Spitzer* proposals due
September 15-16, 2015	UV-Visible Investigators Workshop, Washington DC
October 5-7, 2015	STScI Workshop "Feedback in the Magellanic Clouds"
October 7, 2015	SOFIA Third Generation Instruments proposals due
October 15, 2015	WFIRST Science Investigation Team proposals due
October 22–23, 2015	Astrophysics Subcommittee Meeting
November 6, 2015	*Hubble* Fellowship deadline
November 6, 2015	Nancy Grace Roman Technology Fellowship proposals due
November 10-12, 2015	Mirror Technology Days, Annapolis MD
November 16-18, 2015	Transiting Exoplanet Science with JWST, STScI, Baltimore, MD
December 2015	IR Technology Investigators Workshop, Washington DC
January 4, 2016	COPAG meetings at AAS, Kissimmee, Florida
January 22, 2016	SAT Notices of Intent due
March 18, 2016	SAT and APRA proposals due
April 2016	*Hubble* Proposals Due

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Cosmic Origins
Web site at
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