National Aeronautics Space Administration

Cosmic Origins Newsletter

March 2014 Volume 3 Number 1

Welcome from the Program Office

Mansoor Ahmed, *COR Program Manager*

Welcome to the first Cosmic Origins (COR) newsletter of 2014. We plan to publish this newsletter biannually, to keep the community informed of plans, activities, and accomplishments that further COR objectives.

The budget sequester in 2013 and the government shutdown in October 2013 restricted our ability to interact with the COR community last year, but we are cautiously optimistic about better prospects for 2014. We are sponsoring a workshop, in May 2014, to plan for the future of Far-Infrared science, described later in this newsletter. We also plan to sponsor a second workshop to follow up on the very successful Request For Information (RFI) on science investigations with a future UV/Visible telescope. These are both discussed further in the following section.

Later in the newsletter, we report on two studies of future UV/Visible/NearIR telescopes. These studies are outside the COR program, but highly relevant to future COR science.

The COR program continues to foster the important work of identifying and supporting key technologies that will make or break future possible missions. COR is currently funding technology development in areas such as detectors and optics, which are expected to enable future COR missions. Please see the articles later in the newsletter about COR's Strategic Astrophysics Technology (SAT) program, and about other ways to support COR-relevant technology work through collaboration with other parts of NASA. We also include an article explaining how COR technology investments are prioritized.

We continue to regard young scientists to be a crucial component of realizing our future visions. We introduce you to one of our *Hubble* Fellows, Dr. Jessica Werk, who is exploring how the gas around and between galaxies affects their evolution.

The former COR chief scientist, Dr. Dominic Benford, has begun a two-year detail at NASA headquarters as the program scientist for the WFIRST mission. His departure is a big loss to the COR program office. I am happy to announce that Dr. Susan Neff has been appointed as the COR chief scientist.

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COR Science and Science Future Planning

Susan Neff, *COR Chief Scientist*

Cosmic Origins science, which encompasses almost all of traditional astronomy, is alive and healthy. COR-related missions, both those still operating and those that have completed their operational phase, continue to deliver scientific breakthroughs. Scientific results based on archival data, and those based on multiwavelength data from more than one mission, often figure prominently in these new insights. In this newsletter, we highlight a few of the compelling new science results from COR missions.

New discoveries are expected to continue, using existing and future COR missions. As this newsletter is being prepared, the operating missions *Hubble* and *Spitzer* are heading into the biennial Senior Review of Astrophysics Operating Missions. *Hubble* is soliciting proposals for its 22nd cycle, and *Spitzer* is executing its 13th cycle of proposals. SOFIA is preparing for its second year of science and second cycle of guest observations. All *James Webb Space Telescope* (JWST) instruments have arrived at GSFC and are ready for integration into the Science Instrument Module, and all primary mirror segments have been delivered.

Inside this Issue

The 2010 US Decadal survey endorsed the planned science goals for the JAXA-led Space Telescope for Cosmology and Astrophysics (SPICA), and recommended US involvement if it were financially feasible. However, the future of the SPICA mission has entered a new time of uncertainty, with a likely launch delay possibly providing a new opportunity for US participation. The time is appropriate for the US community to revisit the question of possible future directions in far-infrared science, including both SPICA and other possible future missions. To this end, we are sponsoring a workshop on the Future of Far-Infrared Astrophysics, described later in this newsletter. We hope that this workshop will lead to further work on future Far-IR science possibilities prior to the next U.S. decadal survey.

The paper "Scientific Objectives for UV/Visible Astrophysics Investigations: A Summary of Responses by the Community" (Scowen, Perez, Neff, & Benford), summarizes the responses to the 2012 Request for Information (RFI) on science investigations with a future UV/Visible telescope. It was accepted for publication in October 2013 and can be found on the COR website (**cor.gsfc.nasa.gov/docs/Experimental_Astronomy_Paper.pdf**). We intend to sponsor a second workshop to build scientific community consensus around future UV/Visible mission(s). We anticipate that the workshop will lead to a call for further work in advance of the 2020 Astrophysics Decadal Survey.

The Wide-Field Infrared Survey Telescope (WFIRST) was the highest priority space mission in the 2010 Decadal Survey. The planned surveys and the GO program will provide an extremely rich archive, of great interest for Cosmic Origins science. Further, the choice of instruments and capabilities may be of great value for COR science investigations. As you will read later in this newsletter, the COPAG has already started to engage with the WFIRST science team, starting two new Science Analysis Groups related to WFIRST science.

The COR program seeks to involve the full COR community in planning for future Cosmic Origins science, through open COPAG meetings, workshops, and telecons, and in the crucial activities of the Science Analysis Groups and Science Interest Groups (SAGs and SIGS). In the past months, the COPAG has started several new SAGs and SIGs, with the desire to expand science community involvement in the important work of COR science and technology planning. The COPAG is open to all interested individuals: your expertise is needed and your participation is desired.

Further information about recent COPAG activities can be found at

http://cor.gsfc.nasa.gov/copag/

To join the COPAG, or to indicate interest in the SAGs and SIGs, please visit

http://cor.gsfc.nasa.gov/copag/joinCOPAG.php

Also, please don't hesitate to share your interests and concerns, or to suggest possible new directions for Cosmic Origins Science!

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Message from the Astrophysics Division Director

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

As astrophysicists, we are fortunate that our most compelling science questions—how does the universe work, how did the familiar sky of galaxies and stars come to be, are we alone—resonate with the American public and Government policy makers who support us. At this time, we are poised to answer these questions scientifically using the suite of large and small space-based observatories spanning the electromagnetic spectrum.

As I described during the NASA Town Hall at the 223rd meeting of the American Astronomical Society in National Harbor, MD, we have made progress towards addressing the priorities of the 2010 Decadal Survey for Astronomy and Astrophysics.

- Preformulation and focused technology development for a 2.4m version of the Wide-Field Infrared Survey Telescope (WFIRST), a mission concept referred to as the Astrophysics Focused Telescope Assets (AFTA), are underway to enable a new start when funding becomes available as the James Webb Space Telescope approaches launch, no earlier than FY 2017. Reports from the Science Definition Team and other WFIRST information is available at **http://wfirst.gsfc.nasa.gov/**.
- An augmentation has been made to the Explorer program to enable more frequent flight opportunities, including a planned SMEX AO later this year (see the community announcement at **http://explorers.larc.nasa.gov/APSMEX/**).
- Strategic technology investments are being made and partnerships are being discussed with the European Space Agency in their gravitational wave and X-ray observatories.
- Strategic technology investments are being made to advance the medium scale programs.
- Modest augmentations have been made to small programs including the selection of six Theory and Computation Networks (co-funded by NSF).

A goal of the Astrophysics Division is to be prepared to start a new strategic NASA Astrophysics mission to follow JWST as soon as funding becomes available, while continuing to advance Decadal Survey science during the interim.

The FY 2014 appropriations bill for NASA (being voted on as this message is being written) provides $658M for continued development of JWST toward its launch in 2018 and $668M for the rest of NASA astrophysics, including funding for continued preformulation of WFIRST. The FY 2014 budget also includes funding for several new missions including the Transiting Exoplanet Survey Satellite (TESS), the next Astrophysics Explorer mission, the Neutron Star Interior Explorer (NICER), the next Astrophysics Explorer Mission of Opportunity, and the NASA contribution to the European Space Agency's Euclid mission.

The major impacts of the October 2013 Government shutdown included the cancellation of the 2013–2014 Antarctic balloon campaign including three long duration balloon flights; the cancellation of nine SOFIA science flights and a delay in the beginning of Cycle 2; a stand down in ASTRO-H soft X-ray spectrometer (SXS) integration and test that will result in a ~5 week deliv-

ery delay to JAXA; and delays in sending out research funding for those grantees whose awards were scheduled to start or be funded at the beginning of FY 2014.

Major activities planned for 2014 include the Astrophysics Senior Review of flight missions and release of a Small Explorer Announcement of Opportunity targeted for Fall 2014. A task force of the Astrophysics Subcommittee has completed a 30-year visionary roadmap, *Enduring Quests, Daring Visions*, to address enduring questions in Astrophysics.

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

Storm-tracking on Brown Dwarfs by *Spitzer*

7 January, 2014

Artist's concept of weather on brown dwarf, with lightning and molten "rain."

Brown dwarf stars are, in many ways, more like Jupiter than like the Sun or other stars. They are thought to form as other stars do, but lack the mass to initiate nuclear fusion. Now, *Spitzer* has detected massive storm clouds swirling across their surfaces, analogous to the "Great Red Spot" on Jupiter.

In a *Spitzer* program titled "Weather on other Worlds", astronomers monitored 44 brown dwarfs as they rotated. Half of the stars were seen to vary in brightness, suggesting that massive storm clouds are present on most, or even all, brown dwarfs.

Scientists think that the cloudy regions on brown dwarfs take the form of torrential storms, accompanied by winds and possibly lightning more violent than that seen on any planet in the Solar System. However, the brown dwarfs are far too hot for water to exist in liquid form. Astronomers believe the rain and clouds are hot sand, molten iron, or melted salt compounds.

"We needed *Spitzer* to do this" said Stanimir Metchev (U. of Western Ontario), who led the brown dwarf research. "*Spitzer* ... is above the atmosphere, and it has the sensitivity to see variations in the brown dwarfs' brightness."

Because of the long, uninterrupted observations, astronomers on the team were also able to determine that the brown dwarfs rotated much more slowly than any previously measured—another puzzle to be solved. The work will lead to a better understanding of both brown dwarfs, and gas-giant planets, which seem to be ubiquitous.

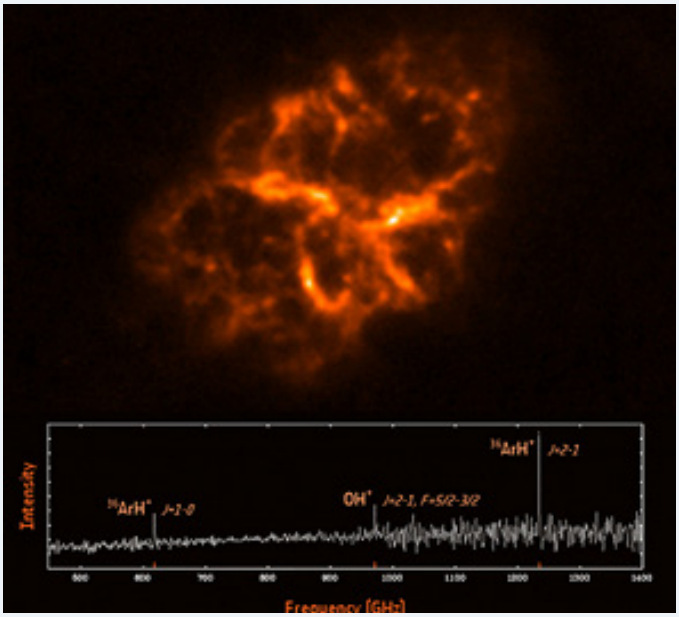
See full article at: **www.spitzer.caltech.edu/news/1599-feature14-01-Stormy-Stars-NASA-s-Spitzer-Probes-Weather-on-Brown-Dwarfs**

Herschel Finds Noble-gas Molecules in Space

12 December 2013

Inert elements are generally thought to exist in isolation. Gases such as helium, neon, argon, krypton, xenon, and radon take part in chemical reactions only rarely. A few compounds are known and have been studied in terrestrial laboratories.

Over the decades, astronomers have detected noble gas atoms and ions in stellar atmospheres, in dense nebulae, and in the diffuse interstellar medium. Before now, no compounds of "inert" gases had been found in any astronomical environment, suggesting that these elements might not be able to react with



Herschel image and spectrum of the Crab nebula, with emission lines from the molecular ion argon hydride. Credit ESA/Herschel/PACS, SPIRE/MESS Key Programme Supernove Remnant Team

other elements or to form compounds in space.

However, recent *Herschel* observations led by Michael Barlow (UC London), have detected a compound of argon, ArH+, in an unlikely location. Argon hydride was detected in filaments of the Crab Nebula, one of the youngest and most famous supernova remnants in the Galaxy. Argon is known to be produced in supernova explosions, and to be ionized in the most energetic regions of the remnant. ArH+ is formed by reacting with molecular hydrogen, but the H2 is usually found in dense, cold regions. "At first, the discovery seemed bizarre," commented Barlow.

Barlow continued, "We soon realized that even in the Crab Nebula, there are places where conditions are just right. ... In the transition regions between ionized and molecular gas, argon hydride can form and survive." The team's conclusions are supported by comparisons with other wavelength observations, which show that ArH+ occurs at locations with high concentrations of both Ar+ and H2.

The discovery was completely serendipitous—the astronomers were observing the Crab Nebula to study its dust content.

See full article at **sci.esa.int/herschel/53332-herschel-spies-active-argon-in-crab-nebula/**

Hubble Unveils Long-sought Small and Faint Galaxies

7 January, 2013

Lensing cluster Abell 1689, showing locations of newly-discovered galaxies behind the cluster. Credit: NASA, ESA, and B. Siana and A. Alavi (UCRiverside)

Hubble has uncovered the long-suspected population of galaxies that produced most of the stars formed in the early universe. These are the smallest, faintest, and most numerous galaxies seen in the distant universe, occurring at least 100 times more frequently than the more massive galaxies previously detected at these distances. The galaxies found by *Hubble* were imaged as they were more than 10 billion years ago, during the time of peak star formation.

These galaxies would usually be too faint for even *Hubble* to see. *Hubble* was able to detect them by observing in the direction of a massive galaxy cluster, which acts as a "gravitational lens" to magnify and brighten the distant young galaxies.

The gravitational lensing also stretches the galaxy images, allowing *Hubble* to resolve them and to determine their sizes and shapes; without the distortion many of the small galaxies would appear as unresolved points. Most of the young galaxies are irregularly shaped and measure only a few thousand light-years across: are less than one one-hundredth the size of our Milky Way.

If this sample is representative of the universe's population at this early time, then the majority of stars formed in small galaxies like the newly detected systems. This lends support to the idea that hot stars in small galaxies produced enough radiation to ionize hydrogen in the first billion years after the big bang. The "reionization" allowed the universe to become transparent to light, allowing astronomers to look back in time to near the beginning of the universe.

Hubble will make deep observations of background galaxies with five other lensing clusters over the next three years. This survey, known as Frontier Fields, is hunting for galaxies that were forming stars up to 13 billion years ago, which will be prime targets for NASA's James Webb Space Telescope.

Some of the faint galaxies, as seen in ultraviolet light, showing massive clumps of star formation in these tiny systems which are only a few thousand light-years across. These appear to be the most numerous galaxies in the early universe.

See full article at **http://hubblesite.org/newscenter/archive/releases/2014/07/full/**

Strategic Astrophysics Technologies (SAT) Program

John Gagosian, *COR Program Executive*
Mario Perez, *COR Program Scientist*
Michael Garcia, *Deputy COR Program Scientist*

As we have completed another round of COR SAT proposal evaluations and selection in 2013, we are pleased to announce that three new investigations have been selected joining the previous eight COR-related grants awarded in prior years (Table 1). The portfolio of these investigations continues to be managed by the COR Program Office, through the COR Chief Technologist office. This group directed the 2013 meetings of the Technology Management Board (TMB) updating the COR Program Annual Technology Report (PATR), which is available at: **http://cor.gsfc.nasa.gov**. This document describes the process of identifying and prioritizing technology needs that later influence the solicited technologies within the SAT program, as summarized in the following article.

In the past year collaborations with the Space Technology Mission Directorate (STMD) have resulted in the funding by STMD and co-funding of several technologies of interest to the Astrophysics Division. For example: the STMD Early Stage Innovation (ESI) solicitation selected a topic submitted by Astrophysics on the subject of "thin-film physics or optical coatings," and solicited investigations on both UV reflective coatings around Lyman alpha and antireflective coatings in the far-infrared targeted for Cosmic Microwave Background (CMB) investigations. After evaluation and selection was carried out by STMD, with the assistance of expert reviewers provided by Astrophysics, NASA announced the selection of two investigations on antireflective coatings technologies. These two-year grants will provide $250K per year for each investigation. It is anticipated that other future joint solicitations will be carried by STMD on astrophysics topics of interest.

On 19 December 2013, NASA Astrophysics issued a SAT Research Opportunities in Space and Earth Sciences (ROSES) amendment (Appendix D.8) to modify the current solicitation of proposals due on 21 March 2014. Due to a short-term lack of funding available to support new investigations, this SAT amendment cancels the COR-related element only for ROSES - 2013. This amendment further modifies and restricts the areas solicited for PCOS and TDEM. It is expected that next year, all three SAT themes will be competed.

For the first time, the SAT program held a special session entitled "Preparing for Future NASA Missions: The Strategic Astrophysics Technology Program," during the January 2014 AAS meeting. This oral session included an introduction of the SAT program and highlighted some of the progress and advances achieved in the prior three competed cycles. Two technologies from each theme (COR, PCOS and TDEM) were presented to illustrate the breadth of topics covered by SAT. A parallel poster session with additional presentations by grantees was also held and attracted attention by the AAS audience.

As usual we always welcome your comments, thoughts, questions, and suggestions to any of us at NASA HQ.

Table 1. COR SAT selections for 2013

Investigation	PI	Institution
Advanced Mirror Technology Development Phase 2	P. Stahl	MSFC
A Far-Infrared Heterodyne Array Receiver for CII and OI Mapping	I. Mehdi	JPL
Development of Digital Micromirror Device Arrays for use in future Space Missions	Z. Ninkov	RIT

How does the COR Program Prioritize Technology Development?

Thai Pham, *Program Technology Development Manager*

If you have not had the chance to browse through the latest COR Program Annual Technology Report (PATR), you can find it on the COR website at **http://cor.gsfc.nasa.gov/docs/COR_PATR_2013.pdf**. The PATR summarizes the COR Program's technology gaps (previously referred to as "needs"), presents the results of the most recent technology prioritization, and reviews the status of technology developments funded by the COR Strategic Astrophysics Technology (SAT) program in previous years.

The Program Office (PO) works with the COR Program Analysis Group (COPAG) to identify technology gaps and to prioritize them. The prioritized list is used to shape the following year's proposal call and to guide selection decisions for the upcoming year's COR SAT. The COR technology priorities are shared with other technology development planning within the Astrophysics Division and in NASA's Space Technology Mission Directorate (STMD), and inform other technology funding such as the Small Business Innovation Research (SBIR) program.

The technology gap identification and prioritization process is described in detail in the PATR, and is summarized as follows: The community identifies technology gaps by submitting inputs to the COR website or by working directly with the COPAG. Inputs received via our website are forwarded to the COPAG to be consolidated into one unified list by the end of June. The COR Program's Technology Management Board (TMB) reviews and prioritizes these technology gaps in July and recommends investment considerations to NASA Astrophysics via the PATR. Prioritization is based on alignment with science priorities, benefits and impacts, scope of applicability, and timeliness. The 2013 prioritization criteria are shown in Table 2. The criteria have evolved (and will continue to do so) in response to both community and TMB feedback and to the changing programmatic environment. The prioritized list of technology gaps are published each year in the PATR, which is released in October.

Some suggestions for improving the prioritization process in 2014 include:

- Focus on technology gaps associated with missions prioritized in the Astrophysics Implementation Plan and any other relevant documents or current programmatic directives (an example is the Astrophysics Roadmap (**http://science.nasa.gov/media/medialibrary/2013/12/20/secure-Astrophysics_Roadmap_2013.pdf**), released in December of 2013).
- Exclude gaps that don't require technology development, are poorly defined, are redundant (duplicates of, similar to, or subsets of other gaps), are already at Technology Readiness Level (TRL) 6 or higher, or are outside the COR program's charter (e.g., launch vehicles, rovers, avionics, or spacecraft systems)
- Submit inputs as technology capability gaps between the current state-of-the-art and the *science* objectives, not as specific implementations or missions.
- Exclude descriptions with proprietary or ITAR-sensitive information, or those endorsing specific individuals or organizations.

Table 2. Criteria for Prioritizing COR Technology Development

#	Criterion	Weight	Max Score	Weighted Score	General Description/Question	Score Meaning				
						4	3	2	1	0
1	Strategic Alignment	10	4	40	Technology enables or enhances a mission concept that is prioritized by the Astrophysics Implementation Plan (AIP) (which incorporated the recommendations of the Decadal Survey within current budgetary constraints) or current programmatic assessment.	Applicable mission concept receives highest AIP ranking	Applicable mission concept receives medium AIP ranking	Applicable mission concept receives low AIP ranking	Applicable mission concept was not ranked by the AIP but was positively addressed in the 2010 Decadal Survey	Not ranked by the AIP or the 2010 Decadal Survey
2	Benefits and Impacts	9	4	36	Impact of the technology on a notional mission concept. Degree of unique or enabling/enhancing capability the technology provides toward the science objective and the implementation of the mission.	Critical and key enabling technology; required to meet mission concept objective(s)	Highly desirable technology; significantly enhances science objective(s) and/or reduces need for critical resources	Desirable; offers significant science or implementation benefits but not required for mission success	Minor science impact or implementation improvements	No science impact or implementation improvement
3	Scope of Applicability	3	4	12	How cross-cutting is the technology? How many mission concepts could benefit from this technology?	The technology applies to multiple mission concepts across multiple NASA programs and other agencies	The technology applies to multiple mission concepts across multiple NASA programs	The technology applies to multiple mission concepts within a single NASA program	The technology applies to a single mission concept	No known applicable mission concept
4	Time to Anticipated Need	3	4	12	When does the technology need to be ready for a decision point or implementation?	Decision point is now or overdue, and implementation is needed within 7 years (this decade)	Decision point is now or overdue, or implementation is needed in 8 to 12 years (early to mid 2020s)	Decision point is less than 5 years away, or implementation is needed in 13 to 17 years (late 2020s)	Decision point is 10 years away, or implementation is needed 18 years or later (early 2030s)	No anticipated need

A concise and COR-relevant list of technology gaps will allow the TMB to focus their limited resources and to produce a prioritization list directly relevant to the SAT program and to other NASA technology development planning.

The community is strongly encouraged to identify capability gaps between current state-of-the-art technology and the requirements of future missions (particularly missions recommended by the Decadal Survey and supported in the Astrophysics Implementation Plan. (AIP, **http://science.nasa.gov/media/medialibrary/2012/12/20/Rev1-StrategicIImplementationPlan-20Dec2012.pdf**))

We welcome continued feedback and inputs from the astrophysics community in developing next year's technology gaps prioritization. For more information, or to provide feedback, please visit our COR website: **http://cor.gsfc.nasa.gov/**

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Cosmic Origins Program Analysis Group (COPAG) Update

Kenneth Sembach, *COPAG Chair*

The Cosmic Origins Program Analysis Group (COPAG) is constituted by, and reports to, the Astrophysics Subcommittee (APS). COPAG solicits and coordinates community input for issues related to NASA's Cosmic Origins (COR) program. The COPAG Executive Committee oversees the various activities of the COPAG, which include articulating and prioritizing key science drivers for COR research, evaluating capabilities of potential missions for achieving COR science goals, and identifying focus areas for technologies needed to advance COR science. New members on the Executive Committee starting in January 2014 include Daniela Calzetti (U. Mass - Amherst), Dennis Ebbets (Ball Aerospace), James Green (U. Colorado), and Sally Heap (GSFC). Members rotating off include Jonathan Gardner (GSFC), Paul Goldsmith (JPL), Charles Lillie (Consultant), and Christopher Martin (Caltech). The current COPAG membership is listed in Table 3.

The COPAG and ExoPlanet Analysis Group (ExoPAG) held a joint meeting at the January 2014 AAS meeting in Washington. Topics of discussion included a description of the WFIRST-AFTA coronagraph designs, example COR uses for the coronagraph, the status of the JWST and Beyond study being conducted by the Association of Universities for Research in Astronomy, and the status of ongoing Science and Technology Definition Team studies for potential Exoplanet Probe missions. The COPAG and ExoPAG agreed that it would be beneficial to continue this tradition of joint meetings to discuss items of common interest to the COR and Exoplanet communities. Another joint session is being considered for the June AAS meeting in Boston. Details will be announced on the COPAG website.

During the coming year, the COPAG also plans to hold several webinars on topics of interest to the astronomical community. Details and a schedule of events will be announced on the COPAG website this spring.

The COPAG has started three new science analysis groups (SAGs). All three SAGs are seeking members and input from the community and will produce white papers documenting their findings later this year:

Table 3. Current COPAG Executive Committee Membership

Name	Institution	Expertise	Term End Date
Kenneth Sembach (chair)	STScI	UV, ISM, IGM, galaxies	March 2016
Daniela Calzetti	U.Mass. Amherst	Star formation, Galaxies	January 2017
Julianne Dalcanton	U. Washington	Stellar Populations	October 2014
Dennis Ebbetts	Ball Aerospace	Detectors, S/C technology	January 2017
James Green	U. Colorado	UV instrumentation	January 2017
Sara Heap	GSFC	Galactic Astronomy	January 2017
Lynne Hillenbrand	Caltech	Near-IR, YSOs	October 2014
David Leisawitz	GSFC	Far-IR, Interferometry	October 2014
James Lowenthal	Smith College	Far-IR, Galaxies, QSOs	March 2015
Paul Scowen	ASU	UVOIR, Detectors	December 2014

- SAG #6, led by Dennis Ebbets, will examine non-exoplanet science enabled by the WFIRST-AFTA coronagraph.
- SAG #7, led by James Green, will study the science benefits of overlapping operation of HST and JWST, and identify compelling COR science enabled by simultaneous or complementary HST and JWST observations.
- SAG #8, led by Sally Heap, will consider the COR science enabled by the WFIRST-AFTA archive and identify the types of data products that the community will need to conduct this science.

The COPAG has also formed a new Far-Infrared Science Interest Group (SIG #1), chaired by Paul Goldsmith. The Far-IR SIG will facilitate community discussions of longer-term science drivers and technology needs for COR science at these wavelengths. The SIG is organizing a workshop on the future of Far-Infrared Space Astrophysics, as described later in this newsletter.

Community participation in these SAGs and SIG is encouraged and welcomed. Suggestions for future SAGs or SIGs are welcome. Further information can be found at **http://cor.gsfc.nasa.gov/copag/**. You can join the COPAG, or indicate interest in the SAGs and the SIG, at **http://cor.gsfc.nasa.gov/copag/joinCOPAG.php**

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Beyond JWST Study—AURA

Julianne Dalcanton, University of Washington

(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 Association of Universities for Research in Astronomy (AURA) has convened a group to investigate the possibilities for a next generation flagship UV-optical-NIR space telescope. The committee, chaired by Julianne Dalcanton and Sara Seager, is exploring whether a single mission could meet the science goals of both the exoplanet and the general astronomy communities. The scientists, instrumentalists, and engineers on the committee are

currently identifying high-value science opportunities and using these to narrow down the landscape of possible mission concepts. At the end of this process, the committee will produce a report that outlines a coherent plan that leads to a scientifically transformative mission. AURA strongly encourages members of the community to communicate with the committee about possible science drivers and/or technology opportunities that could potentially shape this future facility.

More information can be found at **http://www.aura-astronomy.org/HDST**

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Advanced Technology Large-Aperture Space Telescope Study

H. Thronson and J. Crooke

(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.)

A small group of scientists and engineers at GSFC, JPL, MSFC, and STScI has been working since March 2013 to define priority science goals and possible mission architectures for the Advanced Technology Large-Aperture Space Telescope (ATLAST). If realized, ATLAST would fly after JWST and WFIRST/AFTA, and would be a possible successor to HST. The immediate goal of this multi-institution study is to identify the technology investments required now to enable such a mission in the future.

ATLAST would represent the next major advance in ultraviolet, optical, and near-infrared astronomy from space, and would expand the frontier of knowledge in general astrophysics and exoplanet research. ATLAST's collecting area, resolution, and other performance parameters will far surpass any of its predecessors'. ATLAST promises breakthroughs in our understanding of star formation and galaxy evolution. The observatory would also be able to resolve exo-Earths in the solar neighborhood, if present, and conduct spectroscopic searches for biomarkers in exoplanet atmospheres.

Priority science goals, ranging from exo-Earths to the farthest reaches of the Universe, have been developed and are being used to determine the key characteristics and performance goals required by the observatory. At present, the ATLAST team is assessing designs for a serviceable ambient-operating-temperature telescope with diameters in the range of an 8 m monolith up to a 16 m segmented primary, equipped with a suite of broadly capable instruments and a powerful starlight-suppression system. The designs are optimized for operation from about 0.2 to 2.5 micrometers, with consideration being given to both longer and shorter wavelengths.

Over the coming years, further development of the science goals, technology readiness, mission design, and cost and schedule estimates, will converge to a final configuration, well in advance of the next decadal survey. As the plans evolve, the latest ATLAST designs, technology investment needs, and science goals, will be presented at various professional forums, including SPIE and AAS conferences.

In the near future, additional information will be available at the ATLAST web site: **http://asd.gsfc.nasa.gov/ATLAST/**

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Far-Infrared Community Workshop and the New Far-IR Science Interest Group

D. Leisawitz (NASA/GSFC)
P. Goldsmith (Caltech/JPL)
J. Lowenthal (UMass)

NASA's Cosmic Origins Program is sponsoring a conference called "Bringing Fundamental Astrophysical Processes Into Focus: A Community Workshop to Plan the Future of Far-Infrared Space Astrophysics." Representative science themes are illustrated in the figure on the following page. The workshop will be held at the Goddard Space Flight Center on May 12–13, 2014. To aid the organizers in planning, those who may wish to attend are asked to complete a "Notice to Attend" form on the workshop web site: **http://asd.gsfc.nasa.gov/conferences/FIR/**. There is no registration fee. Attendance will be limited by the venue size to approximately 150 people.

The far-IR workshop will be the next in a series of such meetings held in the US over the past 15 years. A 2002 workshop culminated in the development of a US "Community Plan for Far-IR Space Astrophysics," which gave the workshop participants' consensus recommendations and served as the foundation for later versions of the Plan. The most recent version of the Community Plan was submitted to the U.S. Decadal Survey Committee in 2009.

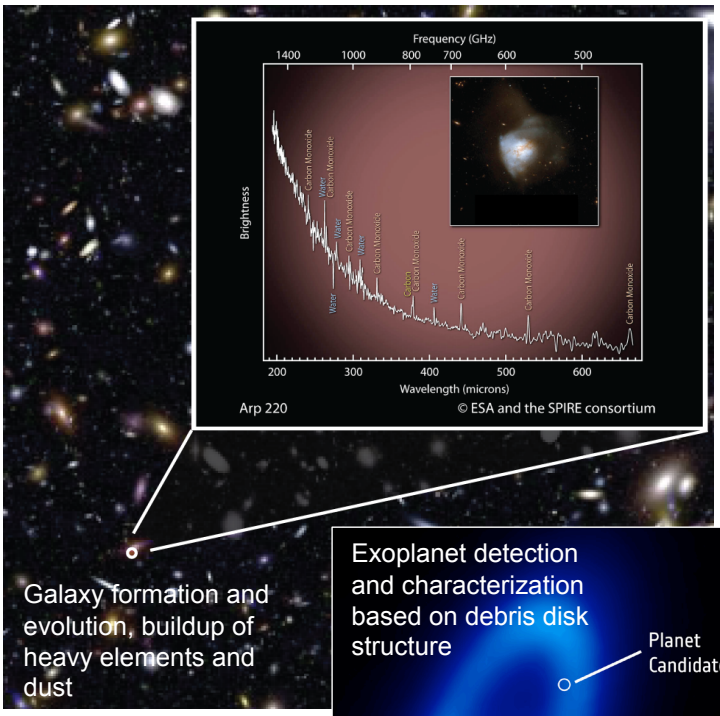
The objective of the upcoming, May 2014 workshop is to reconvene the community, align with a changed scientific, technical, and programmatic landscape, and renew consensus. Many exciting science results continue to emerge from the Herschel mission, which completed its successful operational phase on April 29, 2013. At this juncture, there is a pressing need to adjust to the 2010 Decadal Survey recommendations (science priorities; US participation in SPICA) and NASA's subsequent budget-driven decision to refrain from participating in SPICA. US participation in SPICA was the most urgent but only one of several community priorities voiced in the 2009 Community Plan. Another mission that deserves the community's attention is the Russian Millimetron Space Observatory, which includes a 10m diameter telescope cooled to below 4 K. The NASA Astrophysics Roadmap, ***Enduring Quests, Daring Visions: NASA Astrophysics in the Next Three Decades,*** provides a new framework for discussion.

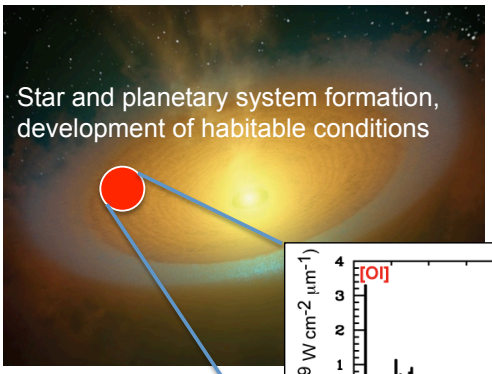
Early-career scientists are particularly encouraged to attend. Workshop participants are expected to come from academia, NASA Centers, and industry. Representatives of the international far-IR community will also participate.

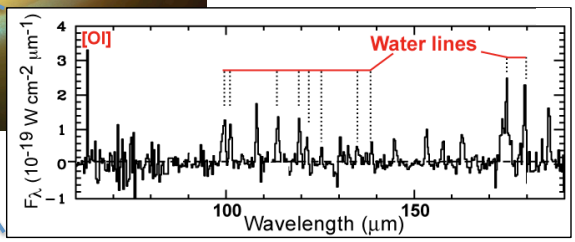
A Far-IR "Science Interest Group" (SIG) was introduced by the COPAG and recently approved by the NASA Astrophysics Subcommittee. This SIG will serve to sustain the discussion begun at the workshop through the years leading up to the 2020 Decadal Survey. All interested members of the community are welcome to join and encouraged to participate in the SIG.

For more information on the workshop, see **http://asd.gsfc.nasa.gov/conferences/FIR** To join the COPAG, or the Far-IR Science Interest Group, see **http://cor.gsfc.nasa.gov/copag/joinCOPAG.php** or contact Paul Goldsmith.

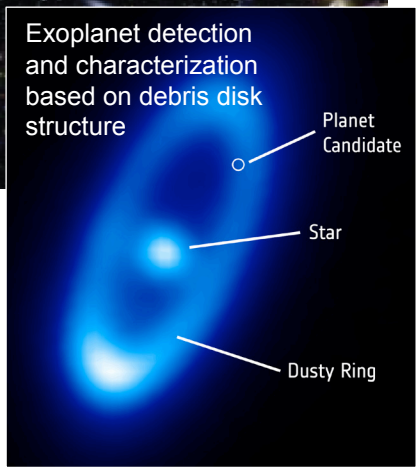
The Far-IR workshop is an important opportunity to discuss science-driven measurement capabilities needed in a "FIR Surveyor" mission such as that featured in the new NASA Astrophysics Roadmap.







Galaxy formation and evolution, buildup of heavy elements and dust



Meet *Hubble* Fellow Jessica Werk

Structures that we see today in the universe, galaxy clusters, galaxy groups, and individual galaxies, are thought to have formed from density enhancements in enormous gaseous structures. A key factor in the evolution of galaxies has been gas flows into and out of the different structures. Jessica Werk and her collaborators are studying how the most extended gaseous components of galaxies relate to gas flows that dominate galaxy formation and evolution.

Jessica earned her B.A. from Wesleyan University, where she explored luminous blue compact galaxies. She then moved to University of Michigan, Ann Arbor, where she earned a Ph.D. characterizing "The Outermost HII Regions of Nearby Galaxies," a regime previously poorly explored. As a research fellow at Columbia University, she continued working on far-flung star-formation regions, determining properties of young star regions in extremely low-density extended HI disks (using GALEX and *Hubble* data). Moving to UC Santa Cruz, where she is now a *Hubble* Fellow, Jessica also moved to studying gas even further out from the typical stellar disk: the Circumgalactic medium (CGM).

In the CGM, inflowing gas meets metal-enriched material ejected from the galaxy, and small satellite galaxies are stripped of their gas and stars. The diffuse, ionized CGM often extends 20-30 times the radius of the stellar disk (at least 1000 light years), and is detected in absorption against a background quasar. Although the CGM typically accounts for 70% of the baryonic mass, influences star formation, shapes galaxy structure, and drives galaxy transformation, little is known about this elusive component or its relationship to the host galaxy.

Jessica, with her colleagues, is taking advantage of *Hubble*/COS to refine our understanding of the CGM in the local universe. So far, she has found that a cool (10,000K) CGM component is common, that the CGM is metal-enriched (indicating gas recycling), and that there may be enough mass in the CGM to account for the "missing baryons" in galactic dark matter haloes. Further work is in progress, to connect the galaxy inflows and outflows with the properties and full geometries of the CGM.

Jessica is passionate about bringing young people into the sciences. In the past two years she has been a MAGIC mentor to middle-school and high-school girls interested in science or technology, has involved high-school students in her research, and is a classroom astronomer for fifth graders. She is an avid duplicate bridge player, and loves hiking in the redwoods around Santa Cruz.

Information about the *Hubble* Fellows Program may be found at **www.stsci.edu/institute/smo/fellowships/hubble/**

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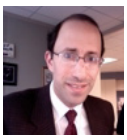

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Upcoming Events

10–12 March 2014	Hubble Fellows Symposium Baltimore, Maryland
17–20 March 2014	Science with the Hubble Space Telescope: Looking to the Future. Rome, Italy
21 March 2014	NASA's Astronomy and Physics Research and Analysis (APRA) proposals due
31 March–2 April 2014	Cosmic Distance Scale Baltimore, Maryland
11 April 2014	Hubble Cycle 22 Proposals due
12–13 May 2014	Future of Far-Infrared Astronomy Greenbelt, Maryland
21–22 May 2014	SOFIA Observers' Workshop Mountain View, California
June 2014	COPAG's SAG and SIG meetings, 224th AAS meeting Boston, MA
22–27 June 2014	SPIE Astronomical Telescopes + Instrumentation Montreal, Canada
Late June 2014	SOFIA Cycle 3 proposals due.
August 2014	Spitzer Cycle 11 proposals due
11–13 August 2014	STScI Calibration Workshop
6 November 2014	Nancy Grace Roman Technology Fellowship proposals due
January 2015	COPAG Town Hall at AAS meeting Seattle, Washington

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