National Aeronautics Space Administration

Cosmic Origins Newsletter

June 2012 Volume 1, Number 1

Welcome from the Program Office

Mansoor Ahmed, *COR Program Manager*

Welcome to the inaugural publication of the Cosmic Origins (COR) newsletter. I hope you will find it informative and engaging, and that it will motivate you to join us in our quest to define the future for COR science. The Program Office (PO) is committed to building a robust COR program, while also being mindful of the current budget realities. I urge you to join us in this critical endeavor by actively participating through our Analysis Groups, and responding to Requests For Information (RFIs).

The first step toward this goal is to establish a strong PO that can work closely with NASA Headquarters (HQ) and the science community. We have achieved this objective already. On August 3, 2011, the Agency gave the PO approval to enter into the implementation phase. This decision followed a thorough review by a Standing Review Board (SRB), chaired by Dr. Michael Bicay, Head of Science at NASA Ames Research Center.

In achieving the COR scientific objectives, our efforts will be closely coordinated with the scientific communities. Mission concept studies can serve as anchors for specific enabling technologies to be funded this decade. The PO is preparing to initiate such concept studies. We will invite the larger community to suggest new ideas for concept studies and technologu development that will enable COR science.

One important goal for the COR PO is to improve the transparency of the Program's technology management process and provide the community a voice in that process. In drafting and publishing the first COR Program Annual Technology Report (PATR) in November 2011, we successfully took the first steps down that path.

The work of the PATR began when the Cosmic Origins Program Analysis Group (COPAG) performed a detailed analysis of the technology needed to enable future COR missions. Their work was vetted through the COPAG and made publicly available on the COPAG website (http://cor.gsfc.nasa.gov/copag/copag.php).

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This analysis was the foundation of the Program's prioritization of technology needs. The PATR was referenced in the FY12 SAT call for proposals and is planned to be used in future calls and in investment decision making. I would like to thank the COPAG for helping us complete this work and for helping us demonstrate how important and constructive it is to have the community actively participate.

The FY12 PATR development process has been initiated. Information on the call for inputs can be found on the COR website (http://cor.gsfc.nasa.gov/technology/). The COR PATR development and use in future calls will continue, and I highly encourage technology devepers proposing to future SAT calls to review the COR PATR as part of their process.

Each year technology needs from the community are collected in late June. Throughout the year, we are interested in feedback about needs, priorities, the prioritization criteria, and the overall process. I encourage you to join this conversation through participation in the COPAG and by visiting the COR website at http://cor.gsfc.nasa.gov/. We in the PO look forward to continuing our discussions with the community to plan the future of COR science.

The PO will have a presence at the AAS Anchorage meeting in June. Also, look for details soon about the upcoming COPAG workshop, UV/visible RFI call for inputs and associated telecons, and the UV/visible RFI workshop. Please take advantage of these opportunities for face-to-face discussions, even as you engage in other ways. ✳

COR Science

Dominic Benford, *COR Chief Scientist*

The Cosmic Origins Program continues to conduct exciting and important science advances. We continue to see that COR science is active and vibrant. Hubble, going for more than two decades, passed 10 kilopapers of refereed discoveries last December; its angular resolution continues to bring unprecedented views of the universe. Spitzer's ongoing warm mission retains its productive role, building on and extending its previous work. WISE has recently released its all-sky infrared images and catalog, providing the basis for a lasting legacy for decades to come. Herschel has passed the third anniversary of its launch and continues its wide range of astronomical investigations. GALEX is continuing to operate, now transferred to Caltech for operations via a Space Act agreement.

In more current news, our long-awaited Request For Information (RFI) on science investigations for a future UV/Visible space telescope has been released! I refer the interested reader to the RFI text on the NSPIRES Web site: http://tinyurl.com/7skstfn and recommend visiting our Web page detailing the RFI and its place in our strategic vision for future COR science: http://cor.gsfc.nasa.gov/RFI2012/.

For those unfamiliar with this strategic vision, I'll elucidate this here and expound further on the upcoming Q&A telecons (June 7 and July 17). Our overall goal is set by the opportunity presented to start a new astrophysics mission in the latter years of this decade, presumed to be scoped for a sub-billion-dollar-class project. Guidance from the mid-decadal survey of astrophysics is likely to provide the de facto selection of this mission, derived from a suite of lucidly defined, prudently designed, and unimpeachably costed mission concepts. Our near-term goal is thus to develop a mission concept to provide the necessary capabilities to produce high-impact scientific discoveries in the post-HST era at UV and visible wavelengths. Other mission concepts will be developed in parallel under the auspices of this Program Office and others to meet similar goals at different wavelengths.

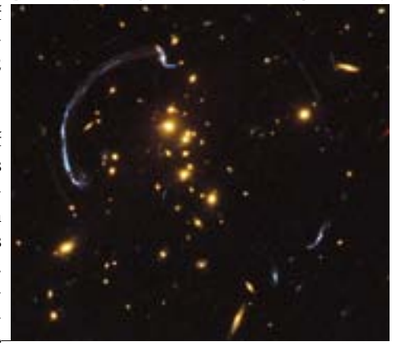
To develop a plan for technology investments and mission concepts, we seek first to discern the future of UV/Visible astrophysics by posing the question: what observing proposal will you write in the next decade? The answers to this question can come from any person or group who have a clear idea of the detailed science investigation they hope to conduct. The answers should be untrammeled by the bounds of any prior mission concepts—there are several—and unrestricted. The answers promote the *demos* that support this mission's science by their ongoing research. The answers serve to provide a working set of science requirements that will end up as the requirements for the future UV/Visible mission concept. How this is to be done depends on the members of the COPAG and the community working together at a workshop on September 18 to synthesize the varied responses into a coherent whole that is the foundation of UV/Visible mission drivers.

Hubble Zooms in on a Magnified Galaxy

February 2, 2012

Thanks to the presence of a natural "zoom lens" in space, NASA's Hubble Space Telescope got a uniquely close-up look at the brightest "magnified" galaxy yet discovered.

A team of astronomers led by Jane Rigby of NASA's Goddard Space Flight Center in Greenbelt, Md., aimed Hubble at one of the most striking examples of gravitational lensing, a nearly 90-degree arc of light in the galaxy cluster RCS2 032727-132623.



Light from a galaxy nearly 10 billion light-years away has been warped into a nearly 90-degree arc of light in the galaxy cluster RCS2 032727-132623.

The presence of the lens helps show how galaxies evolved from 10 billion years ago to today. While nearby galaxies are fully mature and are at the tail end of their star-formation histories, distant galaxies tell us about the universe's formative years. The light from those early events is just now arriving at Earth. Very distant galaxies are not only faint but also appear small on the sky. Astronomers would like to see how star formation progressed deep within these galaxies. Such details would be beyond the reach of Hubble's vision were it not for the magnification made possible by gravity in the intervening lens region.

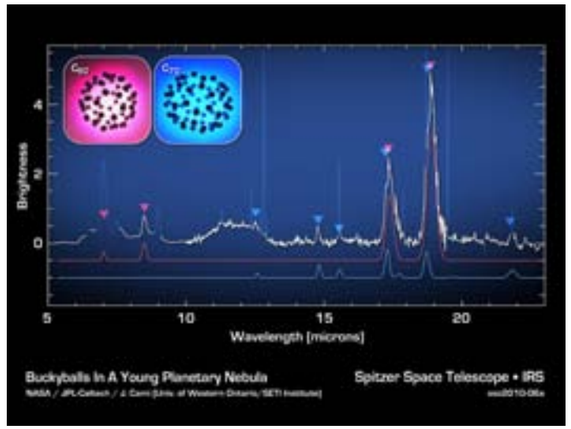
The distorted image of the galaxy is repeated several times in the foreground lensing cluster, as is typical of gravitational lenses. The challenge for astronomers was to reconstruct what the galaxy really looked like, were it not distorted by the cluster's funhouse-mirror effect. See full article at http://tinyurl.com/84vt44s ✳

The above should not be mistaken as a single-minded focus on the UV/Visible wavelengths. A potential U.S. involvement in SPICA, the far-infrared mission led by JAXA, is still under study within the COR Program Office. A recent review of the U.S. instrument concepts technology readiness has shown that there is still much to work on, though the impetus for realizing a sensitive far-infrared spectrometer remains a powerful incentive to continue the effort. However, funding priorities as indicated in the President's budget request do not presently permit the release of an AO specifically for a U.S. SPICA instrument. The upcoming Explorer Mission of Opportunity, anticipated for release in Fall 2012, may present just that: an opportunity for participation in the SPICA mission.

I look forward to a productive summer involving these and other projects, and—I sincerely hope—involving much contact with the COR community. ✳

Spitzer Finds Elusive Buckyballs in Space

February 22, 2012



These data from NASA's Spitzer Space Telescope show the signatures of buckyballs in space. These carbon molecules were first discovered in a lab in 1985, but could not be definitively identified in space until now.

Astronomers using NASA's Spitzer Space Telescope have discovered carbon molecules, known as "buckyballs," in space for the first time. Buckyballs are soccer-ball-shaped molecules that were first observed in a laboratory 25 years ago.

They are named for their resemblance to architect Buckminster Fuller's geodesic domes, which have interlocking circles on the surface of a partial sphere. Buckyballs were thought to float around in space, but had escaped detection until now.

"We found what are now the largest molecules known to exist in space," said astronomer Jan Cami of the University of Western Ontario, Canada, and the SETI Institute in Mountain View, Calif. "We are particularly excited because they have unique properties that make them important players for all sorts of physical and chemical processes going on in space."

The Cami team unexpectedly found the carbon balls in a planetary nebula named Tc 1. Planetary nebulas are the remains of stars, like the sun, that shed their outer layers of gas and dust as they age. A compact, hot star, or white dwarf, at the center of the nebula illuminates and heats these clouds of material that has been shed.

The buckyballs were found in these clouds, perhaps reflecting a short stage in the star's life, when it sloughs off a puff of material rich in carbon. The astronomers used Spitzer's spectroscopy instrument to analyze infrared light from the planetary nebula and see the spectral signatures of the buckyballs.

See full article at http://tinyurl.com/2g8azza ✳

Mapping the Infrared Universe: The Entire WISE Sky

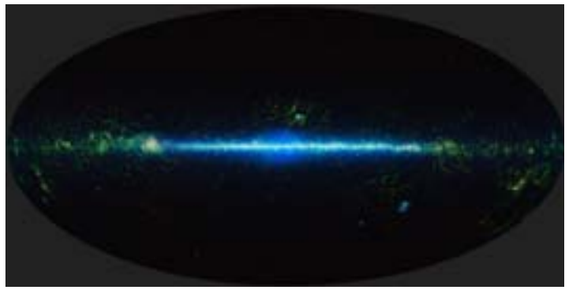
March 14, 2012

NASA unveiled a new atlas and catalog of the entire infrared sky showing more than a half billion stars, galaxies and other objects captured by the Wide-field Infrared Survey Explorer (WISE) mission.

"Today, WISE delivers the fruit of 14 years of effort to the astronomical community," said Edward Wright, WISE principal investigator at UCLA, who first began working on the mission with other team members in 1998.

WISE launched Dec. 14, 2009, and mapped the entire sky in 2010 with vastly better sensitivity than its predecessors. It collected more than 2.7 million images taken at four infrared wavelengths of light, capturing everything from nearby asteroids to distant galaxies. Since then, the team has been processing more than 15 trillion bytes of returned data. A preliminary release of WISE data, covering the first half of the sky surveyed, was made last April.

The individual WISE exposures have been combined into an atlas of more than 18,000 images covering the sky and a catalog listing the infrared properties of more than 560 million individual objects found in the images. Most of the objects are stars and galaxies, with roughly



This is a mosaic of the images covering the entire sky as observed by the Wide-field Infrared Survey Explorer (WISE), part of its All-Sky Data Release.

equal numbers of each. Many of them have never been seen before. WISE observations have led to numerous discoveries, including the elusive, coolest class of stars. Astronomers hunted for these failed stars, called "Y-dwarfs," for more than a decade. Because they have been cooling since their formation, they don't shine in visible light and could not be spotted until WISE mapped the sky with its infrared vision.

"With the release of the all-sky catalog and atlas, WISE joins the pantheon of great sky surveys that have led to many remarkable discoveries about the universe," said Roc Cutri, who leads the WISE data processing and archiving effort at the Infrared and Processing Analysis Center at the California Institute of Technology in Pasadena.

See more about this image at http://tinyurl.com/7u5u75m ✳

News from the Astrophysics Division at NASA Headquarters

John Gagosian, *COR Program Executive (acting)*
Mario Perez, *COR Program Scientist*

Since the beginning of 2012, both the Astrophysics Division (APD) and the Science Mission Directorate (SMD) have been under new leadership. Paul Hertz became the Acting Astrophysics Division Director on January 5, followed by his permanent assignment two months later. Paul replaced Geoff Yoder, who had been Acting Division Director since Jon Morse's departure in September 2011. Also, John Grunsfeld became the new Associate Administrator for SMD in January, replacing Ed Weiler.

Michael Moore is currently serving as Acting Deputy Director of the APD. On March 12, John Gagosian assumed, on an acting basis, Mike's role as Program Executive for the Cosmic Origins theme. Despite these leadership changes, we have experienced a smooth transition with minimal changes to the directions provided by the prior leadership.

The Cosmic Origins (COR) theme represents a broad and a full suite of science drivers. It studies the vast time period from the dawn of the universe up to the formation of our Earth. In another sense, it follows the flow of baryonic matter across time and space. The COR theme at NASA HQ was instituted about five years ago, and in the last two years the COR Program Office was formed at the Goddard Space Flight Center.

The COR Program Office is conducting three studies relevant to COR science and missions: the UV/Visible Technology and Mission Concept Study, the HST Disposal Study, and the SPICA U.S. Instrument Participation Study (see "COR Science").

Also, in the last two years the Cosmic Origins Program Analysis Group (COPAG) was formed under the leadership of the NASA Advisory Council Astrophysics Subcommittee member, Chris Martin, from Caltech. Since its formation, the COPAG has been active in promoting and focusing COR technology and science. There are now nine members on the executive committee, working across five Study Analysis Groups, or SAGs (see "Status of the COPAG").

The current portfolio of COR missions in operations includes Herschel, Spitzer, and the Hubble Space Telescope. The Stratospheric Observatory for Infrared Astronomy has begun limited science operations while still completing the latter stages of its development. The James Webb Space Telescope (JWST) remains as the only COR-related mission purely under development, with a launch date of 2018. The JWST Program has been elevated to a Headquarters Division-level office while the observatory is under development, and organizationally will return under the Astrophysics umbrella during operations.

We are facing a new review and grants award season for ROSES-12 and finishing a few elements of ROSES-11. Under ROSES-11, the deadline for proposals to both the Astrophysics Research and Analysis and the Strategic Astrophysics Technologies (SAT) calls was March 25, 2012. This is the second call for SAT proposals, which supports the maturation (at Technology Readiness Level 3 or higher)

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News from the Advanced Concepts and Technology Office

Thai Pham, *ACTO Chief Technologist*

The Advanced Concepts and Technology Office (ACTO) within the Cosmic Origins (COR) Program Office works with the COR community to shepherd mission concepts and enabling technologies from the initial concept through development to projects in formulation.

Late last year, the ACTO released the inaugural COR Program Annual Technology Report (PATR), which is available online at http://cor.gsfc.nasa.gov/technology/. This report summarizes our annual technology development activities for the fiscal year (FY) 2011. The PATR provides a snapshot of the status of technology development funded by the Program in FY11, includes the community-derived COR technology needs provided by the Cosmic Origins Program Analysis Group (COPAG), and describes the Technology Management Board (TMB) prioritization and investment recommendations with respect to the identified needs. The recommendations contained in the PATR were referenced by the COR Program as the calls for technology development proposals were drafted this year and will be used as input when investment decisions are made.

As described in the report, the technology needs are prioritized using a set of criteria (page 51 of the 2011 PATR) that reflects the COR Program's goals. The PATR and the prioritization process are intended to improve the transparency and relevance of technology investments, provide the community a voice in the process, ensure open competition for funding, and leverage the technology investments of external organizations by defining a need and a customer.

Your insights and suggestions are important to us! Whether you develop cutting-edge technology or use that technology to expand our understanding of the universe, we encourage you to read the PATR and tell us what you think. This is your opportunity to take an active role in shaping the future of COR science.

We appreciate the work of the COPAG and the COR community in developing the matrix of technology needs for this past year. The COPAG is the main conduit for collecting technology needs identified by the community, but one can also submit technology needs via our website. Just download and submit the "Technology Need Input Form" from http://cor.gsfc.nasa.gov/technology/. We look forward to receiving this year's needs list from the COPAG by the end of June. The annual prioritization process begins again in July, and culminates in the release of the next PATR in early October. Please feel free to comment on the technology needs prioritization criteria, our development priorities, and submit new technology needs to thai.pham@nasa.gov. ✳

Status of the COPAG

Christopher Martin, *COPAG Chair*

The Cosmic Origins Program Analysis Group (COPAG) was constituted in early 2011 by the Astrophysics Subcommittee of the NASA Advisory Council. The COPAG has spent 2011 developing an assessment of technology investments needed to make possible the next generation of Cosmic Origins missions in the UV/Visible/IR/Sub-mm bands.

The COPAG considered investments required to enable a large (4–8 meter) UV/Visible mission discussed as a technology target by New Worlds New Horizons. The highest priority technologies are those that are mission enabling. The COPAG found that new UV detector, UV coating, and large mirror technologies were mission enabling. Far IR/sub-mm technologies were also highlighted, relevant to either the Space Infrared Telescope for Cosmology and Astrophysics or new Probe-class missions. These assessments were developed during several community town halls and culminated in a technology workshop at the Space Telescope Science Institute that was held September 22–23, 2011. The results were presented to the community at a workshop during the January 2012 AAS meeting, and constitute a key input to the Cosmic Origins Program Office and NASA Headquarters activities.

During 2012, the COPAG plans to develop quantitative science goals and measurement objects for Cosmic Origins in order to provide benchmarks for assessing both mission concepts and technology impacts. At the top level, future Cosmic Origins missions seek to trace the flow of baryons and growth of structure from the reionized InterGalactic Medium to planets by characterizing the gas, dust, stars, and dark matter over all relevant scales and cosmic epochs. The COPAG plans to examine the science capabilities of Probe-class (<$1B) Cosmic Origins missions as possible candidates for consideration by the 2020 Decadal Survey. We will also likely take up the issue of the two 2.4-meter telescopes now in NASA's possession. Finally, we would like to enhance the level of community involvement and communication with COPAG's activities. ✳

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of key technologies to the point that they are feasible for implementation in space flight missions.

The COR component of SAT is known as Technology Development for the Cosmic Origins Program (TCOP). TCOP received 25 proposals covering all three requested technology areas; namely, detectors across wavelengths from the ultraviolet to the far-infrared, optical coatings, and normal incidence large optics. These proposals will be peer-reviewed during the summer and the new selections are anticipated to be announced in August, with the funds for the selected grants starting in January 2013.

We invite you to be part of the COPAG membership and dialogue by attending the several community meetings being planned this year. Please learn more and participate in enunciating the science drivers, technologies, and mission concepts relevant to the COR theme.

We always welcome your comments, thoughts, questions, and suggestions. Please contact us at Mario.Perez@NASA.gov and John.S.Gagosian@NASA.gov. ✳

Meet Hubble Fellow Karoline Gilbert

Galaxies have not always looked like they do in the present universe. Our current understanding is that the most massive galaxies formed at high-density locations in the early universe, and then grew by interactions with similarly large counterparts, and by accreting smaller neighbors. The origin and evolutionary path of small galaxies, however, are less clearly understood. In an effort to broaden that knowledge base, Karoline Gilbert and her collaborators are working to reconstruct the history of nearby galaxies by characterizing their resolved stellar populations.

Gilbert earned a B.S. at the Ohio State University, where she studied the active nucleus in the galaxy NGC5548. She completed her PhD at the University of California, Santa Cruz, where she began her acquaintance with the Andromeda Galaxy. In 2011, she moved to the University of Washington, where she led the data reduction effort for the ANGRRR (Archive of Nearby Galaxies: Reduce, Reuse, Recycle) Hubble Space Telescope (HST) archival survey, and is a member of the ANGST (ACS Nearby Galaxy Survey Treasury) team.

Most research on galaxy halos has focused on the history of large-disk galaxies, such as Andromeda (the nearest large spiral galaxy) or our own Milky Way galaxy. However, small galaxies also have envelopes of old red stars that extend well beyond the centrally concentrated young stars. Little is known about the nature of the extended stellar populations in dwarf galaxies. Dwarf galaxy stellar halos are unlikely to form by hierarchical merging of smaller systems because the accreted objects would probably not contain enough already-evolved stars to form the observed distributions.

A few years ago, Gilbert and her collaborators found a stellar association in the Andromeda galaxy; the location, motion, and composition of the debris stream was exactly as predicted by a computer simulation of a dwarf galaxy merging into Andromeda about 700 million years ago. Gilbert is currently exploring a much larger volume around Andromeda, at distances up to 180 kpc from the galaxy's center, where she is finding strong evidence for multiple accretion events, and is planning quantitative comparisons with cosmological simulations.

As a Hubble Fellow, Gilbert is using HST observations of ~100 nearby dwarf galaxies to carry out a systematic analysis of their stellar halos. Galaxy halos are repositories of tidal debris. When a merging galaxy is torn apart, streams of stars from the destroyed galaxy remain in the outer reaches of the destroying galaxy.

For each galaxy Gilbert is currently studying, she will determine the structural properties of the halos (size, shape, brightness profile), characterize the star formation history of the stellar population(s), investigate how galaxy properties and history correlate with halo mass and local environment, and compare the observed properties with predictions by evolutionary simulations. Her ultimate goal is to determine the origin and subsequent evolution of these ubiquitous small galaxies. ✳

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Upcoming Events

June 18–21	Ultraviolet Astronomy: HST and Beyond, Kauai, HI. http://uvastro2012.colorado.edu/
July 1–July 6	SPIE Astronomical Telescopes and Instrumentation, Amsterdam, NL. http://spie.org/x13662.xml
July 17	RFI Forum for Questions #2 WebEx™ Meeting http://cor.gsfc.nasa.gov/RFI2012
September 4–7	GALEXFest: Exploring the UV Universe, Pasadena, CA. http://www.galex.caltech.edu/galexfest
September 18	UV/Visible RFI Discussion Workshop, STScI, Baltimore, MD.
September 19	COPAG Workshop, STScI, Baltimore, MD.

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