



# Physics of the Cosmos Newsletter

August 2015

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## Physics of the Cosmos Program Update

Ann Hornschemeier, *PCOS Program Chief Scientist*Mansoor Ahmed, *PCOS Program Manager*

This year, 2015, marks the Centennial of General Relativity and the Physics of the Cosmos (PCOS) program is looking forward to the launch of LISA Pathfinder, currently for November 25, 2015 (see [Ira Thorpe's article](#)). General Relativity was a theme at the American Physical Society (APS) meeting in Baltimore, MD in April 2015 and we were happy to host the first-ever PCOS table at an APS meeting. At the APS, the new "Century

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## NASA's Chandra Captures X-Ray Echoes Pinpointing Distant Neutron Star

Astronomers using NASA's Chandra X-ray Observatory have discovered the largest and brightest set of rings from X-ray light echoes ever observed. These extraordinary rings, produced by an intense flare from a neutron star, provide astronomers a rare chance to determine how far across the Milky Way galaxy the star is from Earth.

The rings appear as circles around Circinus X-1, a double star system in the plane of our galaxy containing a neutron star, the dense remnant of a massive star pulverized in a supernova explosion. The neutron star is in orbit with another massive star, and is shrouded by thick clouds of interstellar gas and dust. Circinus X-1 is also the source of a surprisingly powerful jet of high-energy particles.

The light echo shows that Circinus X-1 is located about 30,700 light years from Earth, and settles the difference in results published in prior studies. The detection and characterization of the rings required the unique capabilities of Chandra—the ability to detect fine details combined with sensitivity to faint signals.

By comparing the Chandra data to prior images of dust clouds detected by the Mopra radio telescope in Australia, the researchers determined that each ring was created by the X-ray reflections off a different dust cloud. The radio data provides the distance to the different clouds and the X-ray echo determines the location of Circinus X-1 relative to the clouds. An analysis of the rings with the combined radio data allows researchers to use simple geometry to accurately determine the distance of Circinus X-1 from Earth.

"We like to call this system the 'Lord of the Rings,' but this one has nothing to do with Sauron," said co-author Michael Burton of the University of New South Wales in Sydney, Australia. "The beautiful match between the Chandra X-ray rings and the Mopra radio images of the different clouds is really a first in astronomy."

Read the full press release at [http://chandra.harvard.edu/press/15\\_releases/press\\_062315.html](http://chandra.harvard.edu/press/15_releases/press_062315.html)



*Circinus X-1, containing a neutron star—the collapsed core left behind after a star exploded—in orbit with a massive star. The Chandra data reveal a set of four rings that appear as circles around Circinus X-1. These rings can be seen in the composite image where X-rays from Chandra are red, green, and blue corresponding to low, medium, and high-energy X-rays respectively, which have been combined with a view in visible light from the Digitized Sky Survey. Credit: X-ray: NASA/CXC/Univ. of Wisconsin-Madison/S. Heinz et al; Optical: DSS*

## Planck Mission Explores the History of Our Universe

Hot gas, dust and magnetic fields mingle in a colorful swirl in this new map of our Milky Way galaxy. The image is part of a new and improved data set from Planck, a European Space Agency mission in which NASA played a key role.

Planck spent more than four years observing relic radiation left over from the birth of our universe, called the cosmic microwave background. The space telescope is helping scientists better understand the history and fabric of our universe, as well as our own Milky Way.

The new data were made available publicly Feb. 5, and now include observations made during the entire mission. The Planck team says these data are refining what we know about our universe, making more precise measurements of matter, including dark matter, and how it is clumped together. Other key properties of our universe are also measured with greater precision, putting theories of the cosmos to ever more stringent tests.

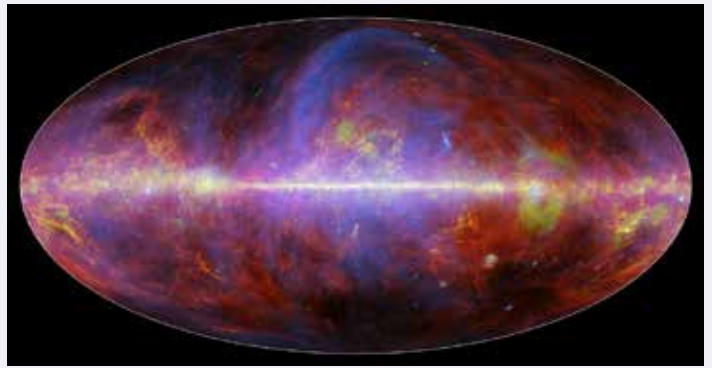
The Planck data also support the idea that the mysterious force known as dark energy is acting against gravity to push our universe apart at ever-increasing speeds. Some scientists have proposed that dark energy doesn't exist. Instead, they say that what we know about gravity, as outlined by Albert Einstein's general theory of relativity, needs refining. In those theories, gravity becomes repulsive across great distances, eliminating the need for dark energy.

What's more, the new Planck catalog of images now has more than 1,500 clusters of galaxies observed throughout the universe, the largest catalog of this type ever made. It is archived at the European Space Agency and, in the U.S., at NASA's Infrared Processing and Analysis Center at the California Institute of Technology in Pasadena. These galaxy clusters act as beacons at the crossroads of huge filamentary structures in a cosmic web. They help scientists trace our recent cosmic evolution.

How can so much information about our universe, in both its past and current states, be gleaned from the Planck data? Planck, like its predecessor missions, captured ancient light that has traveled billions of years to reach us. This light, the cosmic microwave background, originated 370,000 years after the Big Bang, during a time when the flame of our universe cooled enough that light was no longer impeded by charged particles and could travel freely.

"The cosmic microwave background light is a traveler from far away and long ago," said Charles Lawrence, the U.S. project scientist for the mission at NASA's Jet Propulsion Laboratory in Pasadena, California. "When it arrives, it tells us about the whole history of our universe."

Read the full press release at <http://www.jpl.nasa.gov/news/news.php?release=2015-052>



*A festive portrait of our Milky Way galaxy shows a mishmash of gas (shown in yellow), charged particles (shown in green color), and several types of dust (appearing red). The false-colored composite image comes from the European Space Agency's Planck mission, in which NASA plays an important role. It is constructed from observations made at microwave and millimeter wavelengths. Image credit: ESA/NASA/JPL-Caltech*

of General Relativity" brochures were a huge hit (reminder: all brochures are available in PDF form on the [Documents](#) page on the PCOS website) as were the LISA Pathfinder factsheets and the gravitational wave from space hardware displays.

The scientific output of our operating missions remains strong. Chandra has detected an amazing [light echo around the neutron star Cir X-1](#), and there are now extremely high-quality [Planck data available for characterizing Galactic dust](#) as well as the structure of the universe. Fermi has detected [signatures of starquakes on the surface of highly magnetized neutron stars](#) and XMM-Newton has observed [accretion onto a supermassive black hole in a very low mass dwarf galaxy](#) that may show us one path for growing black holes at much earlier times in the Universe.

The Physics of the Cosmos Program Analysis Group (PhysPAG) had a busy spring 2015 with the response to Paul Hertz's charge regarding flagship missions to be studied for the next decadal survey (see [PhysPAG update by Jamie Bock and Mark Bautz](#)), and the PCOS Program Office (PO) is pleased

to have worked with the PhysPAG Executive Committee (EC) on gathering community input in this process.

The PhysPAG EC has also added one additional Science Interest Group, the Cosmic Structure SIG (CosSIG), led by Olivier Doré and Rachel Bean, which will focus on dark energy space missions and large scale structure in the universe. This year, the PhysPAG EC also took a more active role in synthesizing the technology gap inputs from the community. This greatly improved the process by ensuring subject matter experts were more directly involved in defining technology gaps for prioritization by the PCOS Technology Management Board.

We continue progress towards formal partnership in L2/ Athena X-ray Observatory as well as early discussions on possible roles in the L3 gravitational wave observatory. The Gravitational Observatory Advisory Team (GOAT) has just released its interim report (July 2015) indicating laser interferometry as a preferred approach for eLISA and outlining future avenues for study (see article by [Tuck Stebbins](#)). The U.S. now has representation in the Athena calorimeter instrument consortium

and multiple members of the U.S. community were involved in the Athena study on the impact of reduced mirror area (see [article by Rob Petre and Randall Smith](#)) that has resulted in the finding that most of the science may be accomplished by extending the Athena mission by two years.

There have been several personnel changes in the past year, both at NASA Headquarters (HQ) and the PO. The new PCOS program deputy chief scientist is Peter Bertone, on detail to the PCOS program office from NASA MSFC. At headquarters, the new PCOS deputy program scientist is Dan Evans, who has recently joined NASA HQ following a position at NSF astronomy. Shahid Habib is the new PCOS Program Executive, who has also recently joined NASA HQ on a detail from GSFC.

As mentioned later in the newsletter, we are planning a future PCOS newsletter emphasizing suborbital payloads doing PCOS science. Please contact [Ann Hornschemeier](#) or [Peter Bertone](#) soon to be included in this newsletter, anticipated for early 2016. We hope to see you soon. Please visit the last page of the newsletter for the calendar of meetings where PCOS will be present.

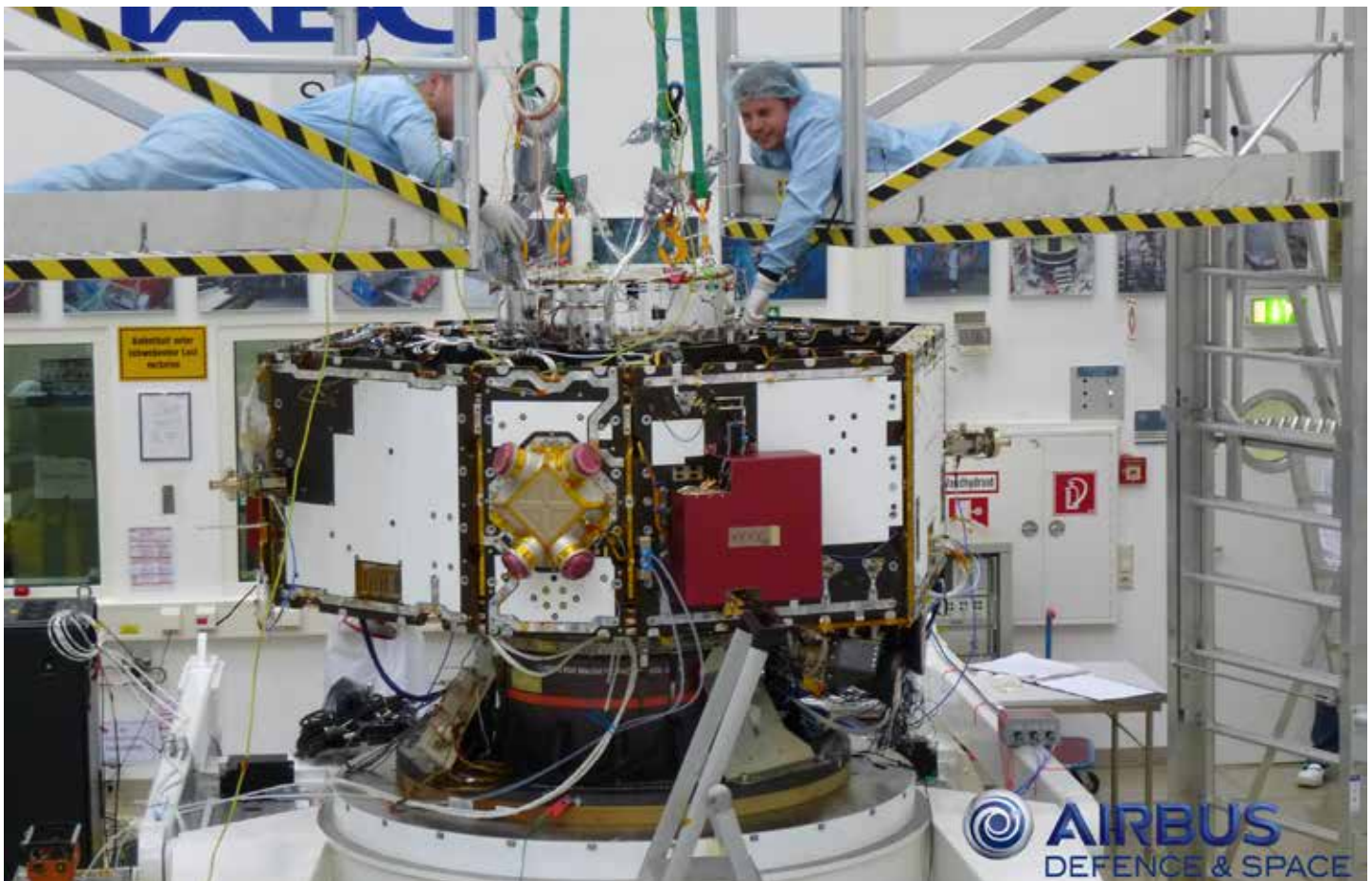
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## Excitement Builds for Fall Launch of LISA Pathfinder

Ira Thorpe, *NASA/GSFC*

The gravitational wave community is eagerly awaiting the launch of their first mission, ESA's LISA Pathfinder (LPF), which is expected to launch this Fall. Consisting of a spacecraft provided by ESA, a primary science payload provided by a consortium of European member states and industrial partners, and a secondary science payload provided by NASA, LPF will demonstrate several key technologies for future space-based gravitational wave detectors and provide valuable flight experience for the community.

The past few months have been marked by rapid progress in the LPF hardware. The primary science payload, the LISA Technology Package (LTP), completed integration in early May and was shipped to IABG (Industrieanlagen-Betriebsgesellschaft mbH) in Munich where it joined the spacecraft and the already-integrated NASA payload, Space Technology-7 Disturbance Reduction System (ST7-DRS). The LTP was successfully integrated in early June and the complete sciencecraft is currently undergoing its final suite of system tests. These tests are expected to be completed in late August, after which LPF will be shipped to Kourou, French Guiana, and launched on Arianespace's new VEGA launch vehicle.



*The primary science payload, the LISA Technology Package, was being lowered by technicians at IABG in Munich into the LISA Pathfinder spacecraft in June. Visible in the foreground is one of two clusters of colloidal micronewton thrusters provided by NASA. Image Credit: Airbus Defence & Space.*

While the spacecraft and payload are nearing completion, the science and data analysis teams are busy preparing their experiment sequences and data analysis tools. The goal is to perform near-realtime analysis of the executed experiments so that the remaining mission can be planned to maximize science return.

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## ESA's Gravitational Observatory Advisory Team (GOAT)

Tuck Stebbins, *NASA/GSFC*

The European Space Agency has assembled a study team to assess a number of items related to future implementation of a gravitational wave mission for their L3 launch opportunity in 2034. As a reminder, in 2013, ESA selected a gravitational wave science theme, but has not yet defined the mission concept.

The GOAT is a ten member body, chaired by Dr. Michael Perryman (University College, Dublin), chartered “to evaluate and recommend on possible scientific and technical approaches for a gravitational wave observatory envisaged for a planned launch date in 2034.” Because NASA is expected to participate in L3, three of the ten members are from the U.S. There are also observers representing JAXA and NASA. For the full member list, please visit the [ESA GOAT website](#).

On June 15th, the GOAT submitted its Intermediate Report to ESA Headquarters. The report has been forwarded to ESA's Advisory Structure and the Science Programme Committee, which are made up of representatives from the national agencies of the Member States and comprise the directing authority for science priorities. The report is now available for public distribution.

The GOAT reported an assessment by members of the European research community regarding 24 mission configurations and their comparative science return. In the report, the GOAT offers a list of prioritized technology activities to which ESA and the Member States may release technology development funding.

The Intermediate Report findings. The GOAT:

1. found that the well-studied laser interferometer mission concept could perform the science recommended by ESA's Senior Selection Committee within a reasonable development timeline,
2. found no technical obstacles in a laser interferometry based design, or in the data analysis associated with an all-sky instrument sensing the tens of thousands of distinguishable sources in the 0.1 mHz to 0.1 Hz band, and
3. is still seeking a full mission concept based on atom interferometry.

A preliminary schedule has been developed that calls for a mission concept selection to start in 2016 and four years for payload development prior to the end of Phase B.

## NASA's Fermi Satellite Finds Hints of Starquakes in Magnetar 'Storm'

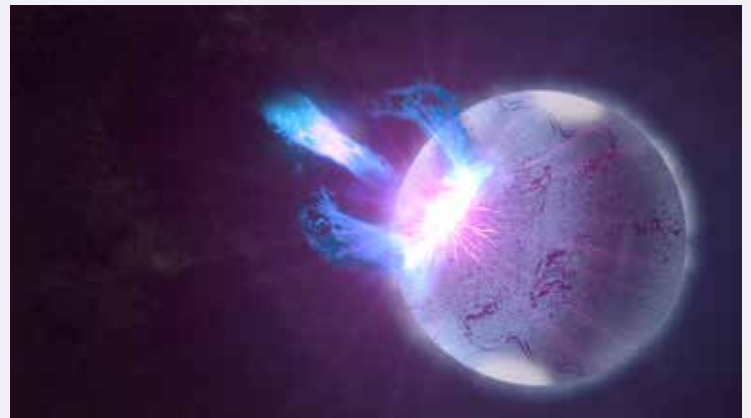
NASA's Fermi Gamma-ray Space Telescope detected a rapid-fire “storm” of high-energy blasts from a highly magnetized neutron star, also called a magnetar, on Jan. 22, 2009. Now astronomers analyzing this data have discovered underlying signals related to seismic waves rippling throughout the magnetar.

Such signals were first identified during the fadeout of rare giant flares produced by magnetars. Over the past 40 years, giant flares have been observed just three times—in 1979, 1998 and 2004—and signals related to starquakes, which set the neutron stars ringing like a bell, were identified only in the two most recent events.

Neutron stars are the densest, most magnetic and fastest-spinning objects in the universe that scientists can observe directly. Each one is the crushed core of a massive star that ran out of fuel, collapsed under its own weight, and exploded as a supernova. A neutron star packs the equivalent mass of half-a-million Earths into a sphere about 12 miles across, roughly the length of Manhattan Island in New York City.

While there are many efforts to describe the interiors of neutron stars, scientists lack enough observational detail to choose between differing models. Neutron stars reach densities far beyond the reach of laboratories and their interiors may exceed the density of an atomic nucleus by as much as 10 times. Knowing more about how bursts shake up these stars will give theorists an important new window into understanding their internal structure.

Read the full press release at <http://www.nasa.gov/content/goddard/nasas-fermi-satellite-finds-hints-of-starquakes-in-magnetar-storm>



*A rupture in the crust of a highly magnetized neutron star, shown here in an artist's rendering, can trigger high-energy eruptions. Fermi observations of these blasts include information on how the star's surface twists and vibrates, providing new insights into what lies beneath. Credits: NASA's Goddard Space Flight Center/S. Wiessinger*

The GOAT expects to conclude with a final report in mid-2016 after making a preliminary assessment of the results from LISA Pathfinder.

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## Physics of the Cosmos Program Analysis Group (PhysPAG) Report

Jamie Bock, *Chair of the PhysPAG Executive Committee*  
Mark Bautz, *Vice-Chair*

The PhysPAG has been busy responding to a request from NASA Astrophysics Division Director Paul Hertz to assist with preparations for the 2020 Decadal Survey. In a document entitled *Planning for the 2020 Decadal Survey: An Astrophysics Division White Paper*<sup>1</sup> released in January 2015, Dr. Hertz presented the Astrophysics Division's plans for preparing and providing information on a small set of large mission<sup>2</sup> concepts to the 2020 Decadal Survey Committee. A two-part study process is envisioned. Part A will identify a small set of candidate large missions, and part B will develop the science case and technical information for each member of that set. Building on the work of the 2010 Decadal Survey and the 2014 Astrophysics Visionary Roadmap<sup>3</sup>, a preliminary set of four large mission concepts is presented in the white paper.

The PhysPAG has responded vigorously to this charge. Five PCOS SIGs (Cosmic-Ray, Gamma-Ray, Gravitational Wave, Inflation Probe, and X-ray) have met face-to-face at least once since the January release of the report to discuss this charge, and the X-ray and Gamma-ray SIGs met during the special HEAD meeting at the end of June. The PhysPAG Executive Committee (EC) has also met face to face with the ECs of the other two PAGs. A draft of the PhysPAG report is due to the

## Seeking new PhysPAG Executive Committee nominations!

Due September 1st.

Please see announcement on [pcos.gsfc.nasa.gov](http://pcos.gsfc.nasa.gov) for more details.

Astrophysics Subcommittee in early October and expected to be available for public comment in August.

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## U.S. Participation in Athena

Randall Smith, *CfA*  
Robert Petre, *NASA/GSFC*

ESA's selection of Athena to accomplish the science theme of "the hot and energetic Universe" has moved the mission into a study phase. In Europe, an "Invitation to Tender" (ITT) has been released to obtain industry bids for the mission assessment (Phase A), and the instrument Announcement of Opportunity (AO) is expected in mid-2016. Once the mission design (Phases A & B1<sup>1</sup>) and costing have been completed, Athena will eventually be proposed for adoption in early 2020.

The Athena Science Study Team has recently completed a study of the science impact of a reduction in the 1 keV mirror effective area from 2 m<sup>2</sup> to 1.4 m<sup>2</sup>, which was suggested as a possible way to meet the ESA mission cost cap. This study was performed with the active assistance of the Athena Science Working Groups, including many U.S. astronomers, and concluded that most of mission science could be achieved at the cost of approximately 2 additional years of observing.

Physics of the Cosmos Program Analysis Group (PhysPAG) Executive Committee			
Name	Affiliation	Expertise	Term Expiration Date
J. Bock, Chair	Caltech/JPL	CMB	December 2016
M. Bautz, Vice Chair	MIT	X-rays	December 2016
R. Bean	Cornell University	Dark Energy	December 2016
J. Bookbinder	SAO	X-rays	December 2015
J. Conklin	University of Florida	Gravitational Waves	December 2017
N. Cornish	Montana State University	Gravitational Waves	December 2016
O. Doré	JPL	Dark Energy	December 2017
H. Krawczynski	Washington University in St. Louis	Gamma-rays	December 2017
M. McConnell	University of New Hampshire	Gamma-rays	December 2016
A. Miller	Columbia University	CMB	December 2017
J. Nousek	Penn State University	X-rays	December 2015
A. Olinto	University of Chicago	Astroparticles	December 2015
Eun-Suk Seo	University of Maryland	Astroparticles	December 2016
E. Wollack	NASA/GSFC	CMB	December 2017

1 <http://science.nasa.gov/astrophysics/documents/>

2 For purposes of the white paper, a large mission is taken to be one with a total cost exceeding \$1B.

3 <http://science.nasa.gov/astrophysics/documents/>

1 [http://www.esa.int/Our\\_Activities/Space\\_Science/How\\_a\\_mission\\_is\\_chosen](http://www.esa.int/Our_Activities/Space_Science/How_a_mission_is_chosen)

The United States and Japan have recently joined the X-ray Integral Field Unit (X-IFU) consortium, bringing in teams currently involved in the ASTRO-H mission. The prime contribution from NASA is expected to be the Transition Edge Sensor (TES) front-end science array of the X-IFU, through a GSFC/NIST/Stanford team led by Richard Kelley (GSFC). This contribution was determined based on a NASA-issued Request for Information (RFI) seeking possible U.S. contributions to the Athena instrumentation. Other potential NASA contributions are still under active discussion with ESA, and discussions with the Wide Field Imager (WFI) consortium are underway as well.

More information about the Athena mission and timeline is available at the website <http://sci.esa.int/cosmic-vision/54517-athena/>

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## Euclid Update

Michael Seiffert, *JPL*

Work within the NASA Euclid Project is proceeding, with two recent notable milestones. The project recently presented the current hardware design and status as part a Critical Design Review (CDR). For its hardware contribution, NASA is providing 16 flight near-infrared detectors and 4 flight spares. The detectors are accompanied by cryogenic readout electronics and cryogenic cabling to connect the detectors and readout electronics. The NASA Euclid project office has been monitoring progress on the near-IR detector fabrication, which is proceeding under contract at Teledyne Information Systems, Inc. A first lot of the HgCdTe detectors has been processed, with 8 proceeding to Sensor Chip Assemblies.

A subset of the independent review team was also present for a preliminary design review of the Euclid NASA Science Center at IPAC (ENSCI). IPAC is the Infrared Processing and Analysis Center at Caltech. NASA has established ENSCI to support U.S.-based investigations using Euclid data. In addition to the ENSCI presenters, the project office, and the review

board, the review was well attended by observers from ESA, the Euclid Consortium (including the Euclid Consortium lead, Yannick Mellier, and the Euclid Science Ground System scientist, Mark Sauvage), along with PCOS and NASA HQ representatives.

The Euclid Consortium recently held its annual meeting in Lausanne, Switzerland. The meeting was attended by over 400 members of the consortium including approximately 35 people from the U.S. Updates from the mission, payload, instruments, and science working groups were presented. The next major milestone is the mission Preliminary Design Review, scheduled for this Fall.

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## Super Pressure Balloon Flight From New Zealand

Vernon Jones, *NASA HQ*

Debora Fairbrother, *Wallops Flight Facility*

There have been many successful balloon programs that do PCOS science, particularly in the area of high energy gamma-ray and particle astrophysics. Here we report on progress in the balloon program that is of interest to the PCOS community. Note that in a future newsletter we plan to highlight suborbital payloads doing PCOS science.

The NASA Balloon Program has for several years focused on developing a Super Pressure Balloon (SPB) as the first totally new balloon design type in more than 30 years. Its development is key to the Program's long-range objective to establish an operational 60-100 day duration flight capability for the multidiscipline research community. Two qualification test flights of the 18 Million Cubic Foot (MCF) SPB balloon have been launched within the past year, one from outside McMurdo, Antarctica and one from Wanaka, New Zealand, in order to certify an operational vehicle. The December 2014 Antarctic flight experienced a leak in the balloon approximately 36 hours into the flight, which resulted in its termination over the Antarctica upper plateau, and ultimately prevented retrieval of



*Euclid Consortium Meeting, June 2015, Lausanne, Switzerland, Credit: Euclid Consortium*

**Our next newsletter will have a focus on suborbital projects related to PCOS. Please contact us if you are interested in making a contribution.**



*The super-pressure balloon, shown here as an artist's concept, is intended to operate for 60–100 days. Image credit: Columbia Scientific Balloon Facility*

the balloon shell for investigation of the anomaly. The second test flight launched from Wanaka, NZ on March 26, 2015 was terminated over Australia on April 28 after 32 days and nights of flight (the long way around the globe) at nearly constant 109,000–110,000 ft altitude. The balloon shell was retrieved along with the 3,500 lb science payload, and both have been returned to the U.S. for detailed study. NASA had obtained prior permission to land the SPB and its payload in Argentina, Australia, New Zealand, or the ocean. The science payload, a prototype gamma-ray telescope named COSI (Compton Spectrometer and Imager), flown on the truncated December 2014 flight from Antarctica is currently planned for re-launch from Wanaka, NZ in April 2016. Plans are underway for conducting a follow-on test flight with a different science payload one year later in April 2017.

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## **TRL Vetting by the Program Office**

Thai Pham, *Program Technologist*

Opher Ganel, *Program Technologist*

The Physics of the Cosmos (PCOS) and Cosmic Origins (COR) 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 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 principal investigator (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?***

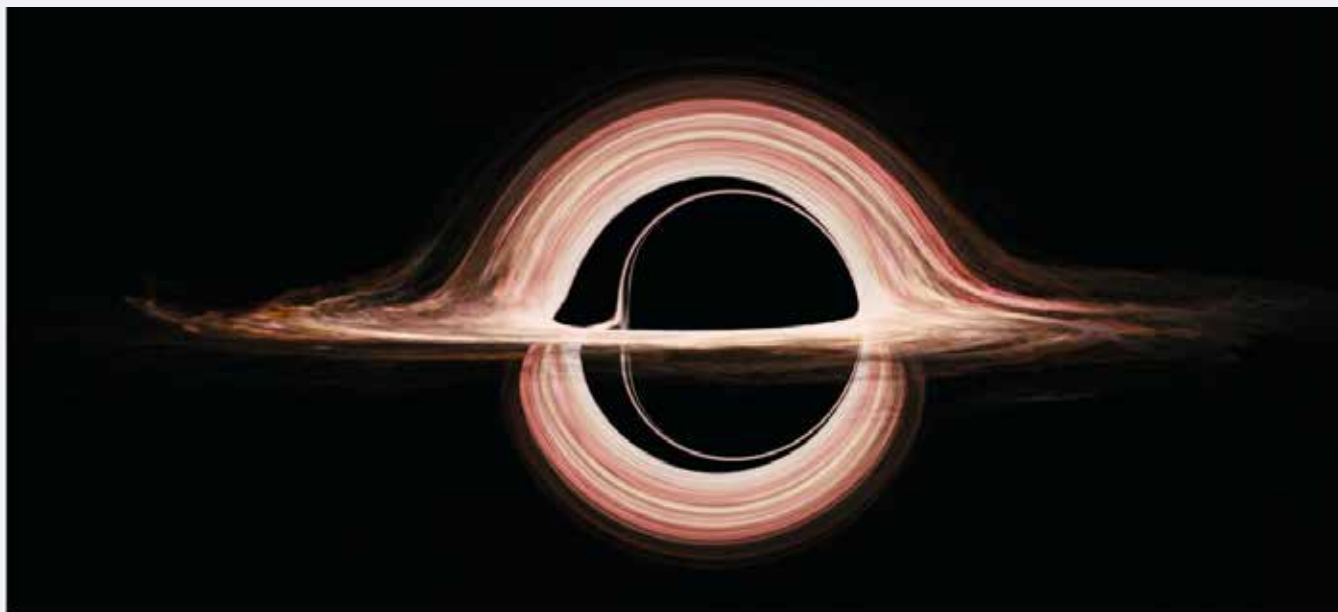
The TRL vetting process is initiated when a PI notifies the PO that the milestones necessary for TRL advancement have been met. The PI then presents the progress to a TMB convened by the PO, which considers the TRL assertion as guided by TRL definitions in NASA Systems Engineering Processes and Requirements, 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 is the benefit 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

## PCOS Science in Hollywood!



The film “Interstellar” relied on some actual physics for many of its visual effects. Caltech physicist Kip Thorne provided the math that the special effects artists turned into movie magic. Image Credit: Oliver James et al., 2015 Class. *Quantum Grav.* **32** 065001. More information: [http://www.iop.org/news/15/feb/page\\_65057.html](http://www.iop.org/news/15/feb/page_65057.html)

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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### Message from the NASA HQ Astrophysics Division Director

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

The enduring science questions for astrophysics—how does the universe work, how did the familiar sky of galaxies and stars come to be, are we alone—form the foundation of the strategic science drivers behind the past five decadal survey documents provided by the National Academy of Science, in-

cluding the 2010 Decadal Survey, *New Worlds, New Horizons in Astronomy and Astrophysics*. As I described during the NASA Town Hall at the 225th meeting of the American Astronomical Society in Seattle, WA, NASA is making progress toward these goals in 2015.

- In 2014, NASA Astrophysics flight missions continued to be highly productive, announcing ground-breaking discoveries every month.
- The FY15 Appropriations Act provides funding for NASA astrophysics sufficient to continue its programs, missions, and projects as planned. The total funding appropriated for NASA astrophysics, including JWST, is \$1.33B, the same as appropriated in FY14. This appropriation fully funds JWST to remain on plan for an October 2018 launch; funds continued pre-formulation and technology work leading toward WFIRST; restores SOFIA to the budget albeit with a 17% reduction from FY14; provides funding for SMD’s education programs; and funds NASA’s core astrophysics research, technology, Explorers, and operating mission programs.
- The astrophysics operating missions continue to generate important and compelling science results, and new missions are under development for the future. Chandra, Fermi, Hubble, Kepler/ K2, NuSTAR, Spitzer, Suzaku, Swift, and XMM-Newton have been awarded mission extensions following the 2014 Senior Review. SOFIA is in prime operations as of May 2014. The next Senior Review for operating missions will be in Spring 2016.
- Missions under development (and their currently planned launch dates) include ISS-LISA Pathfinder (2015), ASTRO-H (no earlier than 2015), CREAM (2016), NICER



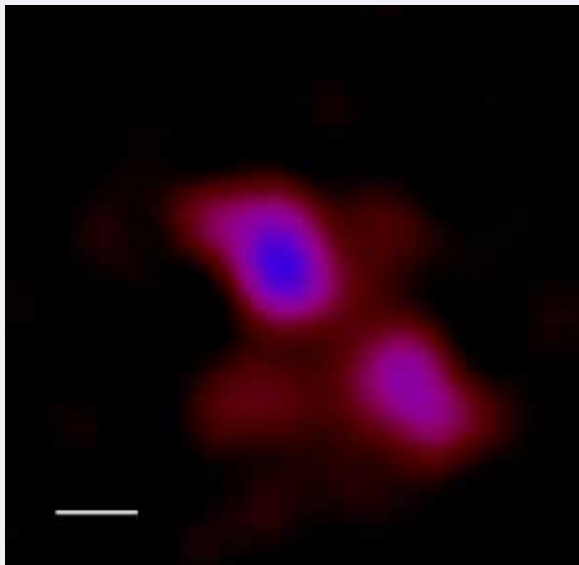
(2016), TESS (2017), JWST (2018), and Euclid (2020). New Explorers will be selected (SMEX in 2015, MIDEX in 2017), and NASA is joining ESA's Athena mission and ESA's L3 gravitational wave observatory.

- JWST continues to make progress. All of the instruments have been reintegrated into the Integrated Science Instrument Module, which is undergoing its final environmental tests in 2015. The telescope backplane is complete, and it will be shipped to GSFC later in 2015 for the start of the primary mirror assembly. JWST remains on cost and on schedule for an October 2018 launch.
- The Hubble Space Telescope 25th Anniversary on April 24, 2015, was celebrated through a series of events including social and traditional media outreach programs; exhibits around the world at museums, airports and other venues; education programs in all 50 states; re-release of the IMAX "Hubble 3D" movie; and many more activities to engage the public, students, and educators worldwide; see <http://hubble25th.org/> for details.
- The pre-formulation study of WFIRST continues in 2015 with the \$50M appropriated for the purpose. In early 2015, the Science Definition Team submitted its report to NASA; it is available at <http://wfirst.gsfc.nasa.gov/>. The

rest of the year will include technology development for the instruments and continued risk mitigation activities for the telescope and the mission.

- NASA and the National Science Foundation have initiated a partnership for Exoplanet research in response to the 2010 Decadal Survey recommendation to "...support an aggressive program of ground-based high-precision radial velocity surveys of nearby stars to identify potential candidates ... for a future space imaging and spectroscopy mission." Initially, the National Optical Astronomy Observatory (NOAO) share of the WIYN telescope will be made available to the U.S. astronomical community using the existing instrumentation for an Exoplanet-targeted Guest Observer program. A NASA-funded facility-class Extreme Precision Doppler Spectrometer for the WIYN telescope will be made available when it is completed around 2018. NASA solicited proposals for instrument development through ROSES, and selected two instrument concepts for that new planet-hunting instrument to study in detail. The two selected concepts were proposed by teams from MIT, led by Principal Investigator Dr. Gabor Furesz; and The Pennsylvania State University, led by Principal Investigator Dr. Suvrath Mahadevan. One of the concepts will be

### XMM-Newton spots monster black hole hidden in tiny galaxy



*X-ray emission from dwarf galaxy J1329+3234. The white bar indicates a width of 10 arcseconds, equivalent to 3.3 kpc at the distance of this galaxy. Credit: ESA/XMM-Newton/N. Secrest, et al. (2015)*

First impressions can be deceptive—astronomers have used ESA's X-ray satellite XMM-Newton to find a massive black hole hungrily feeding within a tiny dwarf galaxy, despite there being no hint of this black hole from optical observations.

The galaxy, an irregular dwarf named J1329+3234, is one of the smallest galaxies yet to contain evidence of a massive black hole. Located over 200 million light-years away, the galaxy is similar in size to the Small Magellanic Cloud, one of our nearest neighbouring galaxies, and contains a few hundred million stars.

The combined X-ray and infrared properties of this galaxy can only be explained by the presence of a massive black hole residing in J1329+3234, similar to the supermassive black holes found at the centers of much more massive galaxies.

While the exact mass of the black hole is not known, it must be at least 3000 times as massive as the Sun, although it is likely to be much more massive than that. If the black hole in J1329+3234 is similar to known low-mass supermassive black holes, then it has a mass of around 150,000 times that of the Sun.

Finding a massive black hole within such a tiny bulgeless galaxy provides support for the theory that black holes may have grown very efficiently within the gaseous haloes of forming galaxies, originating in massive, collapsing clouds of primordial gas.

In recent years, growing numbers of massive black holes have been identified within dwarf and bulgeless galaxies. However, it is much harder to find them than it is to find their supermassive counterparts – they are less likely to show up in optical studies since they are often obscured by dust and are usually much dimmer, making them difficult to detect above surrounding light.

This emphasizes the importance of multi-wavelength sky surveys, says ESA's XMM-Newton project scientist Norbert Schartel. "Using a mix of optical, infrared, and X-ray observations was vital here," he adds. "The sensitivity of XMM-Newton made it possible not only to discover this black hole but to also fully characterize its spectrum, meaning we can say with much more certainty that it's a black-hole-fuelled [active galactic nuclei] AGN."

Read the full press release at <http://sci.esa.int/xmm-newton/55114-xmm-newton-spots-monster-black-hole-hidden-in-tiny-galaxy/>

## Meet the Einstein Fellows: Nicholas Stone



Nicholas Stone was born in Manhattan but grew up in Silver Spring, Maryland, a suburb of Washington, DC. He received a Bachelor of Arts from Cornell University in 2008, triple majoring in mathematics, physics, and economics. In 2013, he obtained a Ph.D. in Astronomy & Astrophysics from Harvard University, and since then has been a postdoctoral researcher at Columbia University. Nicholas's research covers several topics, mostly focused on stellar dynamics in dense star clusters. A recurring interest is the tidal disruption of stars by supermassive black holes (SMBHs)—violent events that offer a natural laboratory to study extremes of accretion astrophysics, and which should serve as a valuable probe of SMBH demographics in the Large Synoptic Survey Telescope (LSST) era. His past work on the subject has examined many different aspects of these events, from the stellar dynamical processes that set their rates to the evolution of the resulting accretion flows. He has also studied short gamma ray bursts, and indirect signatures of exoplanetary systems around white dwarf stars. As an Einstein Fellow at Columbia University, Nicholas will extend his past research on tidal disruption events, focusing on interesting open problems such as the circularization of stellar debris and the uncertain origins of observed optical emission. He will also work on other problems, including the formation of supermassive black hole seeds in collisional runaways, and the evolution of circumbinary disks around SMBH binaries.

selected for implementation next year following an instrument concept study.

- An Announcement of Opportunity for the Astrophysics Explorers Program was released in September 2014, and approximately 25 proposals were received before the December 18, 2014, due date. The target for Step 1 selections is summer 2015 (for additional information, see <http://explorers.larc.nasa.gov/APSMEEX/>).
- The Astrophysics Research Program had a proposal selection rate of between 11% and 56% for ROSES R&A competitions in 2014, with an overall average proposal selection rate of ~20% across all of astrophysics; the details are available in my January 2015 AAS Town Hall presentation. There will be no solicitation for proposals for the Astrophysics Theory Program (ATP) in 2015; there is no loss in ATP funding, just re-synching the solicitation schedule with the availability of funding to reduce the long waiting period for the distribution of funds.
- Progress continues to be made towards achieving 2010 Decadal Survey priorities through strategic technology development and partnerships, as described in earlier newsletters. A “scoreboard” of progress against Decadal Survey prioritized recommendations is available in my Town Hall

presentation, as well as my subsequent presentations to the Astrophysics Subcommittee and the Committee on Astronomy and Astrophysics.

- The Astrophysics Mid-Decade Review will be conducted during 2015–2016. The study will be co-sponsored by NASA, NSF, and DOE, which have charged the National Research Council. The formation of the study committee is underway.
  - A major activity for the Astrophysics Division this year is beginning preparation for the 2020 Decadal Survey. To enable prioritization of large space mission concepts to follow JWST and WFIRST by the 2020 Decadal Survey Committee, NASA needs to conduct mission concept studies and initiate technology development for candidate large space missions. NASA's plans are described in Planning for the 2020 Decadal Survey: An Astrophysics Division White Paper, available at <http://science.nasa.gov/astrophysics/documents/>.
- My entire Town Hall presentation from the January 2015 AAS meeting, as well as the 2014 Update to the Astrophysics Implementation Plan, is available at <http://science.nasa.gov/astrophysics/documents/>

## Honorary Degree Awarded to Fermi Project Scientist, Julie McEnery

On June 16, 2015, Dr. Julie McEnery was awarded an Honorary Degree of Doctor of Science from University College, Dublin. The award was given for leadership in gamma-ray astrophysics and for bridging the divide between the ground- and space-based gamma-ray communities. Julie received her Ph.D. in Physics from University College Dublin in August 1997. Congratulations to Julie for this prestigious award!



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## Calendar of Upcoming PCOS/PhysPAG Events

August 3–14, 2015	XXIX IAU General Assembly, Honolulu, HI <ul style="list-style-type: none"><li>• PCOS Booth</li><li>• Joint PAG Meeting</li></ul>
October 2015	Einstein Fellows Symposium, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA
January 4–8, 2016	AAS 227th Meeting, Kissimmee, FL <ul style="list-style-type: none"><li>• PCOS Booth</li><li>• SIG Meetings (Details TBA)</li></ul>
April 3–7, 2016	AAS/HEAD Fifteenth Divisional Meeting, Naples, FL <ul style="list-style-type: none"><li>• SIG Meetings (Details TBA)</li></ul>
April 16–19, 2016	APS Meeting, Salt Lake City, UT <ul style="list-style-type: none"><li>• PCOS Booth</li><li>• SIG Meetings (Details TBA)</li></ul>

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