National Aeronautics and Space Administration

Physics of the Cosmos Newsletter

March 2012 Vol. 2 No. 1

Program Manager's Perspective

Mansoor Ahmed, *PCOS Program Manager*

The PCOS program accomplished a great deal this quarter. The X-ray and Gravitational Wave study teams evaluated the RFI inputs and are formulating notional mission concepts and evaluating each science case relative to the science priorities outlined in the New Worlds New Horizons (NWNH) decadal survey. By this summer, these teams will have determined what fraction of the IXO and LISA science can be achieved at different cost points. The results of these analyses will be presented to the science community, through the National Research Council's Committee on Astronomy and Astrophysics (CAA). Assuming that the CAA will endorse the science case for a particular cost range, the PCOS program will continue working with the community to develop science and mission requirements for the mission concept(s) and define specific technology development plans for the mission concept(s). These studies are critical in program strategic planning and preparations for a mid-decadal review. Interested community members can follow the progress on the study websites: (see "Studies" under pcos.gsfc.nasa.gov)

Following the release of the Program Annual Technology Report (PATR) in December 2011, we are now into our first quarter of the new technology management process. This process was designed to link technology funding to science objectives through discussions with the community about technology needs and a transparent prioritization of those needs by the PCOS program. The PATR is referenced in the call for Strategic Astrophysics Technology (SAT) proposals, which was also released in December 2011. I highly encourage technology developers proposing to the SAT to review the PCOS PATR as part of their process.

Contents

With the release of the PATR, the next phase of our conversation with the community begins. 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 PhysPAG and by visiting the PCOS website at http://pcos.gsfc.nasa.gov/.

We in the Program Office look forward to continuing our discussions with the community to plan the future of PCOS science. Even with the travel restrictions, the Program Office will have a presence at the AAS Anchorage meeting in June and the SPIE Instrumentation meeting in Amsterdam in July. We are also supporting the PhysPAG workshop in Washington, D.C., in August. Please take advantage of these opportunities for face-to-face discussions even as you engage in other ways.

PCOS Science

Ann Hornschemeier, *PCOS Chief Scientist*

The Physics of the Cosmos (PCOS) program spans the fields of fundamental physics, cosmology, and high-energy astrophysics, and includes a wide range of science goals. Below I give a snapshot of program activities divided by the five core PCOS science areas in our program plan. Note that I highlight a single area of future scientific measurement under each topic, although of course there is significant scientific overlap (e.g., gravitational wave facilities will study the formation and growth of massive black holes, and X-ray facilities will investigate the nature of spacetime around compact objects and constrain cosmological parameters via studies of clusters). Please consider this to be the start of a scientific conversation with your new PCOS program chief scientist.

Test the validity of Einstein's General Theory of Relativity and investigate the nature of spacetime: LISA was named as a top-ranked mission under NWNH large space-based projects. PCOS is currently supporting a study of possible space-based gravitational wave observatories at lower cost points, which involves engineering studies via the TEAM-X facility at JPL; please see Tuck Stebbins report (p. 7). The NASA Advisory Committee Astrophysics Subcommittee (NAC ApS) has also approved a new Gravitational Wave Science Analysis Group

(GWSAG) under the PhysPAG (see Steve Ritz report, p. 4), which will meet for the first time at the August 2012 PhysPAG workshop.

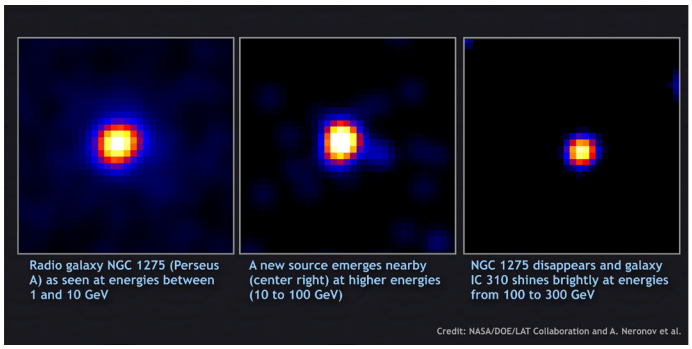
Precisely measure the cosmological parameters governing the evolution of the universe and test the inflation hypothesis of the Big Bang: The Planck mission is now returning important new constraints on foregrounds in Cosmic Microwave Background (CMB) measurements. Going forward, the primary scientific measurement pursued here is that of the B-mode of polarization of the Cosmic Microwave Background; the program office is working towards a future study of Inflation Probe concepts. Technology development for such a mission was called out by NWNH as a top priority among medium-sized space-based projects. We also continue to work with the IPSAG under the PhysPAG to track technology/measurement developments in both ground-based and suborbital experiments to contrain B-mode polarization of the CMB.

Expand our knowledge of dark energy: The Program office has supported NASA's activities for the ESA Euclid mission, including both instrument and scientific support; please see Rita Sambruna's article for more details (PCOS HQ Program Scientist, p. 3). The Program Office is also working with the PhysPAG on its August 2012 workshop; which includes the focus area of dark energy measurements from space (see the piece by Steve Ritz, PhysPAG chair, p. 4). We also are continuing our conversation with the WFIRST study team, regarding dark energy science. As a reminder, programmatically, the WFIRST study falls under the Exoplanet Program, with the science of dark energy falling under the Physics of the Cosmos program.

Understand the formation and growth of massive black holes and their role in the evolution of galaxies: Both Chandra and XMM-Newton continue to produce fantastic new results. Going forward, IXO was named a top-ranked mission under NWNH large space-based projects. PCOS is currently supporting a study of possible space-based X-ray observatories at lower cost points, which involves engineering studies via the Mission Design Lab at GSFC; please see Rob Petre's report (p. 5). The NAC ApS has also approved a new X-Ray Science Analysis Group (XRSAG) under the PhysPAG which will meet for the first time at the August 2012 PhysPAG workshop (see p. 4).

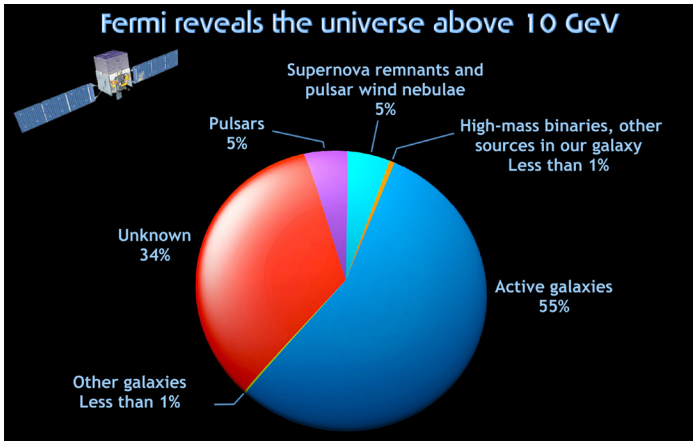
Explore the nature of matter and energy in its most extreme environments: Fermi's (see press release) gamma-ray capabilities enable studies of particle acceleration in a wide variety of extreme environments, as well as searches for signatures of particle dark matter and tests of fundamental physics. For the future, the NAC ApS has approved a Gamma Ray Science Analysis Group (GRSAG) under the PhysPAG which will meet for the first time at the August 2012 PhysPAG workshop (see p. 4). The program office looks forward to continued conversations with the gamma-ray and cosmic-ray communities regarding future plans.

NASA's Fermi Reveals the Universe Above 10 GeV

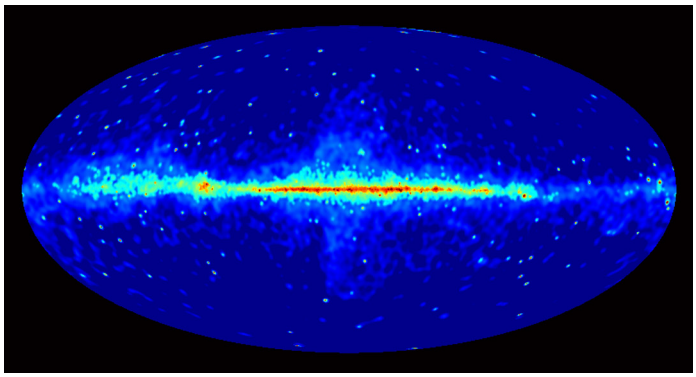


After more than three years in space, NASA's Fermi Gamma-ray Space Telescope is extending its view of the high-energy sky into a largely unexplored electromagnetic range. The Fermi team has announced its first census of energy sources in this new realm.

Fermi's Large Area Telescope (LAT) scans the entire sky every three hours, continually deepening its portrait of the sky in gamma rays, the most energetic form of light. At higher energies, above 10 GeV, gamma rays are rare. Before Fermi, only four discrete sources above 10 GeV were known, all pulsars. With the LAT, hundreds of sources have been found.



More than half of the 496 sources in the new census are active galaxies. Only about 10 percent of the known sources lie within our own galaxy. More than a third of the sources are completely unknown. With the new catalog, astronomers will be able to compare the behavior of different sources across a wider span of gamma-ray energies for the first time.



See full article at http://www.nasa.gov/mission_pages/GLAST/news/energy-extremes.html

News from the Astrophysics Division at NASA Headquarters

Jaya Bajpayee, *PCOS Program Executive*
Rita Sambruna, *PCOS Program Scientist*

Presidential Budget Release for FY2013

On Monday, February 13, 2012, the President released the proposed budget for federal agencies for FY2013. The requested total budget for NASA is $17.7B. The Science Mission Directorate, which houses the Astrophysics Division (APD), would receive $4.9B. The Astrophysics Division would receive $659M, while an additional $628M are allocated to support the continued development of the James Webb Space Telescope for a launch in 2018, as requested by the Agency re-plan.

PCOS Science and Missions Update

The PCOS astrophysics community has a lot to look forward to in the next several years. All the PCOS-related missions in their extended or prime phase (Chandra, Fermi, Planck, Suzaku, Swift, XMM-Newton) continue to operate nominally, enabling breakthrough science on a regular basis. RXTE was decommissioned on January 5, 2012, leaving behind a rich archive for new discoveries. A Symposium celebrating the productive life of RXTE will be held at NASA's Goddard Space Flight Center on March 29–30, 2012 (for more information, please visit http://heasarc.gsfc.nasa.gov/docs/xte/whatsnew/rxte_celebrate.html).

In March 2012, NASA will launch NuSTAR, which will map the high-energy X-ray sky at unprecedented resolution above 10 keV, enabling the discovery and study of many high-energy X-ray sources. Development of both Astro-H (in partnership with Japan's JAXA) and GEMS continue on schedule for planned launches in 2014. Potential international collaborations and partnerships on major missions, with significant science return for U.S. astronomers, are underway, such as the dark energy mission Euclid (see below). We commend the members of our community for remaining productive and achieving exceptional science by new and creative ways.

NASA Participation in Euclid

The European Space Agency (ESA) has selected Euclid as the medium-class mission M2 for launch in 2019. Using a 1.2 m telescope and with a 0.5 degree field of view, Euclid will perform a large-area sky survey allowing the study of distant galaxies via imaging in the optical and near-infrared spectroscopy, leading to measurements of the acceleration of the universe, and putting constraints on the nature of dark energy. It will also conduct a legacy science program that includes a microlensing search for exoplanets.

To evaluate potential NASA participation in Euclid and its relationship with the Decadal-recommended WFIRST, the National Research Council (NRC) convened a panel of experts. The Committee on the Assessment of a Plan for U.S. Participation in Euclid met in Washington, D.C. on January 18–20, 2012, for its final deliberations. A written report was delivered to NASA and the public on February 3 (see http://www.nap.edu/catalog.php?record_id=13357). The panel recommended that NASA proceed forward with a hardware contribution to Euclid of $20M in exchange for NASA participation in the Euclid Science Team (one scientist) and the inclusion of a team of U.S. scientists in the Euclid Consortium, allowing full access to Euclid data and authorship rights consistent with Euclid policies still to be formulated. NASA will issue a call to select the U.S. team in April 2012.

A letter of intent for NASA to participate in Euclid was sent to ESA on February 13, 2012. A Memorandum of Understanding with ESA will be negotiated by April 2012 and signed after Euclid is confirmed for implementation by the ESA Science Programme Committee in June 2012.

WFIRST Activities

Recent activities include two back-to-back conferences at Caltech. The first, held February 13–15, 2012, focused on science to be produced with an IR wide-field imager, and the second, on February 15–17, 2012, was on microlensing for exoplanet searches. A meeting-in-a-meeting related to WFIRST science will be held at the 220th AAS meeting in Anchorage, Alaska on June 10–14, 2012.

After a hiatus following the delivery of the interim Design Reference Mission (DRM) in July 2011 (http://wfirst.gsfc.nasa.gov/), the WFIRST Science Definition Team (SDT) is back at work. In light of the Euclid selection, and the continuous progress of the Large Synoptic Survey Telescope (LSST) and JWST, the WFIRST SDT was tasked with (1) continuing the development of the DRM started in 2011, in particular identifying key technology to fulfill the Decadal science goals, and options for reducing overall cost; and (2) developing a final DRM for WFIRST that does not duplicate the capabilities of Euclid, LSST, and JWST.

The SDT is requested to deliver an interim report no later than April 30, 2012, and a final DRM report to the Astrophysics Division no later than June 30, 2012.

To help accomplish the previous goals, the WFIRST SDT was augmented by the addition of the following new members:

- Chris Hirata, Caltech
- Dave Weinberg, Ohio State University
- Xiaohui Fan, Arizona State University
- Jason Kalirai, STScI
- Nikhil Padmanabhan, Yale University

The SDT met on February 2–3, 2012. The next in-person meeting will be March 1–2, 2012, at GSFC.

Personnel News

On January 4, 2012, we welcomed the arrival of the new SMD Associate Administrator, Dr. John Grunsfeld. Dr. Grunsfeld, an astrophysicist and former astronaut, joined us from the Space Telescope Science Institute, where he was the Deputy Director.

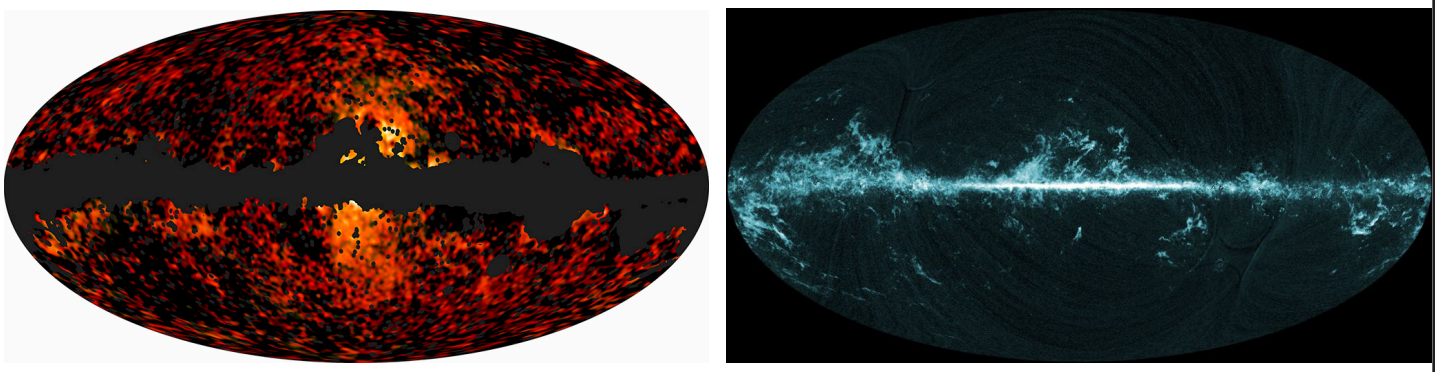
Mr. Geoff Yoder, previous Acting Division Director and Deputy Director of APD, left in January 2012 to assume another position within the Agency. We thank Geoff for his service to APD and his many contributions. Dr. Paul Hertz, SMD Chief Scientist, was appointed Division Director, and Mr. Michael Moore, Associate Director for Innovation and Technology (acting), was appointed Acting Deputy Director.

PhysPAG Report

Steve Ritz, *Chair of the Executive Committee*

Our face-to-face meeting was held on Sunday, January 8, 2012, at the AAS meeting in Austin, Texas. The agenda can be found on the PCOS website here: http://pcos.gsfc.nasa.gov/physpag/meetings/physpag-meeting3.php. Two Special Focus sessions addressed X-ray and Gravitational Wave opportunities in a changing landscape, including international perspectives, and there were also discussions about technology road mapping and planning for possible future Inflation Probe and gamma-ray missions. Representatives from NASA HQ and the PCOS Office were on hand to answer questions and to participate in the lively discussion. Many thanks to all speakers and

New Planck Maps Reveal Unseen Details Across the Milky Way



The mysterious Galactic Haze (left) and the all-sky distribution of molecular gas (right) seen by Planck. Credit: ESA/Planck Collaboration

An unambiguous detection of the Galactic Haze—a mysterious, diffuse emission from the central portion of the Milky Way—and the first all-sky map of carbon monoxide, whose emission traces the molecular clouds where stars are born, are among the results being presented by the Planck Collaboration at an international conference held from 13 to 17 February 2012, in Bologna, Italy. These results have been achieved during the complex task of identifying and removing the foreground contamination due to Galactic and extragalactic emission that obscures the Cosmic Microwave Background.

The primary goal of ESA's Planck satellite is to observe the Cosmic Microwave Background (CMB), the relic radiation from the Big Bang, and to measure its tiny fluctuations across the sky with unprecedented accuracy. These anisotropies contain all-important information about the constituents of the Universe and the origin of cosmic structure. Along with the CMB, Planck also sees almost every source that shone throughout cosmic history. This includes emission from individual galaxies and, most notably, from the interstellar medium (ISM) in our Galaxy, the Milky Way. Diffuse emission from this mixture of gas and dust represents the dominant source of foreground contamination to the CMB at all frequencies of interest across the entire plane of our Galaxy.

The Galactic foreground emission measured by Planck is mostly produced by free electrons and dust present in the ISM. Electrons radiate mainly via two physical processes: they emit synchrotron radiation as they spiral across the Galactic magnetic field, and free-free (or bremsstrahlung) radiation when being decelerated in the presence of protons or heavier ions. Both synchrotron and free-free radiation are most intense at the lowest frequencies probed by Planck. Interstellar dust on the other hand, with temperatures typically below 20 K, shines brightly in the far-infrared and sub-millimetre portions of the electromagnetic spectrum, thus contributing to the emission detected by Planck's high-frequency channels. In addition, nano-scale spinning grains of dust emit at Planck's lowest frequencies—the so-called anomalous microwave emission.

Fortunately for astronomers, these four radiation processes exhibit quite different spectral properties. With its nine frequency channels, spanning the range between 30 and 857 GHz, Planck boasts unprecedented spectral coverage that greatly facilitates the task of identifying and isolating the various sources of emission. Apparently, however, the four processes do not completely account for all Galactic foreground emission.

Hints of this component, dubbed Galactic Haze, were already present in data from NASA's Wilkinson Microwave Anisotropy Probe (WMAP), but the detection had—at least until now—remained uncertain. "Thanks to Planck's high frequency measurements we can better characterise thermal dust emission, and this, combined with refined data-analysis tools, means that the detection of the Galactic Haze is now unambiguous," adds Davide Pietrobon from JPL/Caltech, another Planck team member.

See full article at http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=50004

participants for a very productive meeting! We also held a special AAS session on January 10, 2012, summarizing the activities of all the PAGs (PhysPAG, Cosmic Origins COPAG, and Exoplanets ExoPAG).

Looking forward, with approval at the recent NAC/APS meeting, we are starting three new Science Analysis Groups (SAGs) to serve as community focal points for planning in Gravitational Waves (GWSAG; chaired by Guido Mueller), X-rays (XRSAG; chaired by Jay Bookbinder), and gamma rays (GRSAG; chaired by Liz Hays). More details to follow soon.

As previously reported, the Inflation Probe SAG (IPSAG, chaired by Shaul Hanany) has been very active this year, providing a community focal point for discussions and producing a technology roadmap in close coordination with the TechSAG, and this work will continue. The TechSAG was also very active, providing broad community inputs to NASA PCOS technology planning. Many thanks to all the participants for their excellent work, with special thanks to Roger Brissenden for his very effective leadership of the TechSAG and his service as a PhysPAG Executive Committee member. The TechSAG work will now move to the four continuing SAGs (IPSAG, X-ray SAG, GWSAG, and GammaSAG), with cross-discipline coordination for annual technology inputs provided by the PhysPAG Executive Committee. Roger is rotating off the Executive Committee, and he is succeeded by Jay Bookbinder (SAO). Many thanks, again, Roger, and welcome, Jay!

Our next big event will be a three-day meeting in Washington, D.C. in August (preliminary dates are 14–16 August). The first day will feature detailed reports on the X-ray and Gravitational Wave studies that will be completed shortly beforehand. This will be the first opportunity for the broader PCOS community to hear about and discuss the results of these important studies. In addition, Day 1 will include information exchanges with NASA HQ and the PCOS Program, and a Special Focus session on space-based Dark Energy studies (organized by Jason Rhodes). Day 2 will be largely devoted to parallel SAG meetings, and the morning of Day 3 will include full-group plenary sessions for reports from the parallel meetings and further discussions. The afternoon of the third day will be available for other satellite meetings and other discussions. Workshop plans will be available at http://pcos.gsfc.nasa.gov/physpag/physpag-workshop-2012.php. Please pre-register today!

In 2013, we are planning to have PhysPAG meetings and events at the January AAS and April American Physical Society meetings, as well as at other topical and Division meetings. The Executive Committee welcomes your ideas and feedback, as we are aiming to have expanded participation at future PhysPAG meetings. Please get involved!

The Physics of the Cosmos Program Analysis Group (PhysPAG) provides important conduits for information exchange across Physics of the Cosmos (PCOS) subfields in the community and with the PCOS Program Office at NASA Goddard and HQ. PhysPAG is open to the entire community, and everyone is encouraged to participate. Visit the webpage at http://pcos.gsfc.nasa.gov/physpag/. Here you can find news, links to the presentations from recent meetings, and sign up to receive announcements. Some of our recent reports to the Astrophysics Subcommittee can be found here: http://science.nasa.gov/science-committee/subcommittees/nac-astrophysics-subcommittee/.

The current members of the PhysPAG Executive Committee are Jason Rhodes (JPL), Shaul Hanany (Minnesota), Jay Bookbinder (SAO), Liz Hays (Goddard), Guido Mueller (U. Florida), and Steve Ritz (UCSC). You can sign up for the PhysPAG mailing list at: http://pcos.gsfc.nasa.gov/physpag/physpag-announcements.php.

X-ray Astronomy Mission Concept Study

Rob Petre, *Study Scientist*
Gerry Daelemans, *Study Manager*

PCOS is well underway implementing a study of missions that would fulfill some or all of the scientific objectives of the International X-ray Observatory (IXO) at lower cost. Specifically, the study will assess the range of IXO objectives that can be achieved at a variety of cost points, ranging from $300M to $2B. The study results will be presented to NASA Headquarters in June 2012, and subsequently to the Committee for Astronomy and Astrophysics (CAA) as input for its deliberations about implementation of the recommendations of the 2010 Decadal Survey.

A Request for Information (RFI), soliciting from the community white papers about mission concepts and enabling technology, yielded 29 responses. Approximately half of these describe mission concepts. The others describe enabling technology or programmatic strategies. All RFI responses have been posted on the X-ray Astronomy Mission Study page of the PCOS Program Office website (http://pcos.gsfc.nasa.gov/studies/xray/x-ray-mission-rfis.php).

The PCOS X-ray Study Team, which includes a Community Science Team (CST) chaired by Joel Bregman (University of Michigan), held an open workshop on the December 14th and

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15th at the Maritime Institute, Linthicum, Maryland, inviting all RFI respondents to speak, and the entire X-ray astrophysics community to attend. There was much discussion about each mission concept and enabling technology, and about the future of X-ray astronomy.

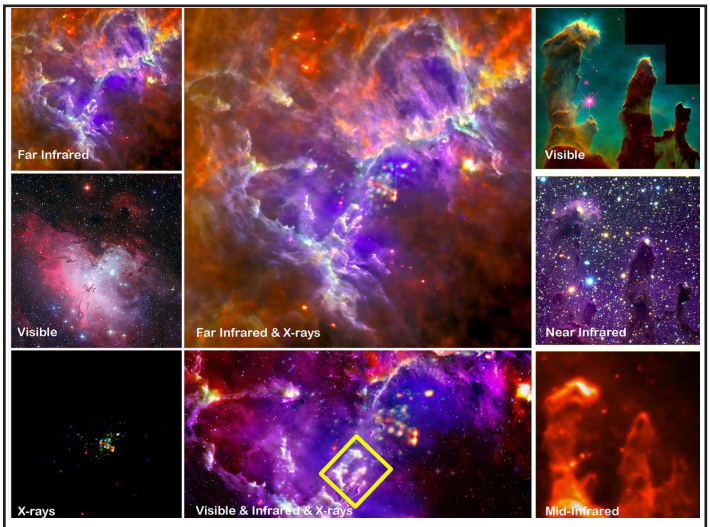
The Study Team participated in two events at the Austin AAS meeting. The study activities were presented at the PhysPAG meeting. The Study Team also hosted an open town hall meeting to update the X-ray community about the status of the study and to solicit feedback from AAS members who did not attend the December workshop.

Based on it analysis of the RFI responses and the feedback it received from the X-ray astrophysics community, the Study Team has decided to study three concepts:

- A grating spectrometer with ~500 cm^2 effective area and spectral resolution of 3000 in the 0.2–2.0 keV band. Low earth orbit and L2 options are being considered.
- A calorimeter instrument with 2–3 eV across the 0.2–10.0 keV band, effective area of 5000 cm^2 at 1 keV and 2000 cm^2 at 6 keV, angular resolution of 10 arcsec and field of view 4 arcmin.
- A wide field imaging mission with effective area of 5000 cm^2 at 1 keV and 2000 cm^2 at 6 keV, a 20 arcmin field of view and 5 arcsec angular resolution. A 3–5 year lifetime at L2 is envisioned here as well.

For the ~$2B concept, the Study Team is using AXSIO, which has already been studied and costed using the methodology being used for the other concepts.

The study of these concepts, using the Goddard instrument and mission design laboratories, will allow validation of their science content, feasibility, and cost. As an ensemble, these concepts enable the Study Team to characterize the full suite of



XMM-Newton Continues to Broaden Our View of the High Energy Universe

Astronomers working with XMM-Newton, Chandra, and optical telescopes, have found a strange object—a very slowly rotating pulsar embedded in the young supernova remnant that made it. The pulsar, named SXP 1062, is located in the Wing of the Small Magellanic Cloud (SMC) and is part of a binary system and is accreting mass from a Be star. With a rotation period of 1,061 seconds, it is one of the slowest pulsars ever observed. Pulsars are born rotating very rapidly, and spin down as they age. Normally, such slow rotation indicates the pulsar is very old; however, the supernova remnant in this case dates to between 20,000 and 40,000 years old, which is fairly young.

Exactly why this young pulsar is rotating so slowly is still a mystery. It is unclear if it was born with a normal, fast spin rate and slowed down more quickly than usual (and, if that is the case, by what mechanism it slowed down so rapidly), or if it was born with a much slower rotation rate than expected. Further, the Wing of the SMC is a very interesting region, known to have a low density of stars, gas, and dust, and much lower metallicity than the Milky Way; it is possible that the environment could have influenced the pulsar's progenitor star's characteristics such that it could generate a slowly rotating pulsar when it died in a supernova cataclysm.

The results highlight the usefulness of complementary observatories. The study relied on XMM-Newton's large effective area to achieve high sensitivity observations of the pulsar and the supernova remnant over a broad X-ray bandpass. These data were examined in conjunction with Chandra images, which examined the object with higher angular resolution, but with lower sensitivity. This combination gave astronomers an in-depth look at the pulsar's X-ray emission. The optical images completed the picture of the system, showing the bubble-like nebula around the system, which appears to be the remnant of the supernova that created the pulsar.

Data from XMM has also been combined with that from Herschel to provide a view of the Eagle Nebula (the location of the iconic "Pillars of Creation") as it has never been seen before, with a stunning combination of X-ray and IR images. In the IR, Herschel detects cold dust, while in the X-ray band, radiation from hot stars can be seen. The X-ray data is being used to investigate the hypothesis that a supernova explosion several thousand years ago triggered star formation in the nebula. The images can be seen here: http://www.esa.int/esaCP/SEMG4NMXDXG_index_1.html

IXO science that can be accomplished at the lower price points called out in the RFI.

Over the coming months, the Study Team will execute the design laboratory runs, integrate and analyze all the results, and produce the final report for NASA HQ in July. An interim report is now posted on the PCOS website.

Please contact us at robert.petre-1@nasa.gov or gerard.j.daelemans@nasa.gov

Gravitational Wave Mission Concept Study

Tuck Stebbins, *Study Scientist*
Ken Anderson, *Study Manager*

The PCOS Program is developing alternative plans to address the high priority LISA science objectives described in the 2010 Astrophysics Decadal Survey report. The PCOS Program is working with the gravitational astrophysics community to develop concepts at multiple cost points for presentation to the NRC's Committee on Astronomy and Astrophysics (CAA) this summer.

As the first part of this effort, a Request for Information (RFI) was issued to the community on September 27, 2011. Seventeen responses were received. These responses may be viewed on the PCOS website (http://pcos.gsfc.nasa.gov/studies/gravitational-wave-mission.php).

On October 7th, a call for the Community Science Team (CST) was issued. The CST is co-chaired by Rainer Weiss (MIT) and Ned Wright (UCLA), and includes Peter Bender (Jila/U. Colorado), Joan Centrella (GSFC), Neil Cornish (Montana State, Bozeman), Jens Gundlach (U Washington), Ron Hellings (Montana State, Bozeman), Guido Mueller (U Florida), Holger Mueller (U Cal Berkeley), and Tom Prince (Caltech). A Core Science Team and a Core Engineering Team are in place to provide science and engineering support to the program office. The Core Team members come from JPL and GSFC. A Science Task Force of volunteers from the gravitational-wave community has organized to provide science analysis of mission concepts.

The PCOS Program Office hosted a gravitational-wave mission concepts workshop on December 20–21, 2011, at the Maritime Institute in Linthicum, Maryland. The workshop brought together the gravitational-wave and astrophysics communities with the CST and the Core Team to explore the concepts submitted in response to the RFI. A preliminary science analysis of the concepts, and all their options, based on the submitted sensitivity curves, was presented. Technical issues were discussed. The CST tentatively recommended three concepts to go forward for further refinement. The selected concepts were: (1) a descoped version of LISA called SGO-Mid, (2) an alternative small satellite approach entitled OMEGA, and (3) one of two non-drag free mission concepts. The specific non-drag free selection was conditional on further analysis of the expected science return.

Meet the Einstein Fellows: Amy Reines

In the early universe, the "seeds" of supermassive black holes are believed to have formed in the low-mass progenitors of today's massive galaxies. However, the birth and growth of these high-redshift black holes are poorly constrained by observations. Amy Reines and her collaborators have recently identified an accreting million-solar-mass black hole in the nearby, bulgeless, dwarf starburst galaxy Henize 2-10. This discovery offers the first opportunity to study a growing black hole in a nearby galaxy resembling those in the early universe, and opens up an entirely new class of host galaxies in which to search for the smallest black holes. Moreover, this finding has important implications for our understanding of the evolution of galaxies and their central black holes. In particular, the lack of a discernible bulge in Henize 2-10 indicates that black hole growth can precede the build-up of galaxy spheroids, which has been a long-standing debate in the community.

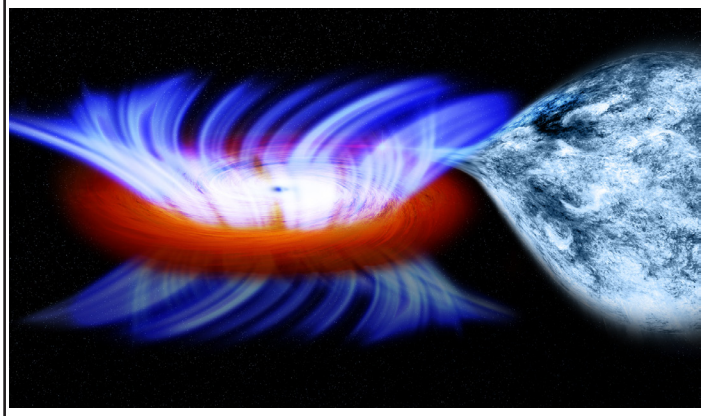
During her Einstein Fellowship, Amy will search for other examples of massive black holes in star-forming dwarf galaxies to begin to characterize them as a population and help constrain theoretical models for the formation of primordial seed black holes. Amy will use X-ray observations from the Chandra X-ray Observatory and radio observations from the Jansky Very Large Array to probe the radiative signatures of black hole growth that can be hidden at optical wavelengths by intense star formation.

Amy earned a B.S. in Astronomy from the University of Maryland and an M.S. in Physics from San Francisco State University. After working outside of academia for a few years, Amy earned her Ph.D. in Astronomy from the University of Virginia, where she was a NASA Earth and Space Science Fellow. She began her Einstein Fellowship in August 2011 at the National Radio Astronomy Observatory in Charlottesville, Virginia.

Since the Workshop, the three concepts have been further analyzed by the Core Team and the CST. Input materials for the Team-X studies are in preparation.

The acceleration and displacement noise budgets for the two non-drag-free concepts were examined for consistency, completeness and correctness. Despite the additional work, the noise budgets remain a concern. Science performance analysis did not clearly differentiate between the two concepts. The LAGRANGE concept was selected because it is expected to have a lower cost.

NASA'S Chandra Finds Fastest Wind From Stellar-Mass Black Hole



Credit: Illustration: NASA/CXC/M. Weiss

Astronomers using NASA's Chandra X-ray Observatory have clocked the fastest wind yet discovered blowing off a disk around a stellar-mass black hole. This result has important implications for understanding how this type of black hole behaves. The record-breaking wind is moving about 20 million mph, or about 3 percent of the speed of light. This is nearly 10 times faster than had ever been seen from a stellar-mass black hole.

Stellar-mass black holes are born when extremely massive stars collapse. They typically weigh between five and 10 times the mass of the sun. The stellar-mass black hole powering this super wind is known as IGR J17091-3624, or IGR J17091 for short.

"This is like the cosmic equivalent of winds from a category five hurricane," said Ashley King from the University of Michigan, lead author of the study published in the Feb. 20 issue of *The Astrophysical Journal Letters*. "We weren't expecting to see such powerful winds from a black hole like this."

The wind speed in IGR J17091 matches some of the fastest winds generated by supermassive black holes, objects millions or billions of times more massive.

Another unanticipated finding is that the wind, which comes from a disk of gas surrounding the black hole, may be carrying away more material than the black hole is capturing.

"Contrary to the popular perception of black holes pulling in all of the material that gets close, we estimate up to 95 percent of the matter in the disk around IGR J17091 is expelled by the wind," King said.

Unlike winds from hurricanes on Earth, the wind from IGR J17091 is blowing in many different directions. This pattern also distinguishes it from a jet, where material flows in highly focused beams perpendicular to the disk, often at nearly the speed of light.

Simultaneous observations made with the National Radio Astronomy Observatory's Expanded Very Large Array showed a radio jet from the black hole was not present when the ultra-fast wind was seen, although a radio jet is seen at other times. This agrees with observations of other stellar-mass black holes, providing further evidence the production of winds can stifle jets.

See full article at http://chandra.harvard.edu/press/12_releases/press_022112.html

The three concepts will be further developed and analyzed by Team-X, the concurrent design facility at JPL, in March and April 2012. The present plan is for the first of the studies (SGO-Mid) to be conducted the week of March 5, and the final study will be completed the week of April 2. These studies will refine the concepts, identify key design drivers, and provide preliminary cost assessments for each concept. This information will be used as part of a final report to the CAA for consideration in the summer of 2012. The recommendations from the CAA will subsequently be used to guide detailed development of scientific, technical, and cost information for future US gravitational-wave missions.

Contact us at robin.t.stebbins@nasa.gov or kenneth.c.anderson@nasa.gov

News from the Advanced Concepts and Technology Office

Thai Pham, *Chief Technologist*

The inaugural Physics of the Cosmos (PCOS) Program Annual Technology Report (PATR) is available online at http://pcos.gsfc.nasa.gov/technology/. A key element of the PCOS Program's technology management process, the PATR describes the Program's technology management activities and technology development progress for the prior year.

The PATR defines priorities for technology investments for the upcoming year. The technology needs are prioritized using a set of criteria (described in the report) that reflects the goals of the PCOS Program (See Table reproduced here from page 92 of the current PATR). As calls for technology proposals are drafted, the priorities established in the PATR are referenced. For this reason, proposers are strongly encouraged to consult the PATR as they develop their proposals.

The Physics of the Cosmos Program Analysis Group (PhysPAG) is the main conduit for collecting technology needs identified by the community. To submit technology needs via our website, download and submit the "Technology Need Input Form" from the "Technology" tab.

We look forward to receiving this year's needs list from the PhysPAG by the end of June. The annual prioritization process begins again in July, and we will release the next PATR in early October 2012.

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 PCOS science. Feel free to comment on the prioritization criteria, our development priorities, and identify new technology needs via the PhysPAG or by contacting me at bruce.t.pham@nasa.gov.

#	Criterion	Weight	Score (0-4)	Weighted Score	General Description/Question	4	3	2	1	0
1	Scientific Ranking of Applicable Mission Concept	4	4	16	Scientific priority as determined by the Decadal Review, other community-based review, other peer review, or programmatic assessment. Captures the importance of the mission concept which will benefit from the technology.	Highest ranking	Medium rank	Low rank	Ranking not known	No clear applicable mission concept
2	Overall Relevance to Applicable Mission Concept	4	4	16	Impact of the technology on the applicable mission concept. Captures the overall importance of the technology to the mission concept.	Critical key enabling technology - required to meet mission concept goals	Highly desirable technology - reduces need for critical resources and/or required to meet secondary mission concept goals	Desirable-offers significant benefits but not required for mission success	Minor implementation improvements	Unknown
3	Scope of Applicability	3	4	12	How many mission concepts could benefit from this technology? The larger the number, the greater the reward from a successful development.	The technology applies to multiple mission concepts across multiple 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	Unknown
4	Time To Anticipated Need	3	4	12	How much time is available before the technology is needed to be at TRL6?	4 to 8 years (this decade)	9 to 14 years (early 2020s)	15 to 20 years (late 2020s)	Greater than 20 years (2030s)	Unknown
5	Scientific Impact to Applicable Mission Concept	2	4	8	Impact of the technology on the scientific harvest of the applicable mission concept. How much does this technology affect the scientific harvest of the mission?	Needed for baseline	Major improvement (> ~2x) to primary scientific goals	Only enables secondary scientific goals	No scientific improvements	Unknown
6	Implementation Impact to Applicable Mission Concept	2	4	8	Impact of the technology on the implementation efficiency of the applicable mission concept. How much does this technology simplify the implementation or reduce the need for critical resources?	Needed for baseline	Enables major savings in critical resources (e.g., smaller launch vehicle, longer mission lifetime, smaller spacecraft bus, etc.) or reduces a major risk	Enables minor savings in critical resources or reduces a minor risk	No implementation improvements	Unknown
7	Schedule Impact to Applicable Mission Concept	2	4	8	Impact of the technology on the schedule of the applicable mission concept. How much does this technology simplify the implementation to bring in the schedule?	Technology drives the mission concept critical path	Technology drives the critical path for a key component	Technology drives the critical path for a minor component	Technology is not likely to be on critical path	Unknown
8	Risk Reduction to Applicable Mission Concept Baseline	2	4	8	Impact of the technology on the risk of the applicable mission concept. How much does this technology reduce the risk?	Major mission concept risks directly mitigated by this technology, workarounds not currently known	Major mission concept risks directly mitigated by this technology, workarounds currently known	Minor mission concept risks mitigated by this techology	No risk benefits or technology is already in mission concept baseline	Unknown
9	Definition of Required Technology	1	4	4	How well defined is the required technology? Is there a clear description of what is sought?	Exquisitely defined	Well defined, but some vagueness	Well defined, but some conflicting goals not clarified	Not well defined, lacking in clarity	Poorly defined, not clear at all what is being described
10	Other Sources of Funding	1	4	4	Are there other sources of funding to mature this technology? If funding is expected to be available from other sources, this will lower the prioritization.	No, the Program is the only viable source of funding.	Interest from other sources can be developed during the development time of the technology	Interest from other sources is likely during the development time of the technology	Already being developed by other programs, agencies, or countries.	Unknown
11	Availability of Providers	1	4	4	Are there credible providers/developers of this technology? Where providers are scarce, there may be a compelling need to maintain continuity for the technology in the event there are no replacement technologies.	Single competent and credible provider/developer known	Two competent and credible providers/developers known	Multiple competent and credible providers/developers known	Providers/developers known but no assurance of competence or credibility	Unknown
	Total Possible Score:			100						

Evaluation Criteria for Technology Prioritization, adopted from Table 24 of the PATR. Send comments to Thai Pham, ACTO Chief Technologist or to the PhysPAG

Upcoming Events

March 31– April 3	American Physical Society Meeting, Atlanta, GA http://www.aps.org/meetings/april/index.cfm
May 7–11	Fermi/Swift Joint Conference: Gamma-Ray Bursts 2012, Munich, Germany http://www.mpe.mpg.de/events/GRB2012/
May 21–23	XMM-Newton Science Workshop 2012 "Galaxy Clusters as Giant Cosmic Laboratories", ESAC, Madrid, Spain http://xmm.esac.esa.int/external/xmm_science/workshops/2012_science/
May 21–25	9th LISA Symposium Paris, France http://lisasymposium2012.in2p3.fr/Welcome.html
June, 10–14	AAS Meeting Anchorage, Alaska USA http://aas.org/meetings/aas220
July 1–6	SPIE Astronomical Telescopes and Instrumentation 2012 Amsterdam, Netherlands http://spie.org/astronomical-instrumentation.xml?WT.mc_id=CAL-AS
July 3	EWASS 2012, Special Session 8: ASTRO-H: High-energy Astrophysics with the Next-Generation X-ray Observatory Rome, Italy http://www.isdc.unige.ch/astroh/ewass_sps8
July 10–12	X-ray Binaries - Celebrating 50 years since the Discovery of Sco X-1 Boston, Massachusetts, USA http://cxc.cfa.harvard.edu/cdo/xrb12/
August 14–16	PhysPAG Workshop American Geophysical Union Building Washington, D.C. USA http://www.agu.org/
September 10–13	Growing-up at high redshift: from proto-clusters to galaxy clusters Madrid, Spain http://www.sciops.esa.int/index.php?project=CONF2011&page=CLUSTERS2012
October 2012 (Dates TBD)	Einstein Fellows Symposium Smithsonian Astrophysical Observatory Cambridge, Massachusetts
October 15–19	The 9th INTEGRAL workshop: An INTEGRAL view of the high-energy sky (the first 10 years) Paris, France http://IntegralWorkshop2012.in2p3.fr
October 28–November 2	Fourth International Fermi Symposium Monterey, California, USA http://fermi.gsfc.nasa.gov/science/symposium/2012/

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