The High Energy Astrophysics Division Newsletter

Editor: M. F. Corcoran (NASA/GSFC & The Catholic University of America)

In this Issue:

From the Chair

ROB PETRE (NASA/GSFC)

HEAD has organized an exciting set of sessions for the January 2020 AAS meeting in Honolulu. Monday, January 6, is HEAD's big day, with two special sessions, followed by the Bruno Rossi Prize talk. This year's special sessions are entitled, "Are Disks just Disks? The Commonalities of Protoplanetary and Black Hole Accretion," and "Black holes in the Mass Gaps." The Rossi Prize lecture will be given by Brian Metzger (Columbia University) and Dan Kasen (University of California, Berkeley) on the topic of Kilonovae from Merging Neutron Stars. On Tuesday, January 7, we will hold our annual business meeting/social hour at 6:30 pm. As usual, there will be refreshments, along with a brief presentation to introduce newly-elected executive committee members and Vice Chair, and to announce the 2020 Rossi Prize winner. All HEAD members are invited.

The HEAD Executive Committee has been putting much effort into planning future HEAD meetings. Planning is well under way for the 18th Divisional meeting, which will take place September 13-17, 2020, in Tucson, AZ, at the JW Marriott Tucson Starr Pass Resort & Spa. The call for special sessions and Town Hall meetings has already been released, so please respond if you would like to organize such a session. While are still looking for a site for the Spring 2022 meeting, we have tentatively selected Waikaloa, Hawaii as the location of the Spring 2023 meeting, and we have signed a contract to hold the spring 2024 meeting in Austin, Texas, at a site excellent for viewing the April 8 full solar eclipse.

We have also been investigating expanding the pool of HEAD prizes. We appreciate the feedback received from HEAD members though the survey we distributed this summer. The results indicate strong enthusiasm for adding prizes in areas not currently covered by our four prizes (the Rossi Prize, the Dissertation Prize, the Mid-Career Prize, and the David N. Schramm Award for scientific journalism). HEAD membership is equally enthusiastic about the three possible new prizes listed on the survey: an early career prize, an instrumentation prize, and a lifetime accomplishments award. Our plan is to phase them in one at a time, with the order yet to be determined.

This next month is HEAD election season. Of particular importance this year will be the election of a new Vice Chair, who will eventually become the division's Chair. Our nominating committee, led by Past Chair Chris Reynolds, has produced a slate of outstanding candidates for both Vice Chair and Executive Committee. I encourage every HEAD member to take a few minutes to read the candidates' statements and help us pick our new leadership.

Finally, on behalf of the entire HEAD membership, I'd like to heartily congratulate our Russian and German colleagues for the successful launch (July 13) and commissioning of the Spektr-RG (SRG) observatory. With its eROSITA and ART-XC instruments, SRG will perform the most sensitive all-sky survey in the 0.2-30 keV band, detecting many (> 170000) new, distant active galactic nuclei and 50,000–100,000 galaxy clusters and groups. The impressive first light images, shown elsewhere in this Newsletter, offer us a taste of the exciting results to come.

HEADlines

MEGAN WATZKE (CXC)

This summer, NASA's *Chandra* X-ray Observatory celebrated 20 years of operations in space. This was a major milestone for a mission that had a nominal lifetime of five years. To celebrate, a series of events and activities for the scientific community as well as many public-facing efforts were planned. These included a press release with six new images, a new 20-minute film, and the release this fall of a new "coffee table" book from Smithsonian Books.

That was far from the only news from high-energy missions in the past six months. For example, Spektr-RG (carrying eROSITA and ART-XC) launched on July 13th. The ART-XC team released its "first light" of the famous X-ray pulsar Cen X-3 on July 30, and the eROSITA team announced its "first light" images in a press release on October 22nd. Coverage from around the world helped celebrate this latest addition to the high-energy explorer community. Also during this period, NASA organized the first ever "Black Hole Week" from September 23–27, featuring many results, video and social media with content derived from HEAD missions.

With *XMM–Newton* set to have its 20th birthday in December and many exciting results for the AAS meeting in January, there will undoubtedly be much to look forward to in the high-energy universe as the calendar flips to the next decade.

Some recent press releases involving or featuring HEAD missions include:

- September 26, 2019: "*TESS* Spots its First Star-Shredding Black Hole"
- September 25, 2019: "Found: Three Black Holes on a Collision Course"
- September 24, 2019 "Black Hole Seeds Missing in Cosmic Garden"
- August 15, 2019: "Moon Glows Brighter than Sun in Images from NASA's Fermi"
- July 24, 2019: "How Black Holes Shape Galaxies"
- June 13, 2019: "NASA's *Fermi* Mission Reveals its Highest-Energy Gamma-Ray Burst"
- May 30, 2019: "*NICER*'s Night Moves Trace the X-ray Sky"
- May 28, 2019: "*Chandra* Finds Stellar Duos Banished from Galaxies"
- May 6, 2019: "Storm in a Galactic Teacup"

LIGO-VIRGO-KAGRA Collaborations

PATRICK BRADY (UNIVERSITY OF WISCONSIN. MILWAUKEE)

LIGO and *VIRGO* completed the first six months of observing run O3 on October 1, 2019. This run marks a new mode of operations in which candidate gravitational-wave signals from compact object mergers and other transient phenomena are publicly announced within minutes of acquiring the data. In the data collected so far, designated O3a, 33 candidate gravitational-wave signals have been identified including multiple binary-black-hole mergers, at least one binary neutron-star merger, and several intriguing candidates that may include the first black-hole neutron-star binary merger. For each candidate, an alert was circulated via the Gamma-ray Coordinates Network (GCN) allowing other astronomers to search for electromagnetic and particle signals associated with the gravitational-wave candidate. No credible counterparts have been identified to date. The *LIGO-VIRGO* Collaboration is preparing publications on four of the candidates identified so far and plans to update the Gravitational-Wave Transient Catalog with O3a detections in April 2020.

Over the past month, the *LIGO* and *VIRGO* commissioning teams have carried out planned maintenance and noise-mitigation work in preparation for the second half of O3 (designated O3b) which will begin on November 1, 2019. The *LIGO* teams targeted reduction of scattered light noise and vacuum system tests and repairs at both sites. At Hanford, they repaired the in-vacuum squeezer and are installing a wind fence to improve stability and reduce noise during windy times. At *VIRGO*, the team was able to increase the input laser power to 25W, reduce scattered light noise, and investigate several other noise sources. Observing run O3 will continue through April 2020.

The Japanese *KAGRA* gravitational-wave project marked the completion of construction by a ceremony held in the underground facility that houses the new detector on October 4, 2019. On the same day, *LIGO*, *VIRGO*, and *KAGRA* signed a Memorandum of Agreement that paves the way for *KAGRA* to join the O3 run at the end of this year and for joint analysis of the data. The agreement covers a period until September 2023, but anticipates joint operations of this international gravitational-wave observatory network into the foreseeable future.

Observing run plans for *LIGO*, *VIRGO*, and *KAGRA* that look forward to the mid-2020s are now available. The document includes estimated sensitivities and tentative dates for two more observing runs O4 and O5. It is planned that *LIGO*-India will join observing run O5, bringing the number of operational facilities to five, thus enabling improved source localization and parameter measurement.

In July 2019, the Gravitational Wave International

Committee (GWIC) sub-committee on 3rd generation gravitational-wave detectors released draft reports describing the science case, challenges, and the research and development roadmap to developing instruments that would be at least ten times more sensitive than current detectors at their design sensitivity. The subcommittee will continue its work over the next year.

The Laser Interferometer Space Antenna

IRA THORPE (NASA/GSFC), GUIDO MUELLER (UNIVERSITY OF FLORIDA), MICHELE VALLISNERI (JPL)

The European Space Agency completed the first major review of *LISA*. Known as the “Mission Consolidation Review”, it marks the mid-point of Phase A activities and reviews progress made on the mission design, spacecraft design, and payload, as well as programmatic considerations such as cost and schedule. The NASA *LISA* Study Office supported this review by providing details of its technology development activities to the review panels as well as by providing experts in *LISA* science and technology for the review process. *LISA* passed this review! We congratulate the team and thank them for their efforts. However, the final report of the review board is not yet available. The outcome of the review will guide activities for the remainder of Phase A, which is expected to last an additional 12-18 months. The mission will then proceed into Phase B for detailed design, setting the stage for the important ESA milestone, Mission Adoption, in the early 2020s. Mission launch is still on track for 2034.

Steady progress is being made on each of the major NASA technology development efforts, which aim to demonstrate critical technologies ahead of Mission Adoption. NASA is currently establishing a contract with an industrial partner to develop a prototype of the *LISA* telescope to validate structural, thermal, and optical performance. In June, a bench-top prototype of the Charge Management Device was delivered from NASA's partners at the University of Florida to ESA collaborators at the University of Trento, where it is being integrated into a torsion pendulum facility for system-level testing. This marks the first delivery of hardware in the LISA mission! A prototype *LISA* laser system, including a newly designed seed laser as well as a fiber amplifier, is scheduled for delivery to ESA next Spring. The NASA micropropulsion team and their industrial partners incorporated lessons learned from the *LISA* Pathfinder mission into a new design. They also improved lifetime models through in-situ measurements of the colloidal beam in various configurations and performed configuration studies on how to accommodate these thrusters in current European *LISA* spacecraft designs. Last but not least, the phase measurement team received delivery of the first prototype phase measurement device from their industrial partner in August and are currently conducting performance testing. Beyond hardware contributions, the NASA *LISA* Study Office and the NASA *LISA* Science Team (NLST) are studying scenarios for US participation in the *LISA* science ground segment, which is expected to be a major component of NASA's *LISA* effort.

The NLST also continues to be active supporting the 2020 Decadal Survey activities. Following up on the 11 science whitepapers (see GWSIG article elsewhere in this issue), the team organized the submission of three Activities, Projects, and State-of-the-Profession Considerations (APC) whitepapers: one on the *LISA* mission and NASA's role, one on science opportunities and technical challenges for missions beyond *LISA*, and one on building the new field of GW astronomy. All of this material, as well as additional information on LISA, can be found at the *LISA* website.

IceCube Neutrino Observatory

FRANCIS HALZEN, ALI KHEIRANDISH (UNIVERSITY OF WISCONSIN–MADISON)

In a multimessenger campaign taking advantage of temporally coincident observations, an active galactic nucleus, TXS 05060+056, was identified as the origin of the 290-TeV neutrino, IC170922, observed in IceCube. Knowing where to look, a search in the archival data revealed a flare of neutrinos in 2014-15 lasting 110 days, which dominates the flux of the high-energy neutrinos from that direction in over a decade of IceCube observations.

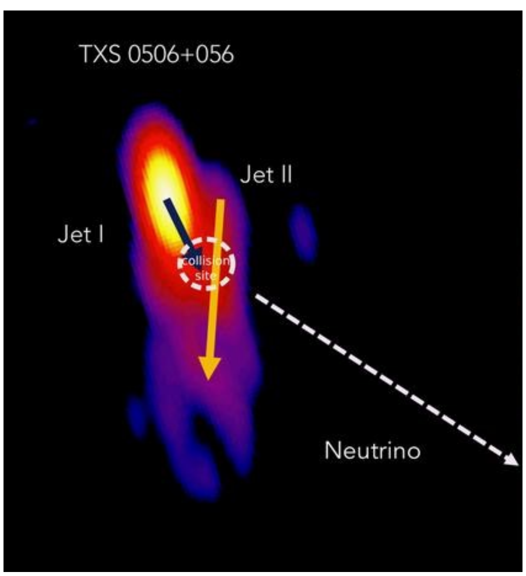
High-energy neutrinos originate in astrophysical beam dumps where accelerated cosmic rays interact with radiation, gas, or molecular clouds with sufficient target density to produce pions and kaons that decay into neutrinos. The birthplace of extragalactic cosmic rays is still a mystery. However, the detection of a source of high-energy neutrinos, TXS 0506+056, has provided a breakthrough in resolving this century old puzzle. A high-resolution radio image of the source has recently produced evidence for the merger of two galaxies, supporting a scenario where a subclass of γ-ray sources is responsible for producing the high-energy cosmic neutrinos.

The high energy level of the observed cosmic neutrino flux has revealed an unexpectedly prominent role for protons relative to electrons in the nonthermal universe, well above what had been anticipated. Meanwhile, the neutrino bursts observed from TXS 0506+056 have not only challenged the conventional modeling of blazar jets, but have demonstrated the inadequacy of the simplest multimessenger interfaces, with γ-rays accompanying the neutrinos in 2017 but not in 2014-15.

The temporal profile of the neutrino emission measured by IceCube in the direction of TXS 0506+056 indicates two episodes of emission: a neutrino burst in 2014 of 13 neutrino events in four months and a 290-TeV neutrino in 2017 that is part of a subdominant burst compared to the 2014-15 one. While the subdominant 2017 observation launched a real-time multimessenger campaign that resulted in a wealth of data on the source, such data is scarce for the time period of the 2014-15 neutrino flare.

Blazar modeling of both bursts has been unsuccessful so far; conventional one-zone models introduced to describe the multiwavelength spectrum of blazars are not able to describe the contemporaneous emission of neutrinos and γ-rays during the flares of TXS 0506+056. The neutrino alert in 2017 coincided with the peak emission of a gamma flare, and additionally, the MAGIC telescope established the source as a relatively rare TeV blazar. In contrast, no γ-ray enhancement was found in coincidence with the neutrino flare in 2014. Although the *Fermi* data hint at a potential hardening of the spectrum, the actual flux level is lower than average. Blazar models at best meet the requirements for the 2017 burst by invoking the Eddington bias for the single neutrino produced.

If every blazar produced neutrinos at the level of TXS 0506+056, the sources would overproduce the total high-energy neutrino flux. TXS 0506+056 must belong to a special subclass of sources that accelerate protons and, additionally, have sufficient target density to produce high-energy γ-rays and neutrinos. This can already be argued for on the basis of its large redshift: the source outshines nearby blazars despite the fact that it is more distant. A subclass of sources at the level of 5%, bursting once in 10 years at the level of TXS 0506+056, can accommodate the total cosmic neutrino flux. A simple energy balance calculation shows that the target density for producing neutrinos is large and inevitably opaque to high-energy γ-rays.



The IceCube neutrino event 170922A, whose path is indicated by the dashed line, appears to originate in the interaction zone (the dashed circle) of the two jets in TXS 0506+056. Image credit: IceCube Collaboration/MOJAVE/S. Britzen/M. Zajacek.

The observation that the energy content in neutrinos and in very high energy cosmic rays are similar underscores the fact that cosmic rays must be highly efficient at producing neutrinos, requiring the large target density that renders them opaque to high-energy γ-rays. A consistent picture emerges when the source's large opacity induces a γ-ray cascade where photons lose energy in the source before cascading to even lower energies in the extragalactic background light. The 2014-15 burst cannot be, and is not, accompanied by a large γ-ray flare. This requirement is consistent with the premise that a special class of efficient sources is responsible for producing the cosmic neutrino flux.

One straightforward mechanism for the selection of a subclass of blazars is redshift evolution: powerful proton accelerators producing neutrinos may have been active in the past but are no longer active today. This would accommodate the large redshift of TXS 0506+056.

Another possibility focuses on the requirement of a large target density. It takes enhancement in the target density in the vicinity of the black hole to accommodate the 2014-15 observation. In this context, follow-up studies of the source with the high-resolution VLBA radio array have revealed a warped jet, potentially a collision of two jets on pc scales. Abundant neutrino emission will result from the interaction of jetted material. This observation not only identifies a striking feature in the jetted material, the neutrino bursts occur during enhanced radio emission. This is an unprecedented observation, demonstrating strong features of particle acceleration and interaction leading to the production of high-energy neutrinos. Evidence for the structure of the jet has been previously suggested by follow-up studies of VLBI data, which further support the presence of the prominent structure in the jet.

Our speculations are possibly reinforced by the recent observation of the blazar PKS 1502+106 in coincidence with a 300-TeV neutrino, IC-190730. OVRO observations indicate that the neutrino is coincident with the highest flux density of a flare at 15 GHz that started five years ago. This matches the similar long-term radio outburst seen from TXS 0506+056 and may be a signature of a merger event. Correlation of radio bursts with the process of merging supermassive black holes had been anticipated. Merging supermassive black holes in principle mean merging galaxies, and when a merger happens, there is plenty of material for accelerated cosmic rays to interact with. This fresh material provides optically thick environments. It is worth noting that there has been speculation before that some radio galaxies involve the merger of two supermassive black holes.

The breakthrough event of September 22, 2017, has generated an unmatched data sample from a cosmic-ray accelerator. Subsequent observations of the first identified source of high-energy cosmic neutrinos, poorly studied prior to its multimessenger observation, have provided us with additional powerful clues that further support the evidence for a class of sources.

There is a development, possibly related, associated with the studies of the time-integrated search for neutrino sources in 10 years of IceCube data. It indicates that at the 3σ level the neutrino sky map is no longer isotropic. The strongest signal is from the nearby Seyfert galaxy NGC 1068 (aka Messier 77). There is evidence for shocks near the core and for molecular clouds with high densities. Once more, a merger onto the black hole is observed, either with a satellite galaxy or, more likely, with a star-forming region. Again, a major accretion event may be the origin of the neutrino emission.

Unlike the previous SN1987A and GW170817 multi-messenger events, the first high-energy cosmic neutrino source could not have been observed with a single instrument. Without the initial coincident observation, IC170922 would be just one more of the few hundred high-energy cosmic neutrinos detected by IceCube and the accompanying radiation just one more flaring blazar observed by *Fermi*-LAT. Neutrino astronomy was born with a supernova in 1987. Thirty years later, this recent event involves neutrinos that are tens of millions of times more energetic and are from a source a hundred thousand times more distant.

Spektr-RG

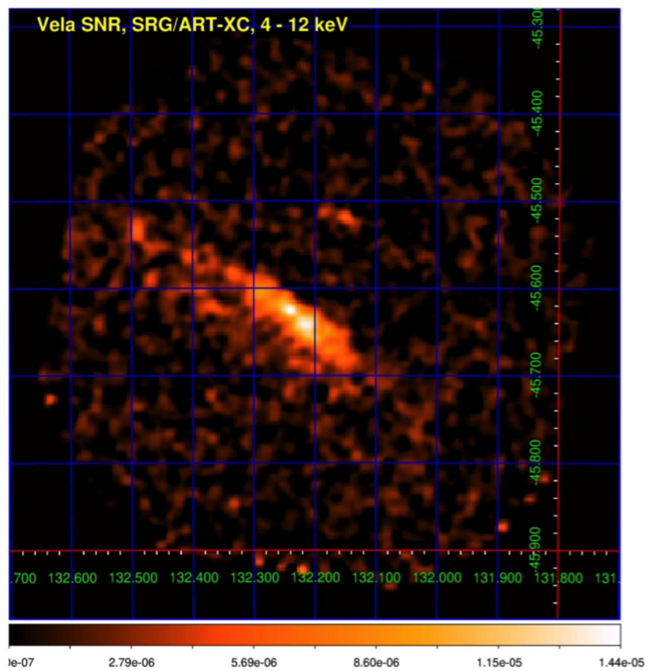
A. Merloni (MPE), M. Pavlinsky (IKI), P. Predehl (MPE), S. Sazonov (IKI)

On July 13, a Proton-M rocket with a DM-3 booster launched the Spektr-RG (SRG) observatory into space from the Baikonur Cosmodrome. The observatory is aimed at surveying the entire sky in X-rays with ground-breaking sensitivity. SRG is equipped with two X-ray focusing telescopes, eROSITA and ART-XC.

The first 100 days of the mission, almost the whole duration of the flight from earth to the vicinity of the L2 Lagrange point of the Sun-Earth system, were used for checking, tuning and calibrating the two instruments as well as for observing interesting fields and sources on the sky as part of the early science (performance verification; PV) program. The 4-year survey of the sky is planned to start in the first half of December 2019.

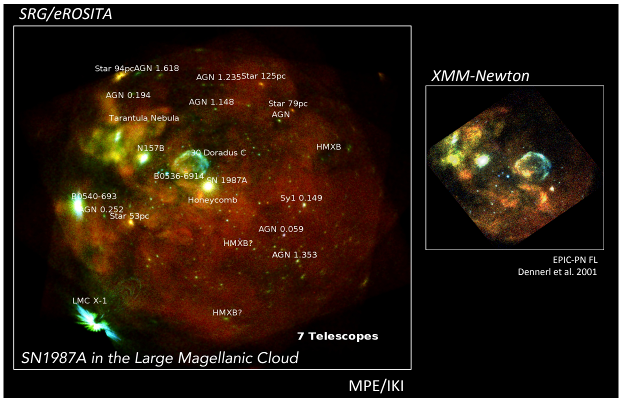
The Proton-M rocket carrying SRG during the first minute of its flight on July 13th, 2019. Credit: Vadim Burwitz (MPE).

On July 30, 2019, ART-XC obtained its “first light” using the famous X-ray pulsar Cen X-3 as the target. Within the early science program, ART-XC conducted a survey of the Galactic Center region over an area of about 40 square degrees and obtained maps in several energy bands between 4 and 30 keV. More than two hundred X-ray sources, including several new ones, were detected. This unique sample of sources will be used for exploring various populations of Galactic X-ray sources. ART-XC also performed two extragalactic surveys (in the well-known Ultra-Deep Survey field and around the PG 1634+706 quasar, the latter being part of the eROSITA performance verification program) and observed a few dozen other fields with X-ray sources of various nature. The capabilities of ART-XC telescope as a surveying instrument and a hunter for heavily obscured sources have been fully confirmed.

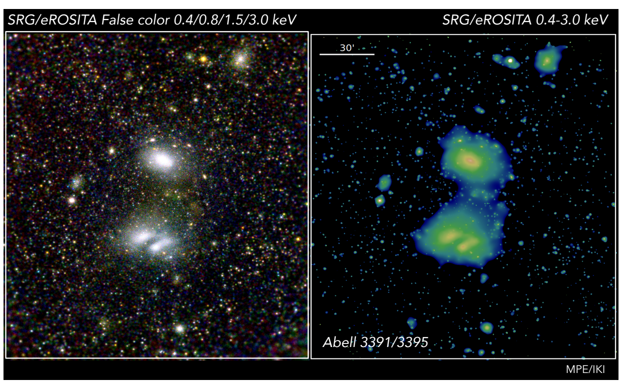


An image of the famous supernova remnant Vela obtained by ART-XC in the 4-12 keV energy band from a 60 ksec exposure. Credit: IKI/ART-XC Team

Due to the longer outgassing period required by its pnCCDs, eROSITA began its commissioning work on August 22nd. During the following weeks, the seven eROSITA cameras were checked-out and a number of tests were carried out to verify the integrity of the instruments and of all sub-systems. With a few weeks delay, due to the necessity to analyse and understand some anomalies in the camera electronics, eROSITA started its Calibration and Performance Verification (CalPV) program on October 13th. “First Light” images were made public during a symposium held at MPE on October 22nd. The CalPV program of eROSITA will continue until early December.



The SRG/eROSITA first light image of the Large Magellanic Cloud (left) compared with the XMM-Newton first light image of the same field. The eROSITA image is taken from a single pointing (one degree diameter) centered on the bright SN1987A, with an exposure of about 80ks. False colors are generated by combining the images from three energy ranges: 0.2-1.0, 1.0-2.0 and 2.0-4.5 keV, respectively. Some notable sources are marked in the image. Credit: F. Haberl, M. Freyberg, C. Maitra (MPE).



These two eROSITA wide-field images show the two interacting galaxy clusters A3391, to the top of the image, and the double-peaked cluster A3395, to the bottom, taken from a 2.5×2.5 deg^2 scan observation for a total exposure of 59ks. In the left-hand image, the red, green and blue colours refer to the three different energy bands of eROSITA (0.4-0.8, 0.8-1.5 and 1.5-3.0 keV). The image on the right, which is a wavelet-filtered one from the full energy band 0.4-3.0 keV, highlights the 'bridge' or 'filament' between the two clusters, confirming the suspicion that these two huge structures do interact dynamically. Credit: T. Reiprich (Univ. Bonn), M. Ramos-Ceja (MPE), F. Pacaud (Univ. Bonn), D. Eckert (Univ. Geneva), J. Sanders (MPE), N. Ota (Univ. Bonn), E. Bulbul (MPE), V. Ghirardini (MPE).

The Chandra X-ray Observatory

Roger Brissenden (SAO),
Martin C. Weisskopf (NASA/MSFC)

We are pleased to report that *Chandra* has now carried out more than 20 years of highly successful and productive science operations. The *Chandra* X-ray Observatory is unique in its capability for producing the sub-arcsecond X-ray images that are essential to accomplish the science goals of many key X-ray and multi-wavelength investigations in current astrophysical research. The *Chandra* Project is looking forward to many more years of scientific productivity.

Chandra's 20th anniversary of operations, which was marked on the anniversary of the launch date of 23 July 2019, is being celebrated with a variety of colloquia, meetings and presentations, including a special session at the January 2019 American Astronomical Society meeting, a gathering at the National Air and Space Museum in August, and a scientific symposium in Boston, December 3–6, 2019. A schedule of events is available on the 20th anniversary meeting website.

The *Chandra* Program participated in NASA's periodic Senior Review (SR) of operating missions, submitting the required proposal in March 2019 and hosting a site visit by the SR panel in May. The SR committee, whose report was issued in July, rated *Chandra* highly in all categories including scientific merit, relevance and responsiveness, technical capability, and cost reasonableness. Subsequently NASA increased *Chandra*'s budget guidelines, albeit modestly, to increase support for General Observer grants and to partly offset the effects of inflation.

The Observatory continues to operate extremely well overall but with a number of incremental changes in performance, due primarily to the gradual accumulation of molecular contamination on the UV filter that protects the ACIS detector, and to progressive degradation of the spacecraft's multi-layer insulation. Condensation on the filter reduces ACIS's sensitivity to low-energy (below 1.5 keV) X-rays. The decline in thermal insulation effectiveness requires extra effort in scheduling observations, but has not significantly affected *Chandra*'s observing efficiency.

The increasingly stringent thermal constraints on *Chandra* pointing have made efficient scheduling of observations more difficult. It is sometimes necessary for *Chandra* to point in a direction that will pre-cool a particular subsystem before pointing at a target that will cause it to warm. To enable *Chandra* to stay within its temperature limits without losing efficiency by pointing at blank sky to cool off, the CXC, after consultation with the MSFC Project Science group and the *Chandra* Users Committee, issued a call for proposals for scientifically useful *Chandra* Cool Targets (CCTs). Peer review of the proposals approved 22 programs, with approximately 22,000 CCTs. Since December 2018, CCT targets have represented over 650 ks of exposure time, or roughly 4.6% of total observing time. We expect to issue additional calls for CCT proposals in the future, to ensure that CCTs adequately cover the sky.

The *Chandra* Operations Control Center (OCC), from which mission operations are conducted, has moved from its previous site in Cambridge, Massachusetts to a new location in Burlington, MA. Following construction of the facility and an accelerated program of installation and testing, the new OCC successfully began operations in

March 2019.

Release 2.0 of the *Chandra* Source Catalog (CSC), which contains over 370k detections from about 316k sources, has been completed.

In December 2018, the *Chandra* X-ray Center (CXC) issued a call for proposals for Cycle 21 observations. Scientists worldwide submitted 516 proposals, including 90 proposals for archive and theory research. The observing proposals requested a total of 83.5 Msec of telescope time, an oversubscription factor of approximately 4.9. The Cycle 21 peer review, held in June, approved 142 observing proposals for a total of 16.8 Msec, and 26 archive and theory proposals for a total of $1.7M.

Poster for the Chandra 20th Anniversary Science Workshop, December 3-6, 2019 Boston, MA. Credit: CXC

The *Chandra* Press Office has been active in issuing image releases, science press releases and other communications of *Chandra* research results. A complete listing is available at the press office website. Additional information about the *Chandra* Observatory is available from the Chandra X-ray Center.

XMM–Newton

Lynne Valencic (JHU & NASA/GSFC)

A mini-symposium in honor of the 20th anniversary of *XMM–Newton*'s launch was held at NASA/GSFC. Invited speakers included France Cordova (NSF), Richard Griffiths (University of Hawaii), Steve Kahn (SLAC), Richard Mushotzky (University of Maryland), Frits Paerels (Columbia University), Craig Sarazin (University of Virginia), and Norbert Schartel (ESA). The speakers gave attendees historical reflections on the US role in *XMM–Newton* and described some of the most exciting science being done today. The *XMM–Newton* GOF would like to thank all who attended and presented for making this event a rousing success!

Attendees at the XMM–Newton 20th Anniversary mini-symposium. Credit: L. Valencic

The 19th Call for Proposals for *XMM–Newton* closed on October 11, 2019. There were 462 proposals submitted; 50 were for Large Programs, 104 were for joint programs with *HST*, *Swift*, VLT, *Chandra*, NRAO, *H.E.S.S*, *INTEGRAL*, or *NuSTAR*. Taking both PIs and Co-Is into account, about 1500 scientists were involved with the response to the AO. The oversubscription rate was 7.7, the same as last year. Successful submissions will be announced in December. Funding will be available for A/B ranked proposals with US PIs, and the GOF will notify elegible PIs. Phase II proposal submission for approved proposals will run from January 8-31, 2020. Approved observations are planned to be performed starting in May 2020.

The "Astrophysics of Hot Plasma in Extended X-ray Sources" science workshop took place at ESAC in Madrid in June, 2019, and presentations are now available online. Also, the agenda, minutes, and presentations from the May 2019 Users Group Meeting are now available online as well.

The Neil Gehrels Swift Observatory

Eleonora Troja, Brad Cenko (NASA/GSFC)

Approaching the 15th anniversary of its launch on November 20, 2004, the Neil Gehrels *Swift* Observatory continues to operate flawlessly. It supports 4 Target of Opportunity (ToO) requests per day, in addition to observing gamma-ray bursts (GRBs), gravitational wave (GW) sources and Guest Investigator (GI) targets. *Swift* is by far the most active mission in terms of the number of ToOs accepted and different sources observed.

In January 2019, the UltraViolet and Optical Telescope (UVOT) aboard *Swift* caught bright ultraviolet light from an infant tidal disruption event, ASASSN-19bt. UV data from *Swift* – the earliest yet seen from a tidal disruption event – were fundamental to determine that the temperature dropped by about 50%, from around 71,500 to 35,500 degrees Fahrenheit (40,000 to 20,000 degrees Celsius), over a few days. It's the first time such an early temperature decrease has been seen in a tidal disruption event. More typical for these kinds of events is the low level of X-ray emission detected by the *Swift* X-ray Telescope.

On August 21, 2016 NASA's *Swift* discovered a new gamma-ray burst, named GRB160821B, and began tracking its light minutes after it was detected. The burst, which lasted less than two seconds, was located in the outskirts of a distant spiral galaxy, 2.5 billion years away from Earth. By using a wide array of ground-based and space-based telescopes, astronomers followed the evolution of its light and found compelling evidence for a kilonova - a turbocharged explosion that instantly forged several hundred planets' worth of gold and platinum. Astronomers suspect that all of the gold and platinum on Earth formed as a result of ancient kilonovae created during the collisions of neutron stars.

The *Swift* Cycle 16 GI program proposal deadline was September 26, 2019. NASA received 120 proposals for Cycle 16, requesting a total observing time of 14.5 Ms and $3.9M in funds for 682 targets. The *Swift* Cycle 16 Peer Review will be held in December. Cycle 16 observations will commence on or around April 1, 2020, and will last 12 months.

NuSTAR

Daniel Stern (JPL), Fiona Harrison (Caltech)

The *NuSTAR* mission continues to operate nominally on orbit. With well over 500 refereed publications, *NuSTAR* continues to be a highly productive satellite exploring the hard X-ray (>10 keV) universe with unrivaled sensitivity and resolution. *NuSTAR* Cycle 5 observations began on July 1, 2019. Recognizing the enhancing value of including hard X-ray photons in lower energy studies of extreme phenomena, *NuSTAR* allows for coordinated observing programs making use of the *Chandra*, *INTEGRAL*, *NICER*, *Swift*, and *XMM–Newton* observatories. *NuSTAR* provides time to the AOs for each of those facilities, and several of those facilities provide time in the *NuSTAR* AO.

The *NuSTAR* Cycle 6 AO was recently released, with a due date of January 24, 2020. The largest change relative to previous *NuSTAR* AOs is that the proposal review will now be done in a dual-anonymous fashion. *HST* spearheaded such dual-anonymous reviews over the previous few years, and this will become the new standard for NASA astrophysics mission time allocations. The *NuSTAR* Cycle 6 AO is the first non-Hubble mission to adopt this standard. Proposers should read the documentation available through the *NuSTAR* site for the implications of this change. In particular, proposers will be required to make their proposals anonymous, with no reference to members of the proposing team. Failure to do so will result in proposals that are rejected with no review by the time allocation committee. The second change in AO6 relative to previous AOs is that proposers may now request observations spread over two cycles, where the science drives such a consideration. For additional details, see the *NuSTAR* Proposal web page.

On the science front, a recent study reports on a pair of *NuSTAR* observations of the Fireworks galaxy, NGC 6946, spread over two weeks in mid-2017 (Earnshaw et al. 2019, ApJ 881, 38). Though the primary objective of the *NuSTAR* target-of-opportunity observations was to study supernova SN2017eaw in the north of the galaxy, this paper focusses on the ultra-luminous X-ray source (ULX) population in the galaxy. During both observations, the previously identified ULX-3 was detected by *NuSTAR*. In the second *NuSTAR* observation, simultaneous with *XMM–Newton*, a new ULX was detected by both X-ray satellites, having appeared in the 11 days between the observations. *Chandra* observations roughly two weeks later showed that this new source, ULX-4, disappeared as quickly as it appeared. The X-ray spectrum and variability of ULX-3 is consistent with the general ULX population, with a steep, soft power law spectrum and spectral variability consistent with expectations from supercritical accretion models of ULXs. In contrast, ULX-4 had a very hard spectrum with a cut-off power-law, also well-fit by a hot multi-color disc blackbody. No pulsations were detected from ULX-4. The paper describes how the transient nature of ULX-4 can be explained either as a neutron star ULX briefly leaving the propeller regime or as a micro-tidal disruption event induced by a stellar-mass compact object.

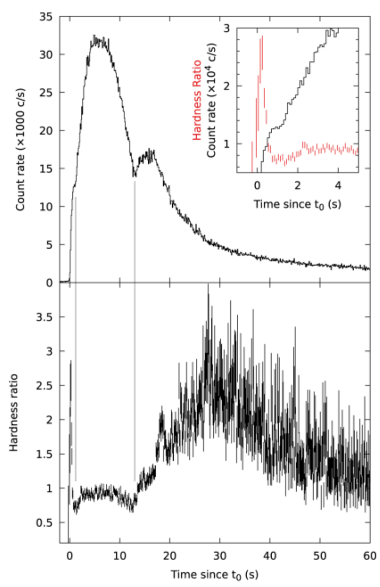
Digital Sky Survey image of the Fireworks Galaxy (NGC 6946) overlaid with data from NuSTAR. Blue indicates hard X-rays captured during the first observation, in May 2017. Green indicates hard X-rays captured two weeks later in a second observation. The green source to the South corresponds to the new, highly variable ultraluminous X-ray source (ULX) identified in this study, ULX-4, while the bright sources in the Northern regions of the galaxy correspond to the known ULX-3 and supernova SN2017eaw.

The Neutron Star Interior Composition Explorer

Keith Gendreau, Zaven Arzoumanian (NASA/GSFC)

The 2019 NASA Astrophysics Senior Review of continuing missions produced a positive outcome for *NICER*: extension of the mission for three years, to meet objectives including expanded neutron star physics investigations, a generous Guest Observer (GO) program for all target classes, and dramatic improvements in *NICER*'s responsiveness to targets of opportunity (TOOs).

The *NICER* payload, approaching 2.5 years on the International Space Station, continues to function very well. Operational restrictions associated with robotic and astronaut extravehicular activities have become somewhat more common, but they remain rare and their impact is minimized through improved coordination and planning between the *NICER* and ISS teams. During normal science operations, *NICER*'s scheduling agility enables high-cadence target visits, to build up deep exposures or monitor source evolution (or both) in the X-ray Timing Instrument's 0.2–12 keV passband, with unparalleled timing resolution, moderate spectral resolution, good sensitivity, and exceptional throughput (several Crabs of flux without pileup).



Top: NICER light curve of an X-ray burst from SAX J1808 at 0.1 s time resolution in the 0.3–10 keV energy band. Bottom: hardness ratio, defined as the 3–10 keV rate divided by the 0.3–1 keV rate. Inset: first four seconds of the same data, with the light curve in black (connected line, units of $\times 10^4$ *ct* s^{-1}*) and the hardness ratio in red (vertical dashes). All panels are relative to* $t_0 = 58716.089362$ *TDB. Vertical gray lines were added to guide the eye. Credit: Bult et al. (2019).*

Courtesy of the ISS communications infrastructure, *NICER* benefits from real-time commanding and prompt data availability, capabilities that foster TOO investigations. (In one instance, *NICER*'s discovery of an 83-second periodicity in the supersoft source V3890 Sgr was published as an Astronomer's Telegram, #13086, within six hours of the TOO request.) Requests from the community are encouraged: a Web-based TOO submission form is available at *NICER*'s HEASARC website, as is the mission's short-term observing schedule. Currently staffed during regular Eastern time business hours, *NICER* operations are being expanded to include on-call duty scientists for after-hours commanding of TOO observations, as well as additional tools and automation to enable target visibility checks and scheduling. Finally, a longer-term plan to trigger *NICER* observations with JAXA's Monitor of All-sky X-ray Image (*MAXI*) ISS payload—both with and without ground intervention—is entering its implementation phase.

Through mid-November 2019, the *NICER* public data archive comprised nearly 17,000 observations (where a unique "ObsID" represents data collected for a single target on a single day). Data analysis tools are distributed through the HEAsoft package, and calibration products are available through the HEASARC Calibration Database. Recent (and pending) upgrades to these packages include improved response files and the release of two tools that model *NICER*'s background in independent ways; these tools draw on a library of blank-sky pointings and use either time-dependent environmental (i.e., space weather and geomagnetic latitude) information or properties internal to the user's data to provide background spectra customized to each dataset's Good Time Intervals. Feedback on the performance of these tools and products is welcome through the HEASARC helpdesk system.

Recent notable *NICER* results include:

- Tracking in great detail the 2019 outburst of SAX J1808.4-3658, the original accreting millisecond pulsar, including precise timing of its persistent pulsations and detailed study of a bright thermonuclear (Type I) X-ray burst. This burst provided direct evidence for both the hydrogen and helium Eddington limits in the expansion of the star's photosphere, as well as burst oscillations at its spin period and a still-mysterious re-brightening during the burst's cooling tail (Bult et al. 2019; ApJL 885, 1).

- A sensitive spectral study of the Seyfert-2 active galaxy NGC 4388 that characterizes neutral obscuration, ionized absorption, neutral-iron reflection, and ionized plasma components to infer the geometry of the obscuring region (Miller et al. 2019; ApJ 884, 106).

- Evolution in ionization states and broadening of iron-line emission across the sub- to super-Eddington regimes in the Milky Way's first ultraluminous X-ray pulsar, Swift J0243.6+6124, indicating that the emission region—whether due to a disk, jet, optically thick curtain, or other structure—is far (~ 5000 km) from the accreting neutron star at low luminosities but close enough at high luminosities to produce line asymmetries from Doppler and gravitational shifts (Jaisawal et al. 2019; ApJ 885, 18).

- The detection of bright and persistent single X-ray pulsations from XTE J1810-197, a transient radio magnetar. The individual pulses show temporal structure that varies from one stellar rotation to the next, uncorrelated with the single radio pulses on rotational timescales and departing significantly from the average X-ray pulse shape.

- Robust inference of the mass and radius of an isolated (i.e., non-binary) neutron star, PSR J0030+0451—together with their implications for the dense-matter equation of state—through modeling of the millisecond pulsar's thermal X-ray lightcurve. These results, to be released prior to the end of 2019, are accompanied by novel insights into the locations, shapes, and temperatures of the "hot spots" responsible for the rotationally modulated X-rays, with the surprising result that these heated regions do not conform with the canonical (antipodal) picture of the polar caps of a simple dipolar magnetic field.

New results and important *NICER* events can be found on the *NICER* website, and be sure to check out the *NICER* science nuggets.

The Fermi Gamma-Ray Space Telescope

Elizabeth Hays (NASA/GSFC), Chris Shrader (NASA/GSFC & CRESST II/CUA), Dave Thompson (NASA/GSFC), Judy Racusin (NASA/GSFC), Julie McEnery (NASA/GSFC), Lynn Cominsky (Sonoma State U.)

The *Fermi* instruments continue to scan the gamma-ray sky continuously. After more than 11 years of observations, *Fermi* offers both a long history of the entire energetic sky and ongoing monitoring of this dynamic energy range.

The final version of the fourth catalog of high-energy gamma-ray sources (4FGL) seen by the *Fermi* Large Area Telescope is now available. With more than 5000 sources, it is the deepest survey yet of the sky at photon energies from 50 MeV – 1 TeV. The catalog is available through the *Fermi* Science Support Center. A catalog of gamma-ray bursts seen by the *Fermi* Large Area Telescope includes a variety of bursts that have unusual properties.

The Large Area Telescope team released a series of images of the gamma-ray moon, with a reminder that at these energies the moon can be brighter than the sun. These gamma-ray observations reinforce the fact that astronauts on the Moon will require protection from the same cosmic rays that produce this high-energy gamma radiation.

Current *Fermi* software and documentation are available through the *Fermi* Science Support Center. The FSSC recently released an update to the Fermitools software, which uses the Conda package manager to install the tools. The latest source code is now hosted on GitHub. For instructions on how to install the tools, release notes, troubleshooting, error reporting, and other related documentation see the Fermitools Wiki).

Cycle 13 Guest Investigator proposals are due on Feb. 19, 2020. Additional information is available at the *Fermi* Science Support Center Proposer's page.

The Ninth International *Fermi* Symposium will be held in South Africa March 29 – April 3, 2020. The deadline for regular registration is Saturday, December 7.

In partnership with members of the *LIGO-VIRGO* Collaboration, *Fermi* outreach will be participating in the development of a multi-messenger master class using GW170817 data. This new master class will focus on joint analysis of data from *Fermi*, *LIGO* and ground based observers by teams of high school students. If you are interested in volunteering to help develop this class or in receiving the latest *Fermi* sky map poster, or art posters developed by Aurore Simonnet, please contact Lynn Cominsky lynnc@universe.sonoma.edu.

INTEGRAL

Erik Kuulkers (ESA/ESTEC), Steve Sturner (CRESST/UMBC & NASA/GSFC)

On 17 October, *INTEGRAL* celebrated 17 years of in space! The spacecraft, payload and ground segment have been generally performing nominally. There were a few issues with the Command and Data Management Unit (CDMU) in July and August and a workaround is now in place. *INTEGRAL*/SPI annealing #33 took place in late September through early October. Considering the high level of degradation before the annealing, the recovery, is satisfactory. Nevertheless, the global energy resolution continues slowly to drift.

The *INTEGRAL* Users' Group (IUG) welcomes 2 new members: Sandro Mereghetti and Sergey Sazonov. They replace Volker Beckmann and Alexander Lutovinov. IUG meeting #22 took place at ESA/ESOC on 11/12 June. The minutes of that meeting are now on-line. The next IUG meeting (#23) is set for 26/27 November.

A study of the gender balance in the *INTEGRAL* TAC process up to AO-16 revealed that women submitted 21% of the *INTEGRAL* proposals with a 74% success rate, while men were 66% successful. About 18% of the approved observing time had a female PI. The conclusion is that there is no large difference between gender success rates and no obvious evolution with time. Over all AOs, about

19% of the panel chairs were female, while about 20% of the TAC members (excluding chairs) were female. There is some evidence for increasing female participation in panel chairs.

The AO-17 call for observing proposals closed on April 5. The total number of proposals received was 63. The total observing time requested was about 73 Msec which corresponds to a time oversubscription factor of 3.5. The non-ToO proposals requested data rights for 361 sources with 22 proposals requesting joint time with *NuSTAR*, *Swift*, and/or *XMM–Newton*. The TAC selected 55 proposals and also granted 300 ks of *XMM–Newton*, 157 ks of *Swift*, and 85 ks of *NuSTAR* observing time. AO-18 will be open from March 2 to April 3, 2020.

ESA's ISOC/MOC operational procedure to allow for (very) fast Targets-of-Opportunity (ToOs) as a best effort activity during working hours has been finalized. A test, including the actual implementation and observation of an urgent ToO (on S190408an, see below), took place on April 10. The procedure has now been formally approved and is therefore available for use.

INTEGRAL performed numerous ToO observations during this reporting period. These included ToO observations of two Gravitational Wave (GW) events (S190408an and S190425z) on April 10 and 25-26, respectively (see GCN #24066 and #24178). There was also a ToO observation (in coordination with *XMM–Newton*) to follow-up on the very-high energy neutrino-event IceCube 190730A, probably associated with the AGN QSO B1502+104 in outburst. During numerous GW events in *LIGO/VIRGO* O3 and 11 very high-energy neutrino events reported by IceCube and HAWC, *INTEGRAL* was operating, but did not find any statistically significant hard X-ray/gamma-ray counterparts (with the usual upper limits) during either the prompt emission or in the follow-up observations mentioned earlier, except for a possible weakly associated counterpart candidate to IceCube-190730A (GCN #25232).

Other ToO targets included the blazar Mrk 421, the repeating fast-radio burster FRB121102 (in coordination with observations at other wavelengths), the rapidly variable and rising nuclear transient AT2019pev, and the black hole X-ray binary GRS1915+105 (in coordination with *XMM–Newton*). Only *XMM–Newton* and *INTEGRAL* are able to provide the long, uninterrupted observations necessary to probe the X-ray emission of GRS1915+105 on hourly time-scales. On July 30–31, *INTEGRAL* supported the recently launched Spectrum-Röntgen-Gamma (Spectr-RG) mission with observations of the X-ray pulsar Cen X-3. The observations were made simultaneously with the seven modules of the ART-XC telescope. The source was nicely detected by IBIS/ISGRI, JEM-X, and ART-XC. These observations will be used for cross-calibration of the ART-XC. Over the period covered, 7 GRBs were detected by IBAS in *INTEGRAL*'s main instruments Field-of-View.

INTEGRAL data of the X-ray transient black-hole binary V404 Cyg have helped to shed light on the workings of inner parts of this binary. *INTEGRAL*'s observations were used to estimate the energy and geometry of the accretion onto the black hole, which were crucial to creating a complete picture of the system. ESA joined a global press release on April 29.

The source of the 511 keV electron-positron annihilation emission in the Milky Way is one of the big unsolved mysteries in astrophysics. As the Milky Way rotates, the Doppler effect should lead to line-shifts about this 511 keV energy. Using more than 10 years of *INTEGRAL*/SPI data, it was possible for the first time to constrain this velocity curve in the inner part of the Milky Way (Siegert et al. 2019). While being consistent with the Galactic rotation speed of about 220 km/sec, the data also allows for higher velocities, as could be expected from the prominent positron source, ^{26}Al, as well as for a flat rotation curve. Both higher and lower velocities would be surprising, as they can only be explained by special configurations, like a preferred direction similar to ^{26}Al, nearby emission regions (same velocity as the Sun), or dispersion dominated halo kinematics.

As of October 21, the number of refereed publications since launch is 1644, including 46 so far in 2019.

Pierre Mandrou

Finally, we are very sad to note that Pierre Mandrou, a colleague at CESR and later IRAP Toulouse, passed away on 25 September, at the end of a courageous fight against his disease. He was 75 years old. He had been retired for 10 years, but remained active. Pierre had an exceptional career accompanying the evolution of experimental gamma-ray astronomy from the beginnings to its heydays. Since the early 70s, he had started developing balloon-borne gamma-ray detectors (BERENICE, OPALE and FIGARO). Throughout the 80s and until the mid 90s he was Co-PI and Project Manager of the SIGMA coded mask instrument, built with colleagues from CNES, CEA and IKI. He then acted as instrument scientist for ESA's *INTEGRAL*/SPI, and finally, up to the limits of his strength, he helped with the development on ECLAIRs/SVOM. Pierre also served as technical director of CESR. He was recognized with several awards during his career including the French Ordre du Mérite and the Crystal of the CNRS. Pierre is survived by his wife and two sons.

CALET

JOHN WEFEL (LSU)

The Calorimetric Electron Telescope (CALET) mission is currently taking data from its attach pallet on the International Space Station (ISS). The instruments (CAL = Calorimeter and CGBM = Calet Gamma Burst Monitor) continue to function nominally and are close to completing five years on-orbit. The team has published (in PRL) its first measurements of the cosmic ray proton spectrum over a very wide energy range and verified the change in spectral index that had been suggested by previous measurements. The team discussed many other aspects of the data analysis at the 36th International Cosmic Ray Conference this past summer in Wisconsin.

Physics of the Cosmos News

T. J. BRANDT (NASA GSFC, PCOS CHIEF SCIENTIST), PANAYIOTIS TZANAVARIS (NASA/GSFC & CRESST), BERNARD KELLY (NASA/GSFC & CRESST)

NASA's Physics of the Cosmos (PCOS) program explores some of the most fundamental questions regarding the physical forces and laws of the universe: from testing General Relativity to better understanding the behavior of matter and energy in extreme environments; the cosmological parameters governing inflation and the evolution of the universe; and the nature of dark matter and dark energy. To enable current and future missions to address these questions, the PCOS Program Office (PO) engages with the community, executes the Strategic Astrophysics Technology (SAT) program, and facilitates formulation of new missions.

The PCOS Program Analysis Group (PhysPAG) includes everyone interested in the PCOS program via six Science Interest Groups (SIGs) and the Multimessenger Astrophysics (MMA) Science Analysis Group (SAG); this probably means you! Other articles in this newsletter give updates on the activities of our SIGs, including X-ray, Gamma-ray, Cosmic Ray, and Gravitational Wave SIGs, and the MMA SAG. The PhysPAG provides fora for the PCOS community to regularly engage with the PO. PhysPAG Executive Committee (EC) members organize meetings, collect and summarize community input, and report to the Astrophysics Advisory Committee (APAC) and the Astrophysics Division Director. EC members' terms last ∼2 years, with several rolling off this December. Following a call for nominations, NASA expects to announce new appointments in the coming months. Stay tuned to PCOS-News emails or check our website!

The MMA SAG aims to identify science goals achievable with multimessenger observations with NASA observatories and ground- and space-based facilities in the 2020s and beyond. The MMA SAG article elsewhere in this issue describes the SAG's most recent activities. The MMA SAG is focused on, and open to, the community, and still welcomes new members. To get involved, subscribe to the MMA SAG mailing list or e-mail the Chair, John Conklin: jwconklin at ufl dot edu.

While the MMA SAG looks at science goals achievable in the next decade and more, NASA's Gravitational Wave - Electromagnetic (GW-EM) task force is nearer-term, focusing specifically on NASA's role in the EM prompt and follow-up observations of events detected by *LIGO* and the future *LIGO* A+. The Task Force has completed a community survey on improving coordination between present and near-future NASA missions and *LIGO* & *LIGO* A+, and will be making public its final report in the near future.

We look forward to seeing you at the PCOS sessions and PCOS table at the January AAS Meeting! Stop by the PCOS table to chat and check out PCOS technology demos and videos, information, and stickers about PCOS-sponsored or -related missions. The Joint PAG and PCOS & PhysPAG sessions are on Saturday, January 4, 2020, before the opening reception; the Cosmic Origins (COR) Great Observatories SAG session is on Sunday, January 5; the X-ray SIG & MMA SAG sessions are on Tuesday, January 7; and the Gravitational Wave SIG & Gamma-Ray SIG sessions are on Wednesday, January 8. We will provide remote connection and links to slides for those who are not able to attend in person. Details will be posted on the PCOS website.

There is still time to submit your 5 minute "lightning talk" abstract for the January AAS PCOS & PhysPAG meeting! Lightning talks will highlight revolutionary multimessenger, multimission astrophysics discoveries from the last decade or potential for future discoveries that include at least one NASA mission. The deadline for submission is Wednesday, November 27, 2019.

At the April 2020 APS Meeting we will have PCOS PhysPAG and SIG/SAG sessions along with a table featuring PCOS technology and information. Plan to join us and look for further details in spring 2020!

The PhysPAG SIGs and SAG enabled community participation in the Astro2020 Decadal by providing a forum for the organization of white papers on PCOS science. The PCOS site provides lists of submitted white papers, including high-energy related ones collected by the Gravitational Wave, X-Ray, and Gamma-ray SIGs. At time of publication of this newsletter, thirteen decadal panels had been announced. Check the Astro2020 website or subscribe on the Astro2020 email list to stay up to date on panel activities and opportunities to participate in town hall meetings or view relevant webinars!

For the first time in SAT gap prioritization, PCOS, COR, and Exoplanet Exploration produced a merged technology gap list, published in the October 2019 Astrophysics Biennial Technology Report (ABTR). The ABTR is a comprehensive compilation of technology gaps across astrophysics driven by strategic missions. Check the ABTR for both updated and new gaps, each program's current technology portfolio, completed and planned technology infusions, and the new proposal & notice of intent due dates for SAT and other technology development solicitations that have been shifted by ∼nine months to October and December, respectively.

On the mission front, we are excited to announce that the NASA 2019 Senior Review report recommends continuation of all eight of the APD's operating missions, including the high-energy missions *Chandra, Fermi, NICER, NuSTAR, Swift,* and *XMM-Newton.* NASA-commissioned studies of possible future missions have published their final reports, including the *Lynx* mission concept study final report and many PCOS science related probe mission reports. The Gamma-ray SIG, X-ray SIG, and *Lynx* articles have further details on wavelength-related studies. The PO continues to host and facilitate work on the *LISA* and *Athena* studies, as described in the *LISA* and *Athena* articles elsewhere in this newsletter. This includes supporting the NASA *LISA* Study Team. Following an open call for nominations, new team members were selected in late October to replace departing ones and augment current membership.

We welcome your input on PCOS science topics, particularly through the relevant PhysPAG SIGs, and by submitting technology gaps by June 1, 2021. We also look forward to seeing you either in person or virtually at our upcoming meetings, and encourage you to join our email list and check our website for news!

The X-ray Science Interest Group

Ryan Hickox (Dartmouth), John Tomsick (University of California Berkeley)

It has continued to be an exciting year for X-ray astronomy, with the 20th anniversaries of both *Chandra* and *XMM–Newton*, as well as the successful launch of the Spectrum-Röntgen-Gamma spacecraft (with the eROSITA and ART-XC instruments) in July 2019. To celebrate these milestones, the community has organized a number of meetings, including the *XMM–Newton* 20th Anniversary GSFC Symposium held at Goddard Space Flight Center in October, and the 20 Years of *Chandra* Science Symposium to be held in Boston this December. In March 2020, the Mapping the X-ray Sky with SRG: First Results from eROSITA and ART-XC will be held in Garching, Germany.

In other X-ray astronomy news, this summer, the *Lynx* flagship X-ray mission concept submitted its final Concept Study Report for consideration by the Astro2020 Decadal Survey. The *NICER* mission has made a number of exciting X-ray measurements of neutron stars, stellar mass black holes, and AGN, and is currently in the review process for Cycle 2 of its successful Guest Observer program.

As the Astro2020 process continues, the White Papers regarding "Activities, Projects, and State of the Profession Considerations (APC)" has seen dozens of submissions directly related to X-ray astronomy, including mission concepts, technology development, and laboratory astrophysics, with many more APC White Papers that are broadly relevant to the X-ray community. At the January 2020 AAS meeting in Honolulu, we will be holding an XRSIG session that will include an overview of the APC White Paper submissions, updates on the *Athena*, *Lynx*, and eROSITA missions, as well as new high-resolution X-ray mirror technology. This fall saw a new round of PhysPAG Executive Committee nominations, and we look forward to new members joining in 2020, as well as to seeing many of you in Honolulu!

The Gamma-ray Science Interest Group

Sylvain Guiriec (The George Washington University & NASA/GSFC), John Tomsick (University of California Berkeley)

The panels for the ASTRO2020 decadal review are now public and most of the white papers related to the GammaSIG activities should be directed to the "Panel on Electromagnetic Observation from Space 2." The GammaSIG will continue to help emphasize the importance of our gamma-ray mission projects for answering fundamental key questions, which can only be addressed in this energy domain. We will hold sessions during the main AAS and APS conferences; the next GammaSIG session will be at the 235th AAS Meeting in Honolulu, Hawaii on Wednesday, January 8, 2020 from 1:15 pm to 2:45 pm (Room 303A at the Hawaii Convention Center).

The Cosmic Ray Science Interest Group

James Beatty (The Ohio State University), Abigail Vieregg (University of Chicago), Marcos Santander (University of Alabama)

The CR SIG chairs would like to receive input from community members regarding the topics they would like the SIG to address, as well as questions and general suggestions. Members are encouraged to contact the chairs directly (James Beatty - beatty.85@osu.edu, Abigail Vieregg - avieregg@kicp.uchicago.edu, Marcos Santander - jmsantander@ua.edu). People interested in the activities of the group are also invited to join our mailing list, and please see the CR SIG website for up-to-date information.

The Gravitational Wave Science Interest Group

Nicolas Yunes (University of Illinois at Urbana-Champaign), John W. Conklin (University of Florida), Kelly Holley-Bockelmann (Vanderbilt University)

The GW SIG organized a Focus Session at the April APS Meeting 2019, which was held in Denver, Colorado. The speakers of the focus session were Nicolas Yunes from Montana State University (now at the University of Illinois Urbana-Champaign), Shane Larson (Northwestern University) and John Conklin (University of Florida). Dr. Yunes spoke about the science we expect to be able to extract with *LISA* in the future, with a focus on modified gravity and tests of General Relativity. Dr. Larson talked about "Adding *LISA* to your Toolbox", a summary of the broad *LISA* science case and tools to help interested researchers begin adding *LISA*-related calculations into their research. Dr. Conklin provided an update on the ESA/NASA *LISA* mission. The GW SIG is planning to organize another Focus Session on *LISA* science at the 2020 April APS Meeting that will be held in Washington, D.C.

A special session at the January 2019 AAS meeting in Seattle was also organized by the GW SIG. This session focused on synergies between *LISA* science and other observatories, including 3G ground-based Gravitational Wave Detectors (Kent Yagi) and the proposed *Lynx* X-Ray observatory (Zoltan Haiman). Kelly Holley-Bockelmann discussed Asto2020 Decadal Survey preparations. Unfortunately the planned *LISA* mission update from Ira Thorpe from NASA Goddard was cancelled due to the government shutdown. A GW SIG session is currently being planned for the upcoming January 2020 AAS meeting in Honolulu. Information about upcoming GW SIG meetings can be found at the PhysPAG website.

The gravitational wave science community wrote 11 science white papers specifically about the science capabilities of the *LISA* mission in preparation to the Astro2020 Decadal Survey. Independently, several dozen other white papers also mentioned the *LISA* mission. Three *LISA*-related APC white papers were also submitted to the Astro2020 decadal survey. These included a paper on the *LISA* mission itself and NASA's role in that mission, a paper on how to build up and support the burgeoning gravitational wave science community, and a paper on gravitational wave astronomy beyond *LISA*.

Last but not least, we would like to thank Dr. Kelly Holley-Bockelmann for her service as Co-chair of the GW SIG and Dr. John Conklin for his service as Co-chair of the GW SIG and Chair of the PhysPAG Executive Committee. We expect NASA to announce new EC members sometime in November 2019.

NASA Multimessenger Astrophysics Science Analysis Group

J. W. Conklin (Chair of the PhysPAG Executive Committee, U. Florida), John Tomsick (University of California Berkeley), Suvi Gezari (University of Maryland), T. J. Brandt (PCOS Chief Scientist, NASA/GSFC)

The NASA Multimessenger Astrophysics Science Analysis Group (MMA SAG) is analyzing potential scientific benefits of multimessenger observations made possible by NASA observatories in the 2020's and beyond, working in conjunction with each other or with other ground- and space-based instruments. This group is charged with (a) Identifying science goals that could be achieved by combining different astrophysical messengers measured by current and future ground- and space-based observatories, (b) identifying measurements that can be made by existing, currently approved, and future planned ground- and space-based observatories that could contribute to MMA in 2020's and early 2030's, (c) Determining how these enhanced or new science goals align with the NASA Astrophysics Division's scientific priorities, and (d) identifying key qualitative technical drivers that are needed to achieve these science goals. The MMA SAG is chaired by John Conklin (University of Florida) and co-chaired by John Tomsick (UC Berkeley) and Suvi Gezari (University of Maryland).

The organization of the MMA SAG is centered on astrophysical sources, rather than the associated messenger (e.g. EM wavelength, GW frequency, or particle). This organization scheme is intended to facilitate interaction between researchers focused on the same source using different observational approaches. Astrophysical sources of interest include AGN and supermassive black holes, compact binary systems with neutron stars, white dwarfs, and stellar-mass black holes, stellar-mass black hole binaries (so-called *LIGO* binaries), and supernovae and their remnants.

The MMA SAG has been active for about a year and plans to wrap up its primary activities by the end of 2019. The SAG organized community Science White papers submitted to the Astro2020 Decadal Survey.

We are currently preparing a near-final report and plan to present our findings at the AAS meeting in January 2020 in Honolulu during a MMA SAG special session. We will solicit community feedback during that session, which will be incorporated into our final report, which will be submitted to the NASA Astrophysics Advisory Committee (APAC) in early Spring 2020.

The MMA SAG is community-driven, community-owned, and open to all. We still welcome new members and if you would like to get involved, you may subscribe to the MMA SAG mailing list, or e-mail the Chair, John Conklin: jwconklin at ufl dot edu.

Athena: Revealing the Hot and Energetic Universe

Kirpal Nandra (MPE), Didier Barret (IRAP), Randall Smith (CfA), Francisco J. Carrera (IFCA, CSIC-UC) for the *Athena* Science Study Team and the *Athena* Community Office

After the successful completion of the Instrument Preliminary Requirement Reviews, *Athena* is currently undergoing another important milestone:the Mission Formulation Review (MFR). Kicked-off in mid-September, this review is expected to close with the final Board Meeting on November 12. Its scope can be summarized as follows:

- Verify completeness, adequacy and consistency of Mission/SpaceCraft (SC) preliminary design, Phase B1 management plan, and risk management plan
- Verify completeness, adequacy and consistency of Mission/SC requirement flow-down
- Verify completeness, adequacy and consistency of Mission/SC interfaces
- Verify completeness, adequacy and consistency of the ESA Technology Plan in light of the overarching goal of achieving the required technical readiness level for all critical components by mission adoption
- Verify the realism of the Mission schedule and cost estimates

The Phase A2 industrial contracts have been closed. Overall the SC designs look feasible (pending confirmation by MFR). Successful MFR will allow the long-sought transition to Phase B1. Additionally, a number of new *Athena* Technological Development Activities (TDAs) have been recently approved, including the keystone SPO-Engineering Qualification Module and Mirror Demonstrator TDAs.

The *Athena* mission relies upon a new technology, Silicon Pore Optics (SPOs), for its combination of angular resolution, high throughput, and low mass. SPOs, in turn, reuse technology and investments made by the semiconductor industry, borrowing materials, processes, and equipment. At the August 2019 SPIE meeting, substantial progress across a wide range of topics was presented. Bavdaz et al. (2019) and Bradshaw et al. (2019) presented measurements from July 2019 of a 10.2 arcsec PSF over 70% of the SPO. The equivalent results in January of 2019 were $13''$, and $19''$ in November of 2017. These rapid changes are due to a number of improvements, including improved metrology throughput the manufacturing process and better control of impurities and defects in the silicon plates.

A key innovation was the discovery of a method to trim an SPO to remove the lateral outer sides of a stack, where the PSF is always seriously degraded relative to the middle, without affecting the optical performance. This allows for the creation of wider SPOs that will be 'chopped' to the correct size to use only the central 70% region with the best PSF. More process improvements are planned; see Collon et al. (2019) for details. SPOs will be aligned and integrated into a full Mirror Assembly Module (MAM) by Media Lario in a new facility whose design was described by Valsecchi et al. (2019). The approach, which has already been successfully demonstrated (Valsecchi et al. 2017), uses a UV beam with a vertically-mounted 2.6m collimator mirror that has already been machined and is in the polishing process.

Following the successful Instrument preliminary requirement review of the X-IFU, entering into phase B, priorities have been set for the X-IFU team to look for any further optimization of the cryogenic chain, addressing micro-vibrations, and consolidating the interfaces between the X-IFU and the Science Instrument Module. These activities are carried out in close contact with the ESA study team, and in support of the on-going Mission Formulation Review. About the cryogenic chain, optimizations being investigated include the accommodation of the cooler cold heads into separate mini-cryostats, the implementation of a single 3 Kelvin Joule-Thomson (JT) cooler stage instead of the current 2K-JT + 4K-JT stage combination, and finally the possibility to remove one of the five 15 K pulse tube coolers. In parallel, to meet the 10 year lifetime requirement on any movable mechanical parts of the instrument, an assessment of the cooler lifetime is necessary for both the European and Japanese supplier options.

The kick-off of the critical design review of the Detector Cooling System (DCS) took place mid-October. The aim of the DCS is to demonstrate a stable 50 mK temperature stage and be able to operate two multiplexed readout channels of the focal plane assembly with representative spectral performance, accounting amongst others, for any electromagnetic and micro-vibration disturbances. This is part of the technology demonstration expected for the mission adoption review, and represents a major effort from the whole X-IFU team.

The 10th X-IFU Consortium meeting took place in Toulouse, with the main objective to review the post-IPRR status of the instrument, with a focus on the on-going actions. Along the meeting, it was decided to integrate a significant reduction (by at least a factor 2) of the travel footprint associated with the many meetings required for developing the instrument. More can be found in the 12th issue of the X-IFU gazette.

Impressive progress has been achieved by the WFI Consortium in all critical development aspects - the production and performance of the DEPFET sensors, the real-time handling of the large data rates by the detector electronics, and the stability of the large-area optical/UV light-blocking filters to acoustic noise loads. The first batch of the pre-flight DEPFET sensor production has been completed at the Semiconductor Laboratory of the Max Planck Society and the devices are now under test at MPE. Preliminary results indicate the expected excellent performance of the devices.

The large collecting area of the *Athena* optics coupled with the impressive readout times of the detectors (5ms for the Large Detector Array and $80\ \mu$s for the Fast Detector) generate high data rates that need to be processed in the Detector Electronics in real time. A breadboard test setup of the Frame Processor has been developed. Using digital data from a programmable emulator, the real-time performance was successfully verified, showing that the electronics can handle sources as bright as in the case of the WFI Fast Detector $2.5\times$ the Crab (~ 195000 photons/s) without losses.

Successful filter and filter wheel acoustic noise tests were performed at the AGH Krakow, Poland, over the summer. These tests, performed with a Filter Wheel Demonstrator and flight-representative filters, validated the survival at qualification level acoustic loads and verified that a vacuum enclosure will not be needed for the instrument.

The progress was presented and discussed during the 10th WFI Consortium meeting, which was held at the University and Astronomical Observatory in Strasbourg, France, October 14–17, 2019.

Since the Spring 2019 issue, four *Athena* Nuggets have been released, dealing with science and technical topics relevant for the mission.

Regarding the *Athena* website, the *Athena* gallery is being regularly updated with figures and images related to the mission. The *Athena* community map has been brought up-to-date with our current 808 community members: look for yourself and your colleagues worldwide! A 3D printer model of the *Athena* spacecraft is available under the "Outreach/Material" section.

The *Athena* community has responded to future planning exercises in both the US and Europe. The Astronomy and Astrophysics 2020 Decadal survey was given 13 coordinated white papers, along with an introduction by Esra Bulbul. In Europe, the Voyage 2050 programme received proposals for five missions that would build upon *Athena* science, three of which (ASTENA, HiReX, and the Cosmic Web Explorer) have been invited to present at the Voyage 2050 workshop.

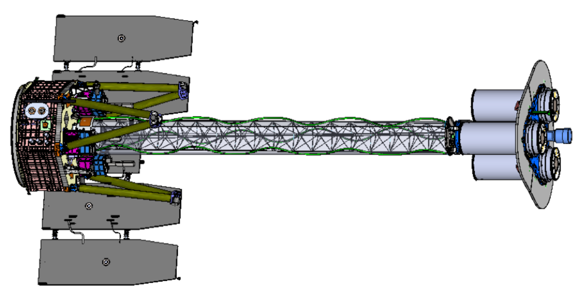
Athena was featured in presentations in a number of recent national and international conferences, including a Special Session in the European Week of Astronomy and Space Science in Lyon (France) dedicated to "3-D spectroscopy from sub-mm to X-ray: the promise of *Athena* in the 2030s multi-wavelength context" and several talks with *Athena* content in the "X-ray Astronomy 2019" at Bologna (Italy), were there was also an *Athena* stand with leaflets, stickers, pens and pendrives. Slides from some of the talks above are available at the *Athena* website.

You can keep up-to-date with *Athena* via the community website, or through our Twitter username AthenaXobs and Facebook. Urgent or important notifications are sent to the *Athena* Community through bimonthly Brief News emails.

The Imaging X-ray Polarimetry Explorer

M. C. Weisskopf, Brian Ramsey, Steve O'dell (NASA/MSFC)

The *IXPE* Team is hard at work preparing the mission for launch in 2021 Spring. Here we provide updates on the status of the mission since the previous Newsletter. The Project successfully completed the Mission Critical Design Review (M-CDR) in late June. Shortly thereafter, the NASA Launch Services Program selected the *IXPE* launch vehicle - namely, a SpaceX Falcon-9. This selection resulted in a few, relatively minor design changes in the Observatory (see figure). Near-term significant events include the Ground System Critical Design Review (GS-CDR) in late November, delivery of the first flight Detector Unit (DU) in early December, completion of the first flight Mirror Module Assembly (MMA) and start of X-ray calibration in February.



IXPE schematic. Credit: MSFC

The X-ray Imaging and Spectroscopy Mission

Richard Kelley, Brian Williams (NASA/GSFC)

The *XRISM* mission continues towards a planned launch in early 2022. This month, the Resolve detector, along with the rest of the hardware for the Calorimeter Spectrometer Insert, will be packed up and shipped from NASA Goddard Space Flight Center to Japan to begin integration and testing with the spacecraft dewar system. The first *XRISM* mirror has been assembled, and will soon undergo testing at the X-ray beamline facilities at NASA Goddard.

NASA GSFC scientists and engineers standing with the XRISM Calorimeter Spectrometer Insert days before its scheduled ship date to Japan. Credit: NASA

The *XRISM* Science Team recently met in Matsuyama, Japan, in October. Despite travel schedules for many of the attendees having to be altered due to an approaching typhoon, the meeting was held successfully, and consisted of mission status updates from all parts of the project, science policy discussions, and presentations on potential targets for the Perfomance Verification phase. This is a phase of the mission, occuring after the initial checkout and calibration phases (which will last a few months), during which the performance of the instruments will be verified through the observations of a wide variety of celestial targets. These targets will be selected via a consensus of the Science Team, and will span the range of the types of targets that *XRISM* will observe during its Guest Observer phase, which will commence immediately after the conclusion of the PV phase. All PV phase data will enter in the public archive one year after the observation is complete.

The targets for the PV phase will be selected in the summer of 2020, with the target list made public shortly thereafter. Plans are in development to construct a program by which astronomers who are not part of the *XRISM* Science Team can become involved in analysis of the PV phase data as a "*XRISM* Guest Scientist."

The *XRISM* mission will have booth space at the upcoming Winter AAS meeting in Honolulu, HI, in January 2020, and meeting attendees are encouraged to come by to hear the latest updates.

Lynx

Jessica Gaskin (NASA/MSFC),
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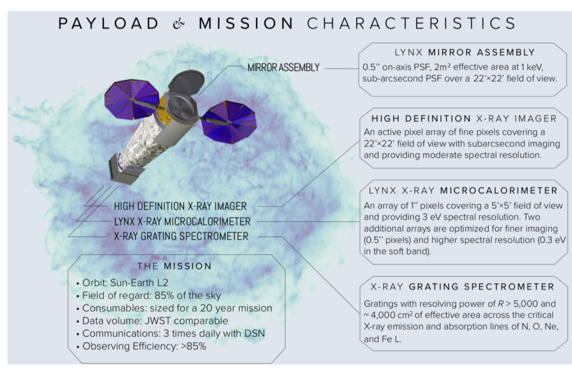
The *Lynx* X-ray Observatory is one of four large-mission concept studies sponsored by NASA for consideration by the 2020 Astrophysics Decadal Survey. The *Lynx* concept study is driven by a community-led Science and Technology Definition Team (STDT) with the charge of defining an exciting mission to address compelling science objectives that will make a profound impact across the astrophysical landscape of the 2030s. The *Lynx* Concept Study Report was submitted to the Decadal Committee in August of 2019. It is available to the community along with extensive technology maturation plans for its four enabling technologies— an X-ray mirror assembly and three science instruments— and 21 peer-reviewed papers detailing the key *Lynx* technologies, their designs, and their current capabilities as published as a Special Section of the Journal of Astronomical Telescopes, Instruments, and Systems (JATIS) in April 2019 (Vol. 5, No. 2). A comprehensive cost book was also generated by the *Lynx* team to support a Technical, Risk, and Cost Estimate (TRACE) to be carried out by Aerospace Corporation under direction of the Decadal Committee.

Lynx is designed to pursue three fundamental science pillars: 1) seeing the dawn of black holes, 2) revealing what drives galaxy formation and evolution, and 3) unveiling the energetic side of stellar evolution and stellar ecosystems. The capabilities required to address these objectives can be implemented within a proven mission architecture based on *Chandra* that provides extraordinary advances in science capabilities thanks to an extremely powerful combination of a 2 m^2 effective area mirror assembly, a large field-of-view high-spatial-resolution X-ray imager, an imaging spectrometer optimized for spectral mapping of extended structures, and an X-ray grating spectrometer for extremely high spectral resolution in the soft X-ray band. *Lynx* will have a baseline lifetime of 5 years with provisions for 20 years of operation at Sun-Earth-L2. Operation beyond 20 years is possible with in-space servicing and/or with redirecting unused mass margins to accommodate additional station-keeping fuel prior to launch.



The Lynx spacecraft is built around the X-ray mirror assembly that is followed by a large-area insertable grating array. The science instrument module is attached to the spacecraft by a rigid optical bench. It includes two interchangable prime focus detectors and an off-centered grating readout array. The spacecraft requires no new inventions and, indeed, can use many existing solutions including those developed for Chandra and other past missions.

Lynx is designed to be the most powerful X-ray observatory ever flown. In all aspects, *Lynx* will be a Great Observatory which will open a new era in our understanding of nature. It will provide an unprecedented view of the otherwise “Invisible Universe” and push outward upon every frontier of the scientific landscape. It will provide the depth and breadth to answer some of the most significant and fundamental science questions facing us today as well as many of those questions we have yet to even ask.

The *Lynx* Team would like to thank the high-energy scientific community for their participation and support over the past many years. This support included everything from insightful discussions to detailed analyses to direct contributions to the *Lynx* Concept Study Report. Without this support, *Lynx* would remain an idea rather than be a flagship-class observatory concept realizable within the coming decades.

AstroPoetry Corner

Go Back

"Where I came from" is ionized hydrogen and interstellar dust
The sloughed-off remains of a giant star
Radioactive sparks in sunbeam suspension

"Where I came from" is a long-lost generation of suns
Those that lived and died and scattered their own remains
Nuclear detonations of compact matter, the death spiral plunges of neutron stars

"Where I came from" is the empty depths, the far-flung glints on the cosmic ocean

"Where I came from" is an eddy in an infrared-hot protoplanetary disk

"Where I came from" is a collision of worlds so violent it tore magma from the Earth to coalesce into the Moon

"Where I came from" is the sky, the ground, the sea, the very air we breathe

"Where I came from" is the infinite

"Where I came from" is the Universe

And one day, when I am good and ready, I will go back
— Katie Mack (reprinted with permission of the author)