The High Energy Astrophysics Division Newsletter

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

In this Issue:

From the Chair

FIONA HARRISON (CALTECH)

I write my first column as HEAD chair under unusual circumstances. We all were looking forward to meeting in Tucson in September, and as you know we have had to cancel our 18th Divisional meeting. The Executive Committee has been discussing the possibility of having a virtual meeting, and to get feedback from membership we sent a poll asking for your opinions. We found, not surprisingly, that we are 'zoomed out', and we have taken the message to heart that we should be looking for the next appealing 'in person' venue. The HEAD membership poll indicates that having a Divisional meeting coincident with the summer 2021 AAS meeting in Alaska is appealing, and we will be looking to that as a prime opportunity to gather HEAD members in person.

The Executive Committee is concerned with the impact that the cancellation of meetings will have on our younger members – in particular graduate students and postdocs. We are committed to continuing to provide venues for our young members to describe their research, hone their presentation skills, and get attention as they enter the job market. We are therefore excited to announce a monthly virtual seminar series, open to all, but hoping to highlight research from our youngest members. We have an exciting series of talks lined up, and the inaugural seminar will be held June 30. Please watch your e-mail for announcements, and let us know if you have a suitable talk topic.

Finally, I want to remind everyone that while this is a challenging time for us all, we look forward to an exciting scientific future. *Spectrum Röntgen-Gamma*'s instrumentation is providing transformative surveys, and the *XRISM* mission is on track to capitalize on the beautiful but brief results from *Hitomi*. On behalf of the HEAD Executive Committee I want to express our enthusiasm for seeing you all in person as soon as it is safely possible.

HEADlines

MEGAN WATZKE (CXC)

Like the rest of world, the field of science journalism has pivoted most of its attention to COVID-19. Of course, there were many high-energy astrophysics stories that were released before the pandemic became prevalent, and several that have pierced through the coronavirus coverage since then. For example, a joint *Chandra/XMM–Newton*/GMRT press release about a record-breaking explosion from a black hole on February 27th was picked up by The New York Times, Associated Press, and many other outlets.

Regardless of the challenges of current times, scientists continue to explore the Universe using high-energy missions, telescopes, and observatories. Perhaps now more than ever, the public is served by sharing the wonders of the cosmos to allow them to focus on wonders beyond the mundane issues here on Earth.

Some stories released in the past half year, including those presented at the January AAS meeting in Honolulu, include:

- April 27, 2020: "NASA's *Swift* Mission Tallied Water from Interstellar Comet Borisov"

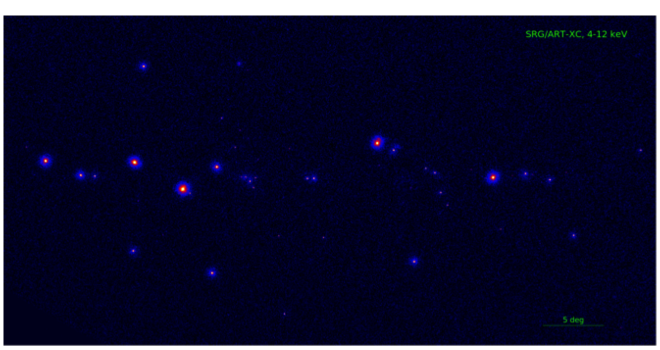
- April 13, 2020: “NASA Missions Help Reveal the Power of Shock Waves in a Nova Explosion”
- March 19, 2020: “*Chandra* Data Tests ‘Theory of Everything’”
- February 20, 2020: “*XMM–Newton* Reveals a Giant Flare from a Tiny Star”
- January 10, 2020: “Team of Telescopes Finds X-ray Engine Inside Mysterious Supernova”
- January 6, 2020: “*LIGO*-Virgo Network Catches Another Neutron Star Collision”
- December 12, 2019: “NASA’s *NICER* Delivers Best-Ever Pulsar Measurements, 1st Surface Map”
- December 8, 2019: “With the Start of the SRG All-Sky Survey, eROSITA Promises Most Accurate Maps of the X-ray Sky Ever”
- January 6, 2020: “Famous Black Hole Has Jet Pushing Cosmic Speed Limit”
- December 19, 2019: “NASA’s *Fermi* Mission Links Nearby Pulsar’s Gamma-ray ‘Halo’ to Antimatter Puzzle”
- November 20, 2019: “NASA’s *Fermi*, *Swift* Missions Enable a New Era in Gamma-ray Astronomy”

As always, if you have science results which might be of interest to the general public (or other bits of not-so-shameless self-promotion), please email the HEAD Press Secretary. Don’t be shy!

Spektr-RG, ART-XC & eROSITA

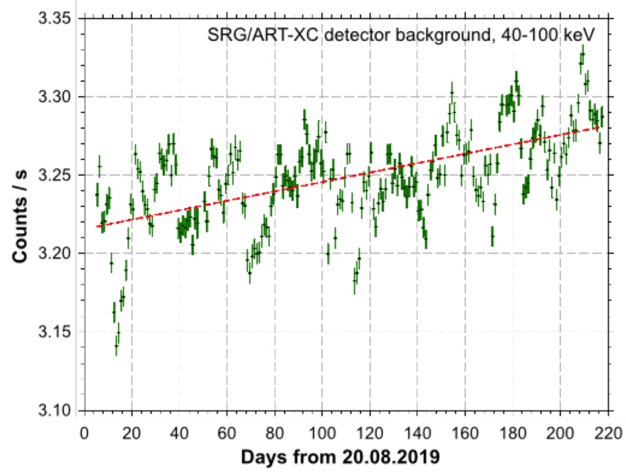
A. Merloni (MPE), M. Pavlinsky (IKI), P. Predehl (MPE), S. Sazonov (IKI)

Despite the lockdown measures imposed by the governments of both Russia and Germany as a consequence of the COVID-19 pandemic, the Mission Operation Center at NPOL Lavochkin in Moscow continues to operate SRG without impediments, supported by the operations teams at IKI and MPE. Thus, SRG continues its scientific observations from its large six-month-periodic halo orbit around the second Lagarange Point of the Sun-Earth system (L2). On April 17, 2020, the first revolution around L2 was completed, a first for a Russian spacecraft.



ART-XC map (4-12 keV) of the Galactic plane region (≈1000 sq. deg) obtained during the first months of the SRG/ART-XC all-sky survey. Credit: IKI; MSFC

SRG started all-sky survey observations on Dec. 8, 2019, after completion of calibration and performance verification observations for its two instruments. In this phase, the spacecraft operates in continuous scanning mode, its field of view drawing great circles on the sky with a period of 4 hours, all intersecting at the ecliptic poles. After six months the entire sky will be scanned as the L2 point moves around the sun. At the time of writing (end of April 2020), about two thirds of the sky has been surveyed by ART-XC and eROSITA. The first all-sky survey will be completed in mid-June 2020.

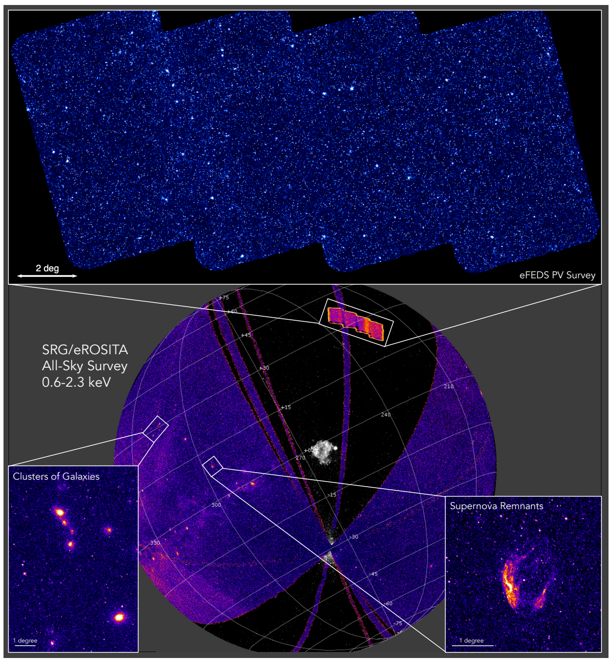


Daily background level of one of the ART-XC detectors in the 40-100 keV energy band during the period from August 20, 2019 to March 24, 2020. Credit: IKI; MSFC

ART-XC is performing an all-sky survey in the 4-12 keV energy band, and all the telescope systems are operating nominally. The depth of the X-ray images obtained so far varies between 10^{-11} erg/s/cm^2 near the ecliptic plane to 10^{-12} erg/s/cm^2 near the ecliptic poles. By the end of the 4-year survey, these limits are expected to improve by about an order of magnitude. The high quality and richness of the obtained data by ART-XC is impressive. For example, ART-XC has detected and localized (to within 30 arcsec) about 100 hard X-ray sources within a ~ 1000 sq. deg region along the Galactic plane. These data nicely complement the much deeper maps of the Galactic Center region obtained by ART-XC during the PV phase.

ART-XC is constantly monitoring the background level at the L2 halo orbit. Its detectors operate at energies from 4 keV to over 100 keV, while the effective area of the mirror systems is negligible at energies above 30 keV. As a result, the background on the ART-XC detectors is completely determined by charged particles at high energies. For more than 200 days of SRG operation at L2, the ART-XC detector background has been remarkably stable in the 40-100 keV energy band. Specifically, it has smoothly increased over this time by approximately 2%, with few per cent variations observed around this trend.

The eROSITA all-sky survey observations in the most sensitive band (0.6-2.3 keV) so far has delivered high quality images of galactic and extragalactic X-ray sky. More than 350,000 point-like sources have been detected in a region covering only about 1/3 of the whole sky. Boresight calibration using WISE and Gaia QSO shows that the point source positional accuracy is < 4 arcseconds (1σ). In addition, a few thousand extended sources have been detected so far.



Spherical projection of the eROSITA All-Sky Survey image in the 0.6-2.3 keV band (purple), taken with an average exposure of ≈250 seconds. In the background, a black and white image of the ROSAT all-sky survey is shown. Two insets at the bottom show details of an extragalactic and a galactic field, centered on the Shapley Supercluster and the Supernova Remnant PKS 1209-52, respectively. The top panel shows the exposure-corrected X-ray image of the entire SRG/eROSITA Performance Verification eFEDS field (≈140 deg^2) in the 0.6-2.3 keV band. The average exposure (2.5ks) is comparable to the final depth that will be achieved over the whole sky after completion of the survey phase of the mission towards the end of 2023. Credit: All-Sky Survey images: A. Merloni, C. Maitra (MPE); eFEDS: M. Ramos (MPE).

Among the Performance Verification observations carried out in November 2019, a mini-survey called eFEDS (eROSITA Final Equatorial Depth Survey) was devised in order to image a small patch of the sky to the same depth expected at the end of the 4-year all-sky survey. The eFEDS data confirm with great accuracy the sensitivity of the X-ray telescope to its main target classes. Over an area of just 1/300 of the full sky, eROSITA revealed more than 20,000 point-like X-ray sources, around 80% of them being distant Active Galactic Nuclei (AGN) harboring growing supermassive black holes, and most of the remainder X-ray active stars. This mini-survey also discovered about 450 clusters of galaxies (including a few at a redshift near 1), easily recognizable from their extended, diffuse morphology in the sharp X-ray images.

LIGO-VIRGO-KAGRA Collaborations

Patrick R. Brady (University of Wisconsin. Milwaukee)

LIGO and *VIRGO* suspended observing run O3 on March 27, 2020 about a month earlier than planned due to the COVID-19 pandemic. Nevertheless, the run was a tremendous success, with 56 candidate gravitational-wave signals identified and publicly announced within minutes of acquiring the data. Papers have been submitted describing GW190425, the binary neutron star merger detected via gravitational waves, and GW190412 a binary black hole merger with mass ratio around 4:1. The asymmetric masses lead to measurable gravitational-wave emission beyond the leading quadrupolar order for the first time. The *LIGO-VIRGO* Collaboration is preparing publications on two more binary merger candidates and plans to update the Gravitational-Wave Transient Catalog with detections from O3a (the first 6 months of O3) in the near future. Analysis of O3 data for continuous waves, stochastic, and unmodeled transients are ongoing and results will be released in papers later this year.

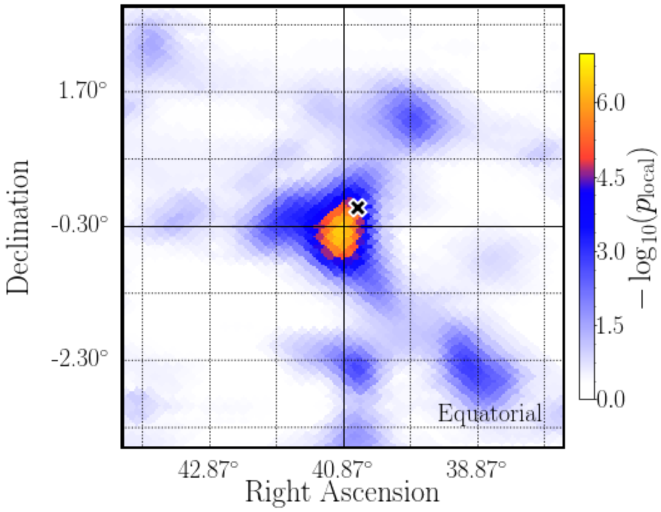
The Japanese *KAGRA* gravitational-wave project has continued to make progress and earlier this year reached a best sensitivity of 1 Mpc range for binary neutron star mergers. Unfortunately, *LIGO* and *VIRGO* had ceased observations before *KAGRA* could join the run. With this milestone, however, the *LIGO-VIRGO-KAGRA* international gravitational-wave observatory network will move ahead. *KAGRA* and *GEO600*, the British-German detector, carried out joint observations for several weeks in April.

LIGO, *VIRGO* and *KAGRA* plan for observing run O4 to start in early 2022. As Italy and the United States begin to relax stay-at-home orders, *LIGO* and *VIRGO* are preparing to resume activities at the observatories and other campus laboratories. It is not yet clear what the impact of stay-at-home orders and social distancing will have on the improvements to be implemented between O3 and O4. Updates will be provided as the situation becomes more clear.

IceCube Neutrino Observatory

Madeleine O'Keefe (University of Wisconsin–Madison)

The IceCube Collaboration recently conducted an all-sky search using 10 years of IceCube data that provides the most sensitive probe of time-integrated neutrino emission of point-like sources. The results of this scan have been published in a paper in *Physical Review Letters*, "Time-integrated Neutrino Source Searches with 10 years of IceCube Data."



The pretrial probability of the observed signal being due to background in a 5x5 degree window around the most significant point in the Northern Hemisphere (the hottest spot); the black cross marks the Fermi-3FGL coordinates of the galaxy NGC 1068. Credit: IceCube Collaboration

The IceCube Neutrino Observatory, an array of optical modules buried in a cubic kilometer of ice at the South Pole, hunts for cosmic-ray sources inside and outside our galaxy—extending to galaxies more than billions of light-years away—using hints from neutrinos.

IceCube has already observed an astrophysical flux of neutrinos, so we know they exist and are detectable—we just don't know exactly where they come from. Identifying the sources of this neutrino flux is just a matter of time and precision.

It is expected that neutrinos are produced by cosmic-ray collisions with gas or radiation near their sources. Unlike cosmic rays, neutrinos are not absorbed or diverted on their way to Earth, making them a practical tool for locating and understanding cosmic accelerators. If scientists can find a source of high-energy astrophysical neutrinos, this would be a smoking gun for a cosmic-ray source.

The principle challenge in searching for astrophysical neutrino sources with IceCube is the overwhelming background of events induced by cosmic-ray interactions in our atmosphere. The signal of faint neutrino sources needs to be extracted via sophisticated statistical analysis techniques.

Using these methods, our collaborators recently "scanned" across the entire sky to look for point-like neutrino sources at arbitrary locations. This scanning method is able to identify very bright neutrino sources not visible in gamma rays.

In order to be sensitive to fainter sources, we also analyzed 110 galactic and extragalactic source candidates that have been observed via gamma rays, which are also produced in cosmic-ray collisions. We then combined the results obtained for individual sources in this list in a "population analysis" that looks for a higher-than-expected rate of significant results from the individual source list search. Researchers also employed a "stacking search" for three catalogs of gamma-ray sources within our galaxy.

The different analyses did not reveal steady neutrino sources, but the results are nevertheless exciting: some of the objects in the catalog of known sources showed a higher neutrino flux than expected, with excesses at the 3σ level. In particular, the all-sky scan revealed that the "hottest" location in the sky is just 0.35 degrees away from the starburst galaxy NGC 1068, which has a 2.9σ post-trial excess over background. NGC 1068 contains one of the closest supermassive black holes; it is embedded in a star-forming region with lots of matter with which neutrinos can interact, while high-energy gamma rays are attenuated, as shown by *Fermi* and MAGIC measurements. This is the most significant excess seen besides TXS 0506+056, the 2017 source that IceCube found to be coincident with a gamma-ray flare. Still, to confirm these sources requires more data with a more sensitive detector, like IceCube–Gen2.

We also found that the Northern Hemisphere source catalog as a whole differed from background expectations with a significance of 3.3σ. These results demonstrate a strong motivation to continue to analyze the objects in the catalog. Time-dependent analyses, which search for flares of peaked emission, and the possibility of correlating neutrino emission with electromagnetic or gravitational wave observations for these and other sources, may provide additional evidence and constrain the origin of neutrino emission. Additional data is needed for more precise direction reconstruction, and the upcoming IceCube Upgrade will provide significant improvements in sensitivity.

The Chandra X-ray Observatory

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

We are pleased to report that *Chandra* has 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.

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.

In response to the exigencies created by the coronavirus pandemic, *Chandra* staff have successfully transitioned science and mission operations to a mostly teleworking model. Our primary goals are ensuring the health of our staff and maintaining the continued normal operation of *Chandra*. Staff are working from their homes, with a minimal number of operators present at the Operations Control Center (OCC) to communicate with the spacecraft. Procedures and schedules are in place to keep operators physically and temporally separated and to properly clean the OCC. *Chandra* science and mission operations have continued without interruption, and the spacecraft and instruments are operating nominally.

Belinda Wilkes with Eileen Collins, Steve Hawley and Cady Coleman (left to right) at the "20 Years of Chandra Meeting". Credit: CXC

The Peer Review for Cycle 22 proposals, scheduled for June 2020, will be conducted remotely. To accommodate proposers affected by coronavirus restrictions, the deadline for proposals was delayed to April 2. The community responded with their usual enthusiasm, with the number of proposals and observing time oversubscription rate similar to those of Cycle 21.

The project conducted a highly successful symposium, "20 Years of *Chandra* Science," in Boston, December 3-6, 2019. The symposium, which hosted 300 attendees and was broadcast in real time via Twitter, included poster and science sessions, as well as a panel discussion featuring astronauts (Mission Commander Eileen Collins, Mission Specialist Steven Hawley, and Mission Specialist Cady Coleman) who flew the Space Shuttle that launched *Chandra*.

Two new books also celebrate *Chandra*'s 20th anniversary. A beautiful "coffee table" book, *Light from the Void*, filled with beautiful *Chandra* images, some combined with data from other great observatories and large telescopes, was published by Smithsonian Books in the fall and is available on Amazon. In addition, a ~ 500-page review of *Chandra* and its science, *The Chandra X-ray Observatory: Exploring the High Energy Universe*, was published by IoP as part of their series in collaboration with the AAS.

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 on the *Chandra* press release webpage. Please see the CXC website for current information about the *Chandra* Observatory and CXC activites.

XMM–Newton

Lynne Valencic (JHU & NASA/GSFC)

Successful submissions from the Nineteenth Call for Proposals for *XMM–Newton* were announced in December 2019, and observations will begin in May. The Twentieth Call for Proposals will open August 18, and the final date to submit proposals will be October 9. The final approved program will be announced in mid-December.

Presentations from the 2019 *XMM–Newton* 20th Anniversary Goddard Symposium held at NASA's GSFC, Greenbelt, MD in October are now online.

Proceedings and presentations from the 2019 20th Anniversary Celebration held at Villafranca del Castillo, Madrid, in December are now online and available from the meeting website.

The SOC has canceled the "X-Ray Universe 2020" conference that was supposed to be held in May. People who have registered and paid will be contacted by the ESA Conference Bureau for a refund. Any questions about this may be sent to ESAConferenceBureau@atpi.com

The Neil Gehrels Swift Observatory

Eleonora Troja (UMD/GSFC) & Brad Cenko (GSFC)

The Neil Gehrels *Swift* Observatory continues to operate flawlessly. It supports four Target of Opportunity (ToO) requests per day in addition to observing gamma-ray bursts (GRBs) and Guest Investigator (GI) targets. *Swift* is by far the most active mission in terms of number of ToO accepted and different sources observed.

On Jan. 14, 2019, just before 4 p.m. EST, *Swift* detected a spike of gamma rays from the constellation Fornax, and alerted the astronomical community to the location of the new gamma-ray burst, dubbed GRB 190114C. The Major Atmospheric Gamma Imaging Cherenkov (MAGIC) observatory began observing the GRB just 50 seconds after it was discovered and captured the most energetic gamma rays yet seen from these events, with energies up to a trillion electron volts (1 TeV).

In late 2019, *Swift* tracked water loss from the interstellar comet 2I/Borisov traveling through our solar system. As the comet approached the Sun, frozen material on its surface warms and begins converting to gas. Thanks to its Ultraviolet/Optical Telescope (UVOT), *Swift* can detect the characteristic UV light emitted by hydroxyl, a molecule composed of one oxygen and one hydrogen atom, and therefore trace water production in comets. *Swift*'s observations determined that, at peak activity, Borisov shed eight gallons (30 liters) of water per second, enough to fill a bathtub in about 10 seconds. During its trip through the solar system, the comet lost nearly 61 million gallons (230 million liters) of water — enough to fill over 92 Olympic-size swimming pools. *Swift*'s measurements also show that material coming off Borisov is similar to solar system comets.

The *Swift* Guest Investigator (GI) program will continue to solicit proposals in GRB and non-GRB research during Cycle 17. NASA's Research Opportunities in Space and Earth Sciences (ROSES) 2020 and the *Swift* Appendix were released on February 14, 2020. Beginning in Cycle 17, all science proposals will be evaluated following a dual-anonymous peer review process. Updates on the Cycle 17 GI Program and the deadline for proposal submission will be posted on the *Swift* Proposals web site.

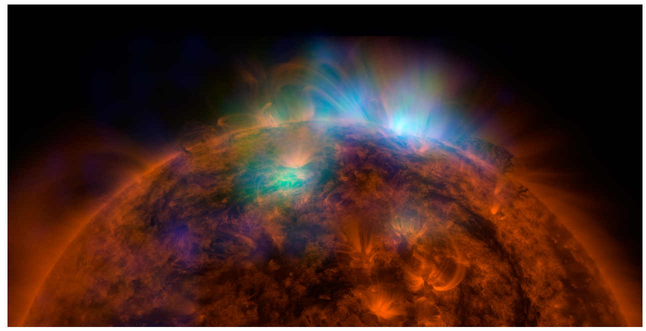
NuSTAR

Brian Grefenstette, Karl Forster (Caltech)

As the *NuSTAR* mission approaches the 8th anniversary of its launch in June, the mission continues to operate nominally on orbit. In addition to Guest Observer (GO) programs, *NuSTAR* also performs multiple target of opportunity (ToO) observations per month, and more than half of all *NuSTAR* observations are coordinated with other facilities. As of early 2020, there were over 700 refereed publications using *NuSTAR* data.

The mission continues to respond to strong community demand. There were 171 proposals submitted for *NuSTAR* Cycle 6, corresponding to an oversubscription rate of 4 (roughly unchanged from the previous several cycles). The peer review occurred at the end of March, and was the first NASA Science Mission Directorate (SMD) ROSES solicitation conducted as a Dual-Anonymous Proposal Review (DAPR). All proposals were required to be anonymous, with a separate team expertise document submitted, as required by ROSES. STScI provided a team of experienced 'levelers' to ensure that panel deliberations focused on science and avoided any discussion about the proposal teams, a key goal of DAPR.

Responding to the coronavirus pandemic, NASA HQ decided in early March to convert to a remote peer review. The teams adapted quickly with a variety of audio-visual online conference and document sharing tools to support six parallel virtual panel review sessions, taking into account local time differences for participants from across the continental US and in Europe. The peer review meeting was completed on time and feedback has been provided to NASA on the *NuSTAR* DAPR experience as well as the remote review procedures. A total of 78 GO proposals were selected for Cycle 6, and the results were released on April 21st. Cycle 6 observations will begin on June 1st. The selected GO proposals include large programs, ToO observations, and joint observations with the *XMM–Newton*, Gehrels-*Swift*, and *NICER* observatories. Cycle 6 was also the first *NuSTAR* cycle to offer multi-year observations, and four such proposals were selected for observations in Cycles 6 and 7.



The NuSTAR hard X-ray (blue and green) view of loops of emission from an active region near the West limb of the Sun overlaid on the Solar Dynamics Observatory (SDO) 171-Å image. Image credit: NASA/JPL-Caltech.

During the COVID-19 pandemic, *NuSTAR* operations have continued to operate nominally, though with some changes. The Science Operations Center (SOC) at Caltech has shifted to remote work and is continuing the mission planning and coordination with the Mission Operations Center (MOC) at the Space Sciences Laboratory at UC-Berkeley. Mission planning has been optimized to minimize the amount of time that personnel are required in the MOC. The primary ground station in Malindi, Kenya has continued to operate nominally, even during locally enforced curfews related to COVID-19. The SOC continues to respond to GO and community-driven ToO requests, as well as scheduling of coordinated, joint observations with *Chandra*, *XMM–Newton*, *INTEGRAL*, Gehrels-*Swift*, and *NICER*. The *NuSTAR* SOC continues to support the GO community to ensure that data processing and quality assurance are completed on schedule and the data are delivered to the *HEASARC* in a timely manner.

Of particular note for observers, a *NuSTAR* flight software upgrade was performed in March/April 2020 to extend the life of the laser metrology system by reducing the duty cycle of the lasers from 96% to 4%. This change in the laser duty cycle does not affect the capabilities of the metrology system nor does it impact the *NuSTAR* data quality. However, this new data mode does require a software upgrade to NuSTARDAS v1.9.2 for observations taken after March 17, 2020. The update was included in the HEASoft 6.27.1 patch, released about 2 weeks after the release of HEASoft 6.27. The *NuSTAR* team would like to extend special thanks to the HEASoft development team for such a speedy turnaround!

On the science front, this month we are highlighting *NuSTAR* solar observations. One of the unique science capabilities of *NuSTAR* is its ability to point directly at the

Sun. As of this writing, and including both Astrophysics and Heliophysics missions, *NuSTAR* is the only focusing telescope covering the hard X-ray band capable of targeting the Sun. Since 2014, *NuSTAR* has routinely observed the Sun, covering many phases of the solar cycle and investigating the processes that are likely responsible for heating the solar corona. Most recently, *NuSTAR* has provided a hard X-ray view of the Sun during Parker Solar Probe perihelion passes. This has occurred as part of both a Director's Discretionary Time (DDT) campaign triggered by the heliophysics community and GO programs in Cycle 5, and it will be continuing through a recently approved multi-cycle GO program to observe the Sun during Parker Solar Probe perihelion passages over the next two years. In addition, there have been a number of GO programs targeting quiescent active regions, studying the "quiet" X-ray Sun, and coordinating with sounding rocket experiments. Over a dozen papers have been published from *NuSTAR* solar observations, including a recent detection of a dominant population of non-thermal electrons in a faint X-ray flare (Glesener et al. 2020) and a paper reporting on broadband X-ray imaging spectroscopy of one of the weakest active region microflares studied to date (Cooper et al. 2020). The data accumulated over the past year of minimum solar activity have particular interest now because of the clear views of the quiet Sun, a first-ever chance to detect processes not associated with "normal" magnetic activity.

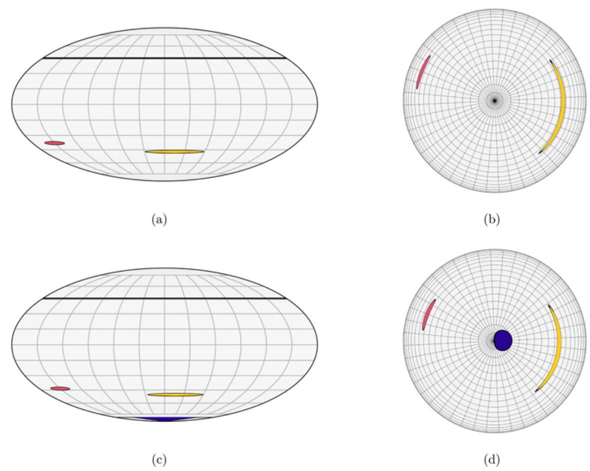
Over the next year, we are also ramping up both the *NuSTAR* news feed at nustar.caltech.edu and a *NuSTAR* science highlights Twitter feed (@NuSTAR_Science), both of which are intended to highlight recent work by the community. If you have a new paper that you wish to highlight, please feel free to @ or DM us. In addition, the *NuSTAR* User's Committee (NUC) will start a rolling transition of members over the next six months. The project expects to ask for a new round of self-nominations from the community to fill these seats. Details will be announced via the *NuSTAR* HEASARC RSS feed and the *NuSTAR* Caltech Webpage soon.

The Neutron Star Interior Composition Explorer

KEITH GENDREAU & ZAVEN ARZOUMANIAN (NASA/GSFC)

NICER mission operations continue unimpeded despite shelter-in-place and telework measures instituted during the COVID-19 pandemic, thanks to accommodations made at NASA's Goddard and Marshall Space Flight Centers that enable operations team members to generate observing schedules, command the *NICER* payload on the International Space Station, and manage pipeline processing of data from their homes.

Data collection for Cycle 2 of *NICER*'s Guest Observer (GO) program began on March 1, 2020. Through this Cycle, more than 7 Ms of science observing time will be devoted to 75 successful GO proposals (of which 34 anticipate targets of opportunity – ToOs – and many are coordinated with other telescopes), while *NICER* also commits substantial time to its Legacy Science program of neutron star studies and fulfills additional ToO observation requests from a growing community of users worldwide. Details of the successful proposals, the mission's short-term observing schedule, and a ToO request submission form are available at *NICER*'s HEASARC website. The deadline for submission of Cycle 3 Phase 1 (science) proposals will be November 12, 2020.



Locations, shapes, and sizes of the hot spots on PSR J0030+0451 in the best-fit waveform models with two oval spots (panels a & b) and three oval spots (panels c & d). Credit: Miller et al., 2019, ApJ, 887, L24

Most notable among *NICER*'s recent scientific output is the collection of results and methodological papers, published in a Focus Issue of The Astrophysical Journal Letters (ApJL), describing unique constraints on the mass and radius of the nearby millisecond pulsar (MSP) J0030+0451, and the implications of these measurements for the equation of state (EOS) of the ultra-dense matter found in the cores of neutron stars. *NICER*'s findings for this pulsar represent:

- the first precise ($\pm 10\%$, 1σ) mass and radius measurements for the same neutron star;
- the first mass measurement for an isolated (i.e., non-binary) neutron star; and
- the first map—fully accounting for relativistic light deflection—of a neutron star's surface "hot spots," providing the locations, shapes, sizes, and temperatures of heated regions and serving as a guidepost to the star's magnetic field configuration.

Several of the *NICER* Focus Issue papers were among the most frequently downloaded from ApJL for 2019, despite the fact that they were published only in mid-December of that year. Subsequent independent work connected these results to EOS constraints derived from *LIGO*'s detection of merging neutron stars, and to PSR

J0030's magnetospheric emissions across the electromagnetic spectrum. Work on deep *NICER* datasets of additional MSPs is ongoing, with results expected later this year.

NICER's rich archive of public data currently encompasses more than 20,000 observations—where a unique "ObsID" represents data collected for a single target on a single day—that yield high-time-resolution spectroscopic information in the soft (0.2–12 keV) X-ray band for hundreds of targets. Data analysis tools are distributed through the HEAsoft package, and calibration products are available through the HEASARC's Calibration Database. Recent upgrades to these collections include improved response files and tools for modeling *NICER*'s background. Comments or questions on their performance are welcome through the HEASARC feedback system. To foster more in-depth communications with users, the *NICER* project intends to establish a Users Group, consisting of 6–8 scientists with substantial experience relevant to *NICER* science and instrumentation serving 2–3 year terms. Letters expressing interest and applicant CVs will be solicited through an announcement posted on the *nicer-announce* mailing list and the *NICER* homepage.

AstroSat

Dipankar Bhattacharya (IUCAA)

AstroSat is now well into its fifth year of operation. Of the three Large Area X-ray Proportional Counter (LAXPC) units on board, two are currently operating – one normally and another with a reduced gain. The Ultraviolet Imaging Telescope (UVIT) has its Far Ultraviolet (FUV) and the Visible (VIS) channels available for operation. The Soft X-ray Telescope (SXT) and the Cadmium Zinc Telluride Imager (CZTI) are functioning normally. Announcement of opportunity for the next annual observing cycle (Oct 2020 - Sep 2021) is about to be opened, with the deadline for proposal submission in early June 2020.

Among the recent highlights from *AstroSat* is the publication (ApJS 247, 47) of a catalog of ~ 75000 point sources detected in the FUV and NUV bands of UVIT in a $3^\circ \times 1^\circ$ region of M31, extracted from survey images at $\approx 1''$ resolution, with a limiting magnitude ~ 23 in the FUV (CaF_2 filter). The *AstroSat* CZTI continues to detect Gamma Ray Bursts regularly and has been able to measure the polarisation of the prompt emission in several of them (ApJ 884, 123). Observations of Black Hole X-ray binaries with the *AstroSat* LAXPC have revealed interesting correlations between their spectral shape and the frequency of quasi-periodic oscillations (QPO) of their X-ray luminosity (MNRAS 488, 720; 489, 1037). Broadband (1-50 keV) X-ray spectra obtained from the SXT and the LAXPC observations of the Black Hole binary GRS 1915+105, simultaneously with a Type C QPO, demonstrated that the QPO frequency may be identified as the inverse of the sound crossing time at the inner edge of a truncated accretion disk (Misra et al., ApJ 889, 36), as predicted by relativistic accretion disk theory for a fast-spinning (spin parameter ~0.9) Black Hole. SXT observations of the X-ray pulsar Her X-1 have found evidence of a hot, diffuse gaseous corona around the system (Leahy & Chen, ApJ 871, 152). Combined SXT and LAXPC observations of the Nov. 2019 outburst from the Be/X-ray binary RX J0209.6-7427 have revealed it to be an ultra-luminous X-ray pulsar in the Magellanic Bridge (Chandra et al., arXiv:2004.04930).

The Fermi Gamma-Ray Space Telescope

Elizabeth Hays, Chris Shrader, Dave Thompson, Judy Racusin, Julie McEnery, (GSFC), Lynn Cominsky (Sonoma State U.)

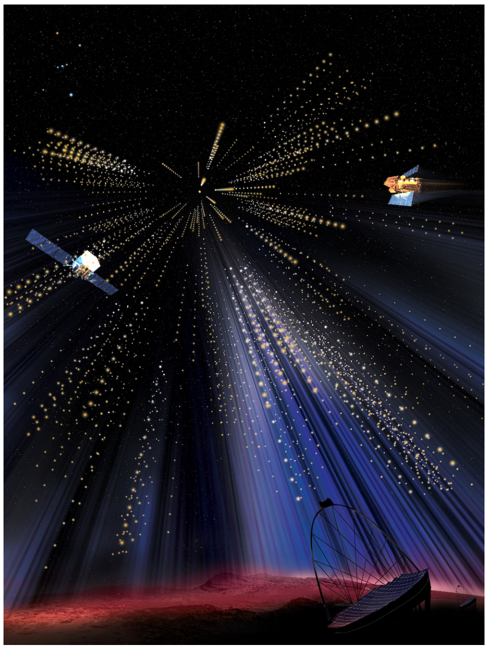
The *Fermi* Gamma-ray Burst Monitor and Large Area Telescope continue to scan the gamma-ray sky. Approaching 12 years of observations, *Fermi* has accumulated a detailed record of the entire high-energy sky and continues to monitor this dynamic energy range. The Flight Operations Team and the Instrument Operations Teams continue to manage the observatory and instruments, working remotely due to the COVID-19 pandemic.

The fourth catalog of high-energy gamma-ray sources (4FGL) seen by the *Fermi* Large Area Telescope has been published (Abdollahi et al. 2020, ApJS, 247, 33). The catalog is also available through the *Fermi* Science Support Center. The companion fourth catalog of Active Galactic Nuclei seen by the *Fermi* Large Area Telescope has also been published (Ajello et al. 2020, ApJ, 892,105A). In addition, the fourth *Fermi*-GBM gamma-ray burst catalog has been published (von Kienlin et al. 2020, ApJ, 893, 46).

There have been a number of *Fermi* science highlights over the past 6 months:

- *Fermi* and *Swift* were instrumental in enabling the first detections of gamma-ray bursts at energies above 100 GeV.
- Data from the Large Area Telescope have revealed a huge GeV halo around the Geminga pulsar, elongated by the pulsar's proper motion. The analysis suggests that at least part of the positron excess observed by several satellites may originate from pulsars.
- Using data from the Large Area Telescope, the BRITE-Toronto nanosatellite, and *NuSTAR*, Elias Aydi and colleagues have found, "Direct evidence for shock-powered optical emission in a nova." (Aydi et al 2020, Nature Astronomy, in press).

Current *Fermi* software and documentation are available through the Fermi Science Support Center. 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. The *Fermi* Gamma-ray Burst Monitor Team is pleased to announce the first public release of the GBM Data Tools, a Python interface for GBM data analysis. The GBM Data Tools package enables GBM data reduction and analysis and allows the general user to incorporate GBM analysis within their own scripts and workflows.

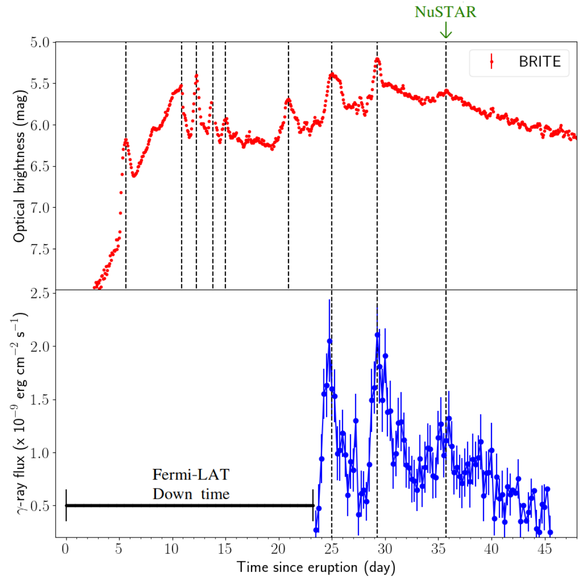


On Jan. 14, 2019, the Major Atmospheric Gamma Imaging Cherenkov (MAGIC) observatory in the Canary Islands captured the highest-energy light every recorded from a gamma-ray burst. MAGIC began observing the fading burst just 50 seconds after it was detected thanks to positions provided by NASA's Fermi and Swift spacecraft (top left and right, respectively, in this illustration). The gamma rays packed energy up to 10 times greater than previously seen. Credit: NASA/Fermi and Aurore Simonnet, Sonoma State University

Cycle 13 Guest Investigator proposals are in review, and selections are expected to be announced in the June 2020 timefame. Additional information is available at the Fermi Science Support Center website.

The Ninth International *Fermi* Symposium, originally planned to be held in South Africa March 29 - April 3, 2020, has been postponed.

In partnership with members of the *LIGO-VIRGO* Collaboration, *Fermi* outreach will be participating in the development of a multimessenger 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 email Lynn Cominsky.



Optical and gamma-ray light curves of Nova V906 Car, showing the correlation that confirms shock acceleration as the power source. Credit: Aydi et al., 2020, Nature Astronomy, in press

INTEGRAL

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

The spacecraft, payload, and ground segment operated largely nominally during this reporting period. The requirement for teleworking since mid-March due to the COVID-19 pandemic is currently without any negative impact on operations. A spacecraft anomaly was experienced on April 13 when a single event upset caused *INTEGRAL* to go into Emergency Safe Attitude Mode (the 7th case since launch). Due to the rapid recovery, only 16 hours of science time were lost. The largest impact was on fuel consumption corresponding to $\sim$3 months of consumption at the current rate of usage. The remaining fuel leaves sufficient margin to execute the currently planned mission and beyond, possibly even until re-entry in 2029. The observed solar array degradation over the last year continues to be significantly less than expected for perigee altitudes below 6000 km (currently at $\sim$2200 km) and thus there might not be any power budget constraints until re-entry. The 34th SPI annealing took place in March, with a satisfactory recovery of the detector's energy resolution ($\Delta E/E \simeq 0.19\%$ at 1.764 MeV). A few of the GeD's showed increasing noise, probably due to an increase of the leakage current.

INTEGRAL is undergoing a mission extension review for 2021–2025. The Mission Extension Operations Review (MEOR) board confirmed that *INTEGRAL* can deliver the data to achieve the expected science return in both the confirmation (2021–2022) and extension (2023–2025) interval.

The *INTEGRAL* Users' Group (IUG) meeting #23 took place on November 26–27, 2019. The main topic of discussion was the next extension cycle. Another issue was the *INTEGRAL* instruments' cross and mutlimission calibrations. Most of this work is done in the framework of the IACHEC. The infrastructure for cross-calibration product generation is in place and several example sources will be processed. The modeling of the instruments' response and cross-calibration are the two priorities for a dedicated calibration group meeting planned for later this year.

The AO-18 call for observing proposals for 2021 (AO-18) opened on March 2 and closed on Monday, May 4, 14:00 CEST (the deadline was postponed from April 3). A total of 52 proposals was received. The total requested observing time was $\sim$70 Msec which corresponds to a time oversubscription factor of 3.35. The non-ToO proposals requested data rights for 336 sources with 14 proposals requesting joint time with *NuSTAR*, *Swift*, and/or *XMM–Newton*. The TAC meeting is planned for June 23–25, to be done online.

The stars in the luminous blue variable (LBV) binary η Car passed the periastron point of its highly elliptical orbit in February 2020, a time which is associated with a strong variability in X-rays. *NICER* and *AGILE* found brightening in X-rays and gamma-ray energies $>$100 MeV, respectively, in November 2019. To study a possible connection between X-ray and gamma ray variability, an out-of-TAC ToO was triggered, with an observation on 6 December 2019. IBIS/ISGRI marginally detected the source at 28–40 keV, triggering further follow-up observations on December 17–27 , 2019.

A coordinated Crab observation with ART-XC onboard Spekt-RG took place on April 1. The aim was a simultaneous spectral and timing calibration of ART-XC with instruments with well calibrated on-board clocks such as *INTEGRAL* .

On January 6, 2020, the *LIGO/VIRGO* Collaboration announced the discovery of the 2nd firm BNS merger, labelled GW190425 (previously S190425z). This system is notable for having a total mass that exceeds that of known Galactic neutron star binaries (Abbott et al. 2020, ApJ, 892, L3). The only electromagnetic counterpart reported so far, is a weak GRB seen by *INTEGRAL*/SPI-ACS, GRB190425, consisting of two marginally significant signals 0.5 and 5.9 s after the merger (Pozanenko et al. 2020, AstL 45, 710). During other Gravitational Wave events reported by the *LIGO/VIRGO* collaboration, as well during very high-energy neutrino events reported by IceCube and HAWC, no statistically significant hard X-ray/gamma-ray counterparts were found by *INTEGRAL*, with the usual upper limits.

The vertical position of the Sun above the Galactic plane is typically based on the distribution of stars in certain populations, but dust and gas can absorb the optical and IR light from these stars. Gamma rays from the radioactive decay of 26Al ejected by massive stars and supernovae are not hindered by interstellar absorption. Using more than 13 years of *INTEGRAL*/SPI data from the 26Al gamma-ray decay line at 1.809 MeV, it is possible to constrain the vertical position of the Sun to between -2 and +32 pc with respect to the Galactic plane (Siegert 2020, A&A 632, L1).

The radiation data collected by the Standard Radiation Environment Monitors (SREMs) onboard *INTEGRAL*, Rosetta, Herschel, Planck and Proba-1, and by the high-energy neutron detector (HEND) aboard Mars Odyssey, were analysed to study the Galactic cosmic rays (GCRs) in the inner heliosphere (Honig et al. 2019, Ann. Geophys. 37, 903). Based on *INTEGRAL* and Rosetta SREM data, a GCR helio-radial gradient of 2.96% AU^{-1} was found between 1 and 4.5 AU. In addition, during the last phase of the Rosetta mission an unexpected and unexplained 8% reduction of the GCR flux in the vicinity of the comet 67P/Churyumov-Gerasimenko was found.

Due to the COVID-19 situation, the final dates of the *INTEGRAL* Conference "*INTEGRAL*: towards the 3rd decade of X and gamma-ray observations" (planned to be held in Sardinia, Italy, October 5–9 , 2020) will be confirmed at the end of May.

As of 4 May, there have been 1703 refereed *INTEGRAL* publications since launch; of these, 25 appeared in 2020.

CALET — John Wefel (LSU)

The *CALET* (CALorimetric Electron Telescope) instrumentation on the International Space Station (ISS) continues to function well and return excellent data. *CALET* will achieve its 5 year mission duration by the time of the fall newsletter, and discussions are underway among the international partners for an extended mission. The operating temperature of the instrument has increased by a few degrees due to added load put onto the ISS cooling loop. Since detector responses are temperature dependent, a revised calibration had to be developed. The revised calibration has now been deployed and validated. As with other space instruments, operations mode and data processing have had to proceed with a minimum number of personnel, socially distanced in response to the current pandemic. We have successfully met that challenge and analysis is proceeding.

The *CALET* instrumentation consists of the main calorimetric telescope (CAL) plus the *CALET* Gamma-ray Burst Monitor (CGBM). CAL data is currently being analyzed to increase the statistical precision of the electron, proton, heavy nuclei and gamma-ray spectra; first results of each have been described in previous newsletters and in journal publications. The CGBM has been reporting Gamm-ray Burst emissions from 7 keV to 1 MeV from the Hard X-ray Monitor (HXM) and from 40 keV to 20 MeV from the Soft Gamma-ray Monitor (SGM) as well as above 1 GeV (LE mode) and above 10 GeV (HE mode) from the CAL telescope. In this arena, *CALET* searches for emission associated with Gravitational Wave events as well as burst and transient sources. For example, for the neutron star merger event GW170817, CGBM observed no emission at the time of the merger event nor in windows ± 60 seconds from that time, leading to an upper limit (90% confidence level) of 1.3×10^{-7} erg/cm^2/s in the 10–1000 keV band assuming no shielding by ISS structure. As well, no emission was detected in the CAL for two months following the event. Of more interest was the recent outburst of SGR 1935+2154 on April 22, 2020 which was observed by the CGBM detectors. The light curve shows a short bright pulse with a duration of about 0.6 second, and emission is seen up to about 200 keV. This may indicate that the source is entering a new active phase.

The High Energy Astrophysics Science Archive Research Center

LORELLA ANGELINI (NASA/GFC)

HaloSat data are now available at the *HEASARC*. *HaloSat* was designed to survey the distribution of hot gas in the Milky Way and constrain the mass and geometry of the Galactic halo. The mission, led by the University of Iowa (PI P. Kaaret), is a CubeSat launched from the NASA Wallops Flight Facility and delivered to the International Space Station on May 21, 2018. *HaloSat* was deployed into orbit on July 13, 2018. Science operations began in October 2018 and are still ongoing.

The *HaloSat* archive is populated with science events data, housekeeping and spectra, obtained with the three independent non-focusing detectors (0.4-7.0 keV). *HaloSat* data are processed at the University of Iowa.

The *HaloSat* archive opened at the HEASARC on April 15, 2020 and contains all data from the first year of operations, together with the calibration data stored in the *HEASARC* CALDB. The data can be selected and analyzed with the suite of tools available within HEASoft. Further information about the *HaloSat* archive is available from the *HEASARC* website.

HEASARC released Version 6.27 of the HEASoft software package on March 26, 2020 with amendments on April 13 (6.27.1) and April 23 (6.27.2). These releases include important updates of the mission specific software for the operating missions *MAXI*, *NICER*, *NuSTAR*, and *Swift*. They also incorporate numerous updates for the mission-independent and FITS manipulation packages, as well as changes to maintain the software from old missions (see the complete release notes for further details).

In September 2019, HEASARC phased out data access via unencrypted FTP. The access to the archival data via FTP was the first protocol in use since *HEASARC* began, a protocol that only a few archives allowed. Unencrypted FTP access was disabled because of the new general Federal policy that requires all network communications to be encrypted. Users can still have direct access to the FTP area via the HTTPS protocol. A script based on wget is also available to download multiple datasets from the command line.

Physics of the Cosmos News

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

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); this probably means you! Other articles in this newsletter give updates on the activities of our SIGs, including Cosmic Ray, Gamma-ray, Gravitational Wave, and X-ray SIGs. The PhysPAG provides 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 $\sim$2 years, and several members rolled off in December 2019. We thank former members for their service and welcome newly appointed ones! Several members will be rolling off again in Decembr 2020. We will welcome applications for new EC members in the fall. Stay tuned to PCOS-News emails or check our website for details.

Between June 2018 and January 2020, PhysPAG also included the Multimessenger Astrophysics (MMA) Science Analysis Group (SAG). The MMA SAG was open to the community and aimed to identify science goals achievable with multimessenger observations by NASA observatories and ground- and space-based facilities in the 2020s and beyond. The MMA SAG has now completed its activities and produced a final report describing its findings in detail. In summary, the report presents four key findings:

1. It stresses the need for maintaining and extending wide electromagnetic (EM) and gravitational wave (GW) wavelength coverage, with emphasis on fast response and the time domain.
2. It calls for NASA and NSF to coordinate proposal opportunities & time frames, as well as databases &

catalogs, since both ground- and space-based measurements are essential.
3. It highlights the need to develop highly autonomous software and capabilities for rapid commanding and repointing.
4. It encourages astrophysicists to leverage progress in computer science and a wide range of physics to take full advantage of MMA data fidelity.

PCOS sessions at this year's January AAS and April APS meetings included exciting science results and forward-looking themes. The MMA SAG session at AAS presented the final report's findings. We were happy to meet many of you at the January AAS PCOS table that featured PCOS technology demos and videos, information, and stickers about PCOS-related missions. Due to the COVID-19 pandemic, the April APS meeting was held virtually. We would like to thank all those at APS and our SIG & SAG members who made the extra effort to set up and successfully utilize the virtual APS environment. As always, all presentations can be found on our website. You can also watch the recordings from the April APS meeting. We are looking forward to hosting more PCOS & PhysPAG and SIG sessions in 2020 & 2021 at the next HEAD meeting, the January AAS meeting, and the April APS meeting. We encourage you to join us in person or virtually!

On the mission front, we are excited to announce that NASA Astrophysics selected two proposed astrophysics Small Explorer (SMEX) missions and two proposed Missions of Opportunity (MO) for further study. The SMEXs are the Extreme-ultraviolet Stellar Characterization for Atmospheric Physics and Evolution (ESCAPE) and the Compton Spectrometer and Imager (COSI). The MOs are the Gravitational-wave Ultraviolet Counterpart Imager (GUCI) and the LargE Area burst Polarimeter (LEAP). Check the Cosmic Ray SIG, Gamma-ray SIG, Gravitational Wave SIG, X-ray SIG, *LISA*, and *Lynx* articles for further details on specific messenger-related studies. The PO continues to host and facilitate work on the *LISA* and *Athena* studies, described in the *LISA* and *Athena* articles elsewhere in this newsletter.

We welcome your input on PCOS science topics, including through the relevant PhysPAG SIGs, and by submitting technology gaps (due 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! We also regularly highlight news items on our website, ranging from opportunities to apply for funding, eg for *HaloSat* data analysis or a job as a NASA/HQ Civil Servant Program Scientist, to changes to the APS April meeting and multiple changes to ROSES 2020. Stop by if you're wondering and send us an email if you have further questions!

The X-ray Science Interest Group

RYAN HICKOX (DARTMOUTH), JOHN TOMSICK (UNIVERSITY OF CALIFORNIA BERKELEY)

X-ray astronomy continues to make progress and pass new milestones. The *Chandra* X-ray Observatory completed its 20-year celebration in December with the 20 Years of Chandra Science Symposium in Boston that included not only a great deal of wonderful science, but a visit from the STS-93 Space Shuttle crew. December also saw the 20th Anniversary Celebration Event for *XMM–Newton* at ESAC in Madrid.

The NASA PCOS X-ray Science Interest Group, including new co-chairs Jillian Bellovary (QCC/AMNH) and Grant Tremblay (CfA), hosted a standing-room only meeting at the January 2020 AAS meeting in Honolulu. We saw some fascinating talks on new instruments and technologies. Mara Salvato (MPE) presented new results from the eROSITA telescope aboard the Spectrum-Röntgen-Gamma spacecraft, as it and ART-XC continue successful operations. Rob Petre (GSFC) gave an update on the status of the X-ray Imaging Spectroscopy Mission (*XRISM*), which continues development with delivery of the calorimeter spectrometer insert to JAXA in late 2019 and the release of the *XRISM* Science White Paper in March. Finally, Herman Marshall (MIT) delivered an overview of new diffraction-limited X-ray optics technology, and a paper on this has now been accepted for publication. In other news, *NICER* has completed its Cycle 2 Guest Observer review, with approved targets announced in February.

Along with the rest of the world, the X-ray astronomy community has seen disruption due to the COVID-19 crisis. For instance, we saw the postponement of the symposium on Mapping the X-ray Sky with SRG: First Results from eROSITA and ART-XC in Garching, Germany, and the cancellation of the X-ray Universe 2020 symposium in Noordwijk, The Netherlands. Activity on technology and telescope development also has necessarily been affected. However, all NASA X-ray missions continue to operate nominally, and the community has taken many steps to continue to move forward. The X-ray SIG hosted a successful virtual session at the American Physical Society April meeting, with updates on silicon metashell optics from Will Zhang (GSFC) and science with the *Lynx* mission concept from Ryan Hickox (Dartmouth). We also heard another update on *XRISM* from Brian Williams (GSFC), who emphasized the continued collaboration between scientists in the U.S. and Japan as *XRISM* continues construction despite travel restrictions. The *NuSTAR* mission completed its Cycle 6 General Observer review by moving to a remote TAC process, while also successfully adopting dual-anonymous peer review.

As always, we encourage nominations for the PhysPAG Executive Committee, and we look forward to continuing to engage with the X-ray astronomy community!

The Gamma-ray Science Interest Group

Sylvain Guiriec (George Washington University & NASA/GSFC), Bindu Rani (NASA/GSFC & USRA)

The GammaSIG thanks John Tomsick, University of California Berkeley, who rotated off as a co-chair, and welcomes Bindu Rani (NASA/GFC & USRA) as the new co-chair.

The Compton Spectrometer and Imager (COSI) and the LargE Area burst Polarimeter (LEAP), both operating in the gamma-ray regime, have been selected by NASA to conduct nine-month mission concept studies as a Small Explorer (SMEX) mission and a Mission of Opportunity (MO), respectively. Congratulations to the COSI mission PI, John Tomsick (University of California, Berkeley) and the LEAP mission PI, Mark McConnell (University of New Hampshire, Durham), and their teams.

The GammaSIG organized a special session at the 235th AAS meeting. The session covered many interesting talks on the current and near-future gamma-ray missions. The presentations are available at the PCOS website.

Due to the COVID-19 crisis, GammaSIG decided to cancel its special session at the virtual 2020 April APS meeting. GammaSIG will resume its regular activities during the future HEAD, AAS and APS meetings. GammaSIG will continue regular telecon meetings to discuss science, to share news and results about current missions, and to keep the community informed about future missions and technology development.

The GammaSIG is planning to organize workshops, hackathons, and similar activities on instrument design, data analysis and analysis tools, and statistical methods, among others. We will circulate a survey to collect your ideas and suggestions.

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 aims to act as a forum to discuss the current status of cosmic ray science and to provide input for NASA regarding future goals for the field. As such, the CR SIG encourages members of the community to provide comments, questions and updates based on their present work and future plans for cosmic ray research relevant to NASA's mission. The SIG chairs (Abigail Vieregg and Marcos Santander) can be contacted directly for such inquiries. People interested in the activities of the group are also invited to join our mailing list.

The Gravitational Wave Science Interest Group

Nicolas Yunes (University of Illinois at Urbana-Champaign), John W. Conklin (University of Florida), Jillian Bellovary (QCC/AMNH) and Sean McWilliams(WVU)

The GW SIG welcomed two new members in December 2019: Jillian Bellovary from Queensborough Community College & the American Museum of Natural History, and Sean McWilliams from West Virginia University.

The GW SIG had planned to organize a Focus Session at the April 2020 APS Meeting in Washington D.C., but due to the COVID-19 pandemic the April APS meeting was taken fully online and the Focus session was canceled. The speakers of this session were going to be Terri Brandt from NASA (who was going to present an overview of gravitational wave science from a programmatic perspective), John Conklin from the University of Florida (who was going to present an overview of the *LISA* mission), and Xavier Siemens from Oregon State University (who was going to give a status update of the NANOgrav effort to detect gravitational waves with a pulsar timing array). The GW SIG is planning to organize another Focus Session on *LISA* science at the April 2021 APS Meeting that will be held in Sacramento, California (April 17-20, 2021).

A special session at the January 2020 AAS meeting in Honolulu was also organized by the GW SIG. In that session, Ira Thorpe and Terry Doiron gave a *LISA* science and mission overview, Kelly Holley-Bockelmann provided an NLST update, Sean McWilliams presented both a GW SIG overview and his research on state-of-the-art waveform modeling and its *LISA* applications, and Jillian Bellovary discussed her research on multimessenger signatures of intermediate mass black holes. The GW SIG session is currently planning a session for the upcoming January 2021 AAS meeting in Phoenix, Arizona. Further information about upcoming GW SIG meetings can be found at the PhysPAG website.

Finally, in late November 2019, ESA ministers committed to the first significant boost in funding to the ESA science program in the last 25 years. This boost is intended, in part, to allow *LISA* to fly contemporaneously with the X-ray mission *Athena*, thereby enabling complementary science regarding the distribution of massive black holes and their evolution across cosmic time. NASA remains committed to participating in the *LISA* mission as a partner, and the details are being worked out.

The NASA GW-EM Taskforce

R. M. Sambruna & Valerie Connaughton (NASA HQ)

Gravitational Wave (GW) Astrophysics has recently come of age with the detection, and further characterization, of sources of gravitational waves from the ground with *LIGO* and the search for their electromagnetic counterparts. Because of its access from space to shorter wavelengths than on the ground, both in survey and pointed instruments, NASA is an essential player in this field, as demonstrated by the case of GW170817. With the advent of Advanced *LIGO* in ~ 2023, the field of EM counterparts to GW sources is poised to expand very rapidly.

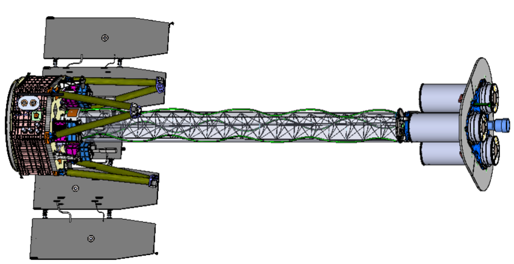
In March 2018, NASA Headquarters set up a Taskforce to look into the current and future capabilities and best practices of NASA for EM counterparts of GW events, or the "GW-EM Taskforce". The Terms of Reference of the Taskforce are posted at the PCOS website. The Taskforce was Co-chaired by Judy Racusin (GSFC), Dan Kocevski (MSFC), and Mansi Kasliwal (Caltech), and drew from the input of many members of the MultiMessenger Astrophysics community. The report of the Taskforce was released in December 2019 and can be found on the PCOS website. Of particular interest is the community survey performed by the Taskforce, which provided the basis for most of the report's conclusions, and additional insights for the future of the field.

The report provides an in-depth analysis of the NASA science and mission capabilities for the search of EM counterparts to GW sources. It has been presented to various astrophysics meetings and NASA advisory bodies. As NASA awaits the 2020 Astrophysics Decadal Survey recommendations, the report of the GW-EM Taskforce provides a framework to position the Agency for a timely response.

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. Here we provide updates on the status of the mission since the previous Newsletter. Recent significant events include a successful Ground System Preliminary Design Review (GS-PDR) in November and the completion of assembly, testing, and X-ray calibration of all three flight detectors by the Italian Instrument Team in March.



The IXPE observatory. Credit: MSFC

The Marshall Space Flight Center completed the first flight Mirror Module Assembly and began its environmental testing, to be performed prior to X-ray calibration. Work at the prime contractor, Ball Aerospace, continues and assembly of the spacecraft has started.

The X-ray Imaging and Spectroscopy Mission

Rich Kelley (NASA GSFC); Brian Williams (NASA GSFC)

Development is ongoing for *XRISM*, the *X-ray Imaging and Spectroscopy Mission*. In November of 2019, the Calorimeter Spectrometer Insert (CSI) for the Resolve detector was shipped from NASA Goddard Space Flight Center to Tokyo's Narita airport, where it was then delivered by truck to Sumitomo Heavy Industries in Niihama, Japan. NASA and JAXA personnel began integration and testing of the CSI into the dewar system, and the first test campaign was completed just before Christmas.

The dewar containing the Resolve instrument at SHI in Niihama, Japan in January 2020. Credit: R. Kelley

Of course, the hardware integration has been substantially impacted by the COVID-19 crisis. The second test campaign, begun in January, was underway when NASA travel was canceled due to the virus, and since late February, all NASA support of the Resolve I&T has been remote via online videoconferencing software. Communication between the US and Japan remains good, and the IT tools are working well. NASA and JAXA personnel maintain 24/7 open lines of communication, and the teams are doing the best they can under these extremely difficult work conditions.

Both *XRISM* X-ray Mirror Assemblies (XMAs) have been assembled at NASA/GSFC, with work continuing right up until the moment that the center was closed due to COVID-19. The first mirror (XMA1) has completed environmental testing. Once GSFC is re-opened and work can resume, XMA2 will undergo environmental testing, at which point both mirrors will move on to calibration.

The mirrors are still on track to be delivered to JAXA by January of 2021.

On the Science Team side, an internal review process is ongoing to select the targets for the Performance Verification (PV) phase. This is a phase of the mission, occurring 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. We expect to have these targets selected (and publicized) by late summer or early fall of 2020. 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* Science Team recently released a white paper entitled "Science with the X-ray Imaging and Spectroscopy Mission". The paper was prepared for the benefit of the general astronomical community, and describes the capabilities of *XRISM*, offers a sampling of the many science topics that the mission will address, and discusses the synergies of *XRISM* with the plethora of planned and existing facilities in the 2020s and beyond.

In 2019, the *XRISM* Science Team convened a Laboratory Astrophysics working group, chaired by Tim Kallman (NASA GSFC) and vice-chaired by Jelle Kaastra (SRON). This group's purpose is to optimize the science return of *XRISM* by identifying and performing tasks related to laboratory astrophysics. The working group produced two white papers, "Laboratory Astrophysics Needs for X-ray Calorimeter Observatories" and "Laboratory Astrophysics Needs for X-ray Grating Spectrometers", in response to the Astro2020 call for papers on "Activities, Projects, or State of the Profession Consideration".

As we move closer to launch, plans are underway to offer *XRISM* data analysis workshops for interested participants to learn how to plan and propose for *XRISM* observations, as well as how to analyze *XRISM* data. We will also develop online guides and tutorials to assist in preparing the community, both before and after launch. Members of the *XRISM* Project Science Office are available to visit your institution from now through launch (once NASA travel is permitted again, that is) to give a colloquium or seminar on *XRISM* and the breakthrough science the mission will enable. We are also able to give virtual talks.

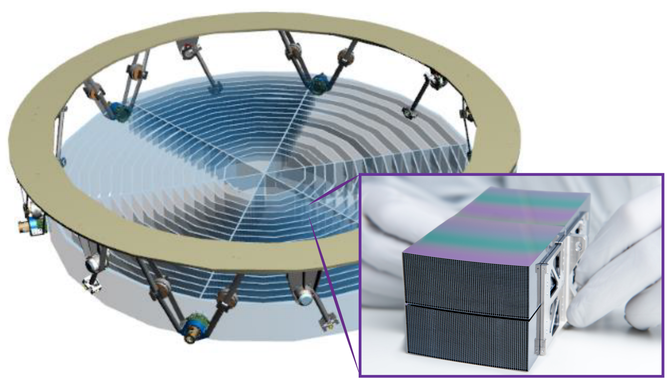
Lastly, the *XRISM* Science Team meeting that was scheduled to be held in May in Ann Arbor, MI, has been rescheduled for June. As with a growing number of spring and summer meetings, this will now take place in the virtual world.

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

The Phase B1 industrial activities are proceeding nominally, now split into separate contracts for the spacecraft and for the Science Instrument Module (*i.e.*, the focal plane instruments). ESA started a frame-contract with *Arianespace* regarding the Ariane 6 rocket that will yield the first performance and trajectory analysis specifically tailored for *Athena*, as well as a Coupled Load Analysis hopefully able to relax the load constraints to the payload. As a result of this activity, a more accurate estimate of the launcher performance should be available.

The combination of the global COVID-19 crisis, and of the possible change of responsibility for the procurement of the X-IFU cryostat, led ESA to conclude that achieving the adoption of the mission by the end of 2021 is untenable. A new schedule is being elaborated. It will be communicated to the Instrument Consortia and the scientific community after discussing it with the Member States contributing to *Athena*, and prior to the next meeting of the ESA Science Program Committee in June 2020.



Conceptual design of the mirror structure: Left, mirror assembly and accommodation. Right, mirror modules and stacks. Credit: ESA, Cosine & the ACO Team

As part of the data package for the Mission Adoption Review, the *Athena* Science Study Team (ASST) shall deliver a "Study Assessment Report" (a.k.a. "Red Book"), describing the overall scientific profile of the mission. The ASST has already identified the need of supporting this process through an extensive involvement of the whole *Athena* scientific community. To this end, an agreement has been reached with the Editorial Board of *Astronomy and Astrophysics* for the publication of a Special Issue on *Athena* science prior to adoption. Its content will be drawn from the enthusiastic response of the community to an ASST call for papers issued in 2019. Over 100 paper ideas were proposed, updating the *Athena* science case as originally described in the proposal, as well as injecting new ideas emerging from the evolution of the field in the last few years.

The development program of the optics proceeds according to plan, with good progress over the whole range of activities. The latest review (March 27, 2020) of the PRESPO (PREparation of the Silicon Pore Optics Engineering Qualification Module) activity demonstrated continuing good progress in all the main areas contributing to the imaging performance: improving or removing bad performing plate sides, matching of the overall curvature to the required specifications, improving cleanliness, reducing entry-and-exit effects, and reducing plate contributions to imaging performance degradation. The production of the first high-quality 34-plate stack for an outer radius is particularly noteworthy, achieving 10″ Half-Energy Width on 70% of the area. This represents a performance comparable to that of middle radii stacks that represent the workhorse of the HEW improvement program. A similar level of improvement is observed on the most recent stacks at an inner radius. The root cause of the main remaining contributions to the angular resolution has been identified as anticlastic effects of the plate ribs coupled to stresses induced by the SiO layer on each plate. Ion Beam Figuring is now seen as a promising technique to improve the homogeneity of the plates, as well as to address the outstanding plate curvature because it would remove the need of a chemical wedging process leading to a thick SiO layer.

At the start of 2020, the baseline readout scheme of the Transition Edge Sensors (TESs) of X-IFU was selected to be Time Domain Multiplexing (TDM). TDM readout has been developed by NIST, Stanford University and NASA. It was selected on the basis of the performance demonstration achieved in a laboratory set-up, in which 2.2 eV at 6.9 keV over an array with 8 TDM readout channels of 32 TESs each was measured. Integration of the TDM readout in the Focal Plane Assembly and conversion of the laboratory electronics into space-qualified electronics is now being implemented, under the leadership of SRON and CNES, in partnership with the US teams, VTT, APC and IRAP.

To lower the overall risk on the development of X-IFU, and hence *Athena* as well, ESA, CNES and X-IFU managements are now investigating the option that the X-IFU cryostat be provided by industry through an ESA funded contract, with the goal of getting on-board a cryostat provider with significant heritage in space cryogenics. This proposal is now being presented to the ESA advisory structure, before implementation in the Prime contracts. At the same time, the implications for the Consortium organization are being assessed. In parallel, the X-IFU team is defining with ESA the technology demonstration objectives achievable at the Mission Adoption Review, in response to the switch of the readout scheme and the change in the cryostat procurement scheme.

Finally, because of COVID-19, the 11th Consortium meeting of X-IFU, which was supposed to be held in Liége (Belgium) was converted into a full virtual meeting. Thanks to the advance of digital technologies, such large gatherings, as well as many other smaller meetings, which in the past were considered only possible through physical presence, are now held smoothly and efficiently by videoconferences. Over the long run, this will have a positive impact on reducing the travel footprint[1] associated with the development of large international projects like X-IFU. More generally, making X-IFU a 'greener' project is a priority of its management.

The WFI development continues towards the aim of demonstrating the technical readiness level of 5/6 for all critical subsystems by mission adoption. The current focus is in particular on the DEPFET sensors for both the Large Detector Array (LDA) and the Fast Detector (FD). The first batch of the pre-flight production sensors, fabricated at the Semi-Conductor Laboratory of the Max Planck Society, is currently being tested at MPE. Results for FD-sized devices (64×64 pixels) already show an impressive performance with full width at half-max of better than 130 eV at 5.9 keV. The laboratory setup for the first LDA quadrant-sized (512×512 pixels) DEPFETs is being prepared. These are the largest such devices that have ever been fabricated, and testing will start soon.

Another critical element of the WFI detector is the performance of the analog application-specific integrated circuits (ASICs) responsible for the DEPFET control and readout. A change in the fabrication technology for the VERITAS readout ASICs has recently been necessitated, which requires some re-design work. This is currently being performed with strong support by US-members of the WFI Consortium. Test chips for the technology evaluation have been designed and are currently in production.

A key parameter for WFI observations of faint and low-surface brightness sources at higher energies is the instrumental background of the LDA. Optimization of the hardware design is ongoing, in particular the graded-Z shield, which lowers the continuum while also suppressing fluorescence line emission. In parallel, US-consortium members are focussing on understanding the origins of the systematic background errors and on strategies to reduce them.

The overall progress on the instrument development was presented and discussed during the 11th WFI Consortium meeting. This meeting was held from April 27-30, 2020, and for the first time, completely virtual, due to the COVID-19 crisis.

The 7^{th} *Athena* Newsletter was published on January 2020, highlighting the progress in the mission mentioned above. At the end of that month we closed the sixth Announcement of Opportunity to join the *Athena* Community, which now boasts 862 members from all over the world. Welcome!

Since last September the ACO has published a total of

[1] A travel footprint calculator has been developed to monitor and reduce the travel footprint of X-IFU related activities.

four *Athena* Nuggets, two on scientific topics and two on technical topics related to the mission. In total we have published 26 science nuggets, showing the wide variety of breakthrough science that can be done with *Athena*, and 16 technical nuggets, highlighting the state-of-the-art technology under development for that mission and its two instruments. All nuggets can be accessed from the *Athena* nuggets section in our web page. Do you want to contribute a nugget on your favourite topic? Let us know! You can also find the latest *Athena*-related scientific papers in the publications section of our web page. Is yours missing? Let us know as well!

A splinter session in the 235^{th} meeting of the AAS in Honolulu on January 7, 2020 was dedicated to "*Athena* X-ray Mission: Multi-wavelength and Multi-messenger Opportunities". The corresponding presentations are *Athena* Document Repository. *Athena* was also present in the presentations to the earlier X-ray Astronomy 2019 meeting in Bologna, Italy (September 8-13, 2019).

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

LISA

IRA THORPE (NASA/GSFC), GUIDO MUELLER (U. FLORIDA), MICHELE VALLISNERI (JPL)

Following the successful completion of the mid-Phase A "Mission Consolidation Review" (MCR) in October 2019, the European Space Agency-led *LISA* mission continued formulation activities throughout the first half of 2020. ESA and its European Member State partners agreed to refine the split of responsibilities such that ESA will play a lead role in payload systems engineering. This change will facilitate coordination between the design of the payload and the spacecraft, which is already under ESA responsibility. In addition, the ESA Science Study Team and the *LISA* Consortium have worked to refine some of the performance requirements in the Science Requirements Document so that the resultant demands on the instrument are more clear. These and other activities will continue through the remainder of Phase A, which is expected to be completed in 2021. The mission will then proceed into Phase B, setting the stage for the important ESA milestone of Mission Adoption ahead of the 2024 goal. The mission is still on track for a 2034 launch date.

The *LISA* science community was also pleased with the outcome of the ESA Council of Ministers meeting held in late Fall 2019 which approved an increase to the budget for the ESA science program that was in part motivated by the scientific potential of operating two large-class missions, *Athena* and *LISA*, in parallel. Simultaneous observations of a merging massive black hole in X-rays and gravitational waves would be an unparalleled technique for understanding the behavior of these objects.

In the US, the NASA team is making steady progress on a number of fronts. The NASA systems engineering and technology teams are actively supporting both their ESA and *LISA* Consortium counterparts in developing and refining the design of the *LISA* instrumentation. Technology development activities continue in five areas: telescopes, lasers, charge management systems, phasemeters, and microthrusters. Highlights for Spring 2020 include the establishment of a contract with L3 Harris to develop a set of prototype telescopes that will be used to validate the design ahead of the Mission Adoption milestone, as well as the completion of a prototype laser system that will be delivered to Europe for testing later this year. The NASA *LISA* Study Team completed a report on the likely scientific user base for *LISA* and the types of data access and support resources that will be required to enable their work. This report will be used to inform development of potential NASA contributions to the *LISA* Science Ground Segment. Scientists interested or curious about *LISA* will have the opportunity to learn more about the mission and network with the *LISA* community at the 13th *LISA* Symposium, which will be a virtual event taking place September 1-3, 2020. Further information on *LISA* can be found at ESA and NASA *LISA* websites, and on the *LISA* mission website.

Lynx X-ray Observatory

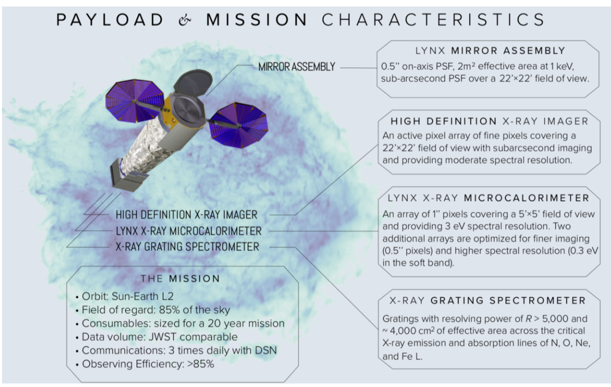
JESSICA GASKIN (NASA/MSFC), DOUG SWARTZ (USRA/MSFC)

The *Lynx* X-ray Observatory is one of four large-mission concept studies sponsored by NASA under consideration by the 2020 Astrophysics Decadal Survey. The *Lynx* Concept Study Report was submitted by the community-led Science and Technology Definition Team (STDT) to the Decadal Committee in August of 2019. Extensive technology maturation plans for the *Lynx* enabling technologies are also publicly available.

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 concept study shows the capabilities required to address these objectives can be implemented with an extremely powerful combination of a large 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. In all aspects, *Lynx* will be a Great Observatory which will open a new era in our understanding of nature by advancing many scientific frontiers. *Lynx* will provide the depth and breadth to answer some of the most significant and fundamental questions on the scientific landscape of tomorrow.

Members of the *Lynx* team, Alexey Vikhlinin (STDT Co-Chair), Jessica Gaskin (*Lynx* Study Scientist) and

Karen Gelmis (*Lynx* Study Manager), presented to the first meeting of the Astro2020 Panel on Electromagnetic Observations from Space 2, held November 5-7, 2019 in Washington, DC. This panel is tasked to identify and suggest a prioritized program of federal investment in research from space and to consider technology development needs to support such a program. The *Lynx* team contribution included key science questions addressed by *Lynx*, the flowdown from science requirements to observatory architecture, mission design trades, technology readiness, and costing methodologies. Presentations and discussions were supported by members of the *Lynx* study office and instrument and optics teams. Additional information has been provided to the EOS2 panel upon request following the November meeting.



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 interchangeable 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. Credit: Lynx Team

A detailed manufacturing study to strengthen the feasibility and required capabilities of industry to produce the *Lynx* mirrors within budget and schedule projections was completed in February 2020. The plan includes transferring the manufacturing process being developed in the laboratory to a scalable factory flow, defining the required factory layout and providing rationale for the basis of this initial design. The study illustrates how the process of maturing the manufacturing readiness level would be managed and how it would lead to a resource-efficient parallelized manufacturing of the *Lynx* mirror assembly. Authored by industry-leading experts from *Lynx* partners Northrop Grumman and L3Harris, the study shows the *Lynx* team knows how to build the most powerful X-ray mirror assembly ever conceived.

Lynx outreach activities continued with *Lynx*-related presentations and an exhibit at the 235th American Astronomical Society meeting in January and reviews to the X-Ray SIG Minisymposium during the American Physical Society's virtual meeting in April. Plans are for a *Lynx* virtual exhibit at the upcoming AAS June meeting. Otherwise, the *Lynx* community is eagerly awaiting the report of the Decadal Survey on Astronomy and Astrophysics 2020.

AstroPoetry Corner

Gravitational Wellness

M. F. Corcoran

Whan that cruel Aprill with shoures soote
Distemper'd March hath perced to the roote
Now warrened within becluttered rooms
Light headlong in dark tunnel blooms
Peering through windows grim visages
We longen folk to goon on pilgrimages

To Lincolnshire with ful devout corage
The warp and weave of spacetime's arc to gage
Horizons fathomless to understanding
Connected gravely by a common stranding
Shined by bend of escaping light
Or fall forever gentle unto that good night

A common journey to a common destination
Falling unnoticed in distinctive isolation
Aprill's fruit weakening at the vine
A small lunation taken for a sign
Were whan than oer alone in nature's schole
Divin'd then attraction's inescapable rule

And at once the cosmos shook our unbelief
Still the dead tree gives no shelter, the cricket no relief
But nathelees, whil the song of tyme and space resound
Truth essential spinning threads to be rewound
Woven in skillful pattern, ornately
are drawn together, inevitably