Spring 2021

The High Energy Astrophysics Division Newsletter

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

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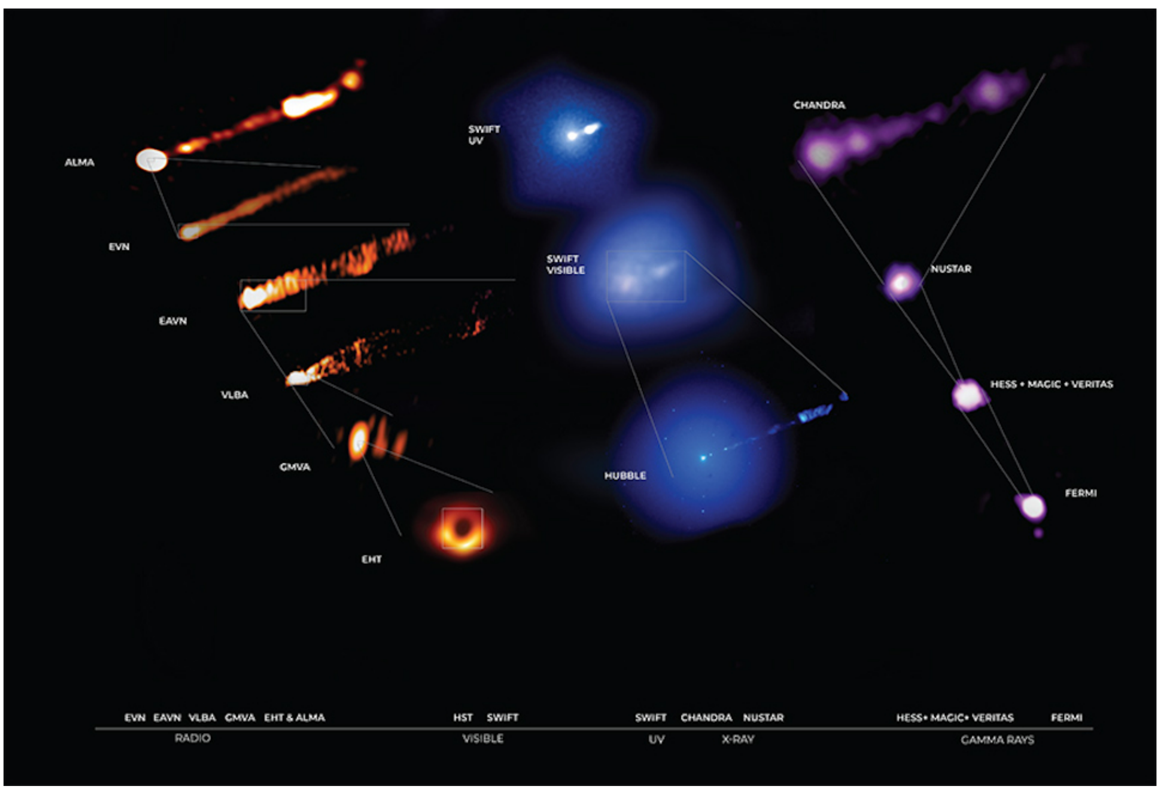


Multi-mission study of the active galaxy M87 and its black hole, on scales of 60 light-hours to 300,000 light years. Credit: the EHT Multi-wavelength Science Working Group; the EHT Collaboration; ALMA (ESO/NAOJ/NRAO); the EVN; the EAVN Collaboration; VLBA (NRAO); the GMVA; the Hubble Space Telescope; the Neil Gehrels Swift Observatory; the Chandra X-ray Observatory; the Nuclear Spectroscopic Telescope Array; the Fermi-LAT Collaboration; the H.E.S.S collaboration; the MAGIC collaboration; the VERITAS collaboration; NASA and ESA

View From the Chair

Fiona Harrison (Caltech)

This spring, hope springs eternal. The pandemic seems to be waning (at least in the US) and people are beginning to plan trips to exotic places like their offices. After having to cancel the 18th Divisional meeting due to COVID-19, we're optimistic we'll be able to hold the 19th Divisional meeting, about a year from now, as a non-virtual, in-person meeting. See you in Pittsburgh!

We've recently renamed the wildly-popular, monthly, virtual seminars (which we instituted in June, last year) as the HEAD Frontier Seminars. These are monthly Zoom talks open to the physics community and intended to highlight new results, particularly from our student and early-career members. We held 6 seminars in 2020 and two so far in 2021. If you've missed any you're highly encouraged to view the videos of the talk, which are posted on the Frontier website. If you have an interesting result, or want to communicate your research, please sign up to give a talk.

As we work towards improving the diversity and inclusiveness of our community, the EC is considering steps we can take to engage a broader segment of the population in the exciting pursuit of exploring the cosmos. Two ideas we are considering are workshops to help minority-serving and under-resourced institutions develop research programs in high energy astrophysics to help increase demographic diversity , and a climate assessment of our community to help calibrate issues and biases. We would love to hear other ideas from the rest of the community. Please contact me or any of the HEAD EC members with any ideas or comments.

At the 238th AAS meeting in January we were treated to a virtual plenary by Shep Doeleman, on behalf of the EHT team, the winners of the 2020 Rossi Prize, and also three excellent presentations by our Dissertation Prize finalists, Renee Ludlam, Adi Foord and Guang Yang. After an extremely difficult decision, the Dissertation Prize for 2021 was awarded to Renee Ludlam. We also announced the award of the 2021 Rossi Prize to Francis Halzen and the IceCube Collaboration "for the discovery of a high-energy neutrino flux of astrophysical origin". These prize awards were announced at our virtual business meeting. (Drink tickets will be held over and distributed the next in-person business meeting, not to worry.) We also celebrated fifteen years of astounding time-domain astrophysics from the Neil Gehrels Swift Observatory with a HEAD special session during the AAS meeting.

Please keep safe, get your vaccinations, and hope to see you (face-to-face) soon.

HEADlines

Megan Watzke (CXC)

As virtual conferences and Zoom meetings are now the new normal, those is pursuit of high-energy astrophysics have adapted to new routines while look for discoveries across the Universe. The good news is that most reporters and bloggers were already adept at virtual means of covering science. While in-person meetings can certainly cultivate relationships between media and scientists and spark ideas for possible new stories, much of this work can be done through emails, phone calls, and, of course, Zoom meetings.

While we all await the day when we can have physical meetings again, there is no reason to pause on sharing the fascinating results that emerge from high-energy astrophysics during this period of global challenge and change. One of the stories I had the chance to work on recently was a spectacular result released in April 2021. It shows the combined data of 19 of the world's most powerful telescopes on the ground and in space – including many HEAD missions – all observing M87 in concert with the Event Horizon Telescope. I think it's a powerful (and visual) example of what high-energy missions can do both with each other and when combined with other facilities.

Here is a sample of the steady stream of intriguing HEAD results that continue to be released and publicized, since the release of the last HEAD Newsletter:

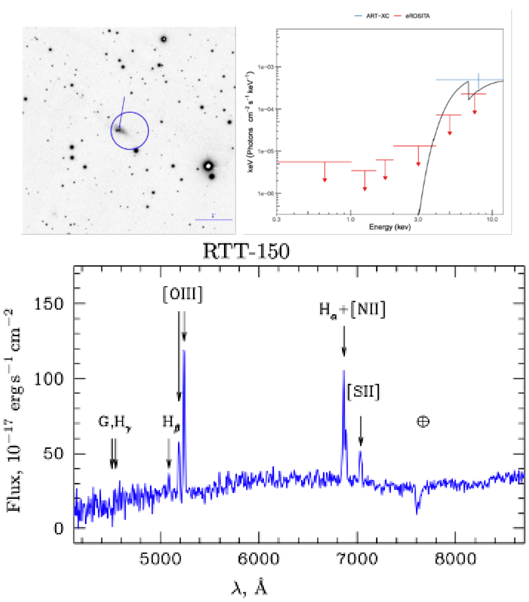
- December 8, 2021 "Astronomers Discover Second Stellar Tidal Disruption Event Caused by Supermassive Black Hole"
- February 8, 2021 "Rare Blast's Remains Discovered in Galactic Center"
- February 22, 2021 "NASA's *Swift* Helps Tie Neutrino to Star-shredding Black Hole"
- March 21, 2021 "Dark Matter is the Most Likely Source of Excess Gamma Rays from Galactic Center"
- March 31, 2021 "First X-rays from Uranus Discovered"
- April 7, 2021 "Telescopes Unite in Unprecedented Observations of Famous Black Hole"
- April 14, 2021 "Bubbles with Titanium Trigger Titanic Explosions"
- April 17, 2021 "NASA's NICER Probes the Squeezability of Neutron Stars"
- April 21, 2021 "For the First Time, IceCube Looks for Neutrinos from Solar Flares"
- Apri 29, 2021 "eROSITA Witnesses the Awakening of Massive Black Holes"

As always we encourage shameless self-promotion. If you've got a recent science result that may be of interest to the public at large, please contact the HEAD press officer, Megan Watzke. And if you've got an interesting image based on (or involving) high-energy observations, contact Mike Corcoran for consideration as a High Energy Astrophysics Picture of the Week.

Spektr-RG, ART-XC & eROSITA

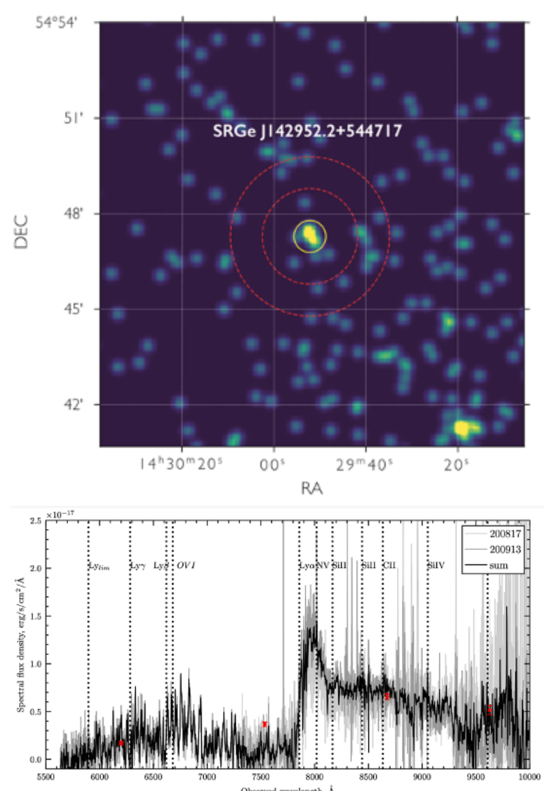
A. MERLONI (MPE), A. LUTIVONOV (IKI), P. PREDEHL (MPE), S. SAZONOV (IKI)

During the ongoing all-sky survey, the Mikhail Pavlinsky ART-XC telescope occasionally finds new objects in the 4 – 12 keV energy range which are not detected at lower energies by eROSITA. Such sources are good candidates for being heavily obscured active galactic nuclei (AGN). An optical spectroscopic follow-up program has ascertained this for a number of objects (Zaznobin et al. 2021). An example is the X-ray source SRGA J232446.8+440756, discovered by ART-XC and located in the irregular galaxy WISEA J232448.36+440756.5 at $z = 0.0462$, which was not known as an AGN before. The ART-XC and eROSITA data together indicate that the hard X-ray source is observed through a column of cold gas of at least 3×10^{23} hydrogen atoms per sq. cm, while the optical spectrum taken at the 1.5-m Russian-Turkish Telescope reveals a number of narrow emission lines typical of Seyfert 2 galaxies.



Top Left: Finding chart for SRGA J232446.8+440756. Galaxy WISEA J232448.36+440756.5 falls within the 30"-radius ART-XC localization region. Top Right: X-ray spectrum. Bottom: optical spectrum (Zaznobin et al. 2021). Credit: SRG/eROSITA

Thanks to the sensitivity and the survey strategy, the Mikhail Pavlinsky ART-XC telescope is able to discover new transient sources, in particular poorly studied weak ones. Using synergy with current public optical surveys, we are revealing the nature of such transients to study their parent populations. The first transient detected by ART-XC was SRGA J043520.9+552226 (= SRGe J043523.3+552234), which was associated with the bright optical counterpart AT2019wey. ART-XC's discovery triggered an extensive observational campaign on the source in X-ray, optical and radio wavebands, which helped establish SRGA J043520.9+552226/AT2019wey as a Galactic microquasar and low-mass X-ray binary (Yao et al. 2020, Mereminskyi et al. 2021, submitted). The object is quite peculiar. The detection of low frequency QPOs in the early stage of the outburst indicates that during the discovery the source was in a low-hard state typical of black-hole X-ray binaries, yet the rise time of the X-ray outburst was significantly longer than usual for such systems. The lack of a strong optical-X-ray luminosity correlation is also unexpected. Moreover, there was evolution in the high-energy emission during the long plateau stage. Interpretation of the multiwavelength properties of SRGA J043520.9+552226/AT2019wey in terms of contributions from the accretion disk, corona and jets is still under discussion (see Mereminskiy et al. 2021 for details).

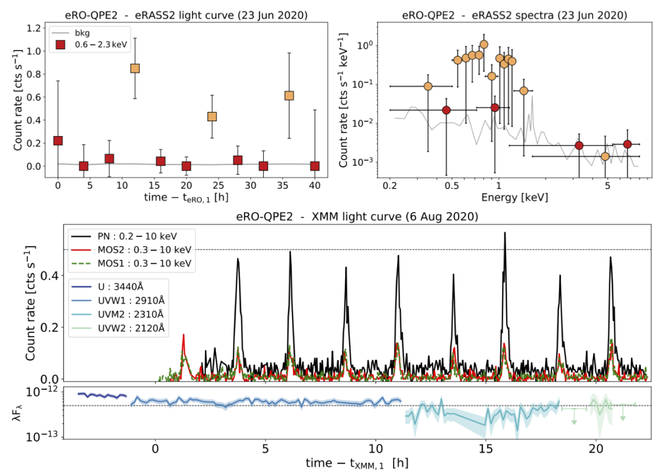


Top: X-ray image of quasar CFHQS J142952+544717 at z=6.2 obtained by SRG/eROSITA on 2019 December 10-11 (Medvedev et al. 2020). Bottom: Optical spectra of quasar SRGE J170245.3+130104 obtained with the BTA telescope (Khorunzhev et al. 2021). A number of emission lines at z=5.466 can be seen. Credit: SRG/eROSITA

The science analysis of the Calibration and Performance Verification data for eROSITA continues, and an "Early Data Release", with a suite of accompanying papers, is expected for July 2021. An important highlight from the C&PV observations concern studies of high-redshift quasars, which reveal the growth of the first supermassive black holes in the Universe. The SRG/eROSITA X-ray all-sky survey offers a unique opportunity to uncover the most luminous distant quasars, which, due to their rarity in space, are missed by small-area surveys. During a scanning observation of the 140 sq. deg eFEDS field (part of the Performance Verification phase of the mission), eROSITA detected X-rays from the previously known quasar SDSS J083643.85+005453.3 at z=5.8. It turned out to be one of the most X-ray luminous distant quasars known, with $L_X \sim 5 \times 10^{45}$ erg/s (Wolf et al. 2021). An even more extreme object, SRGE J142952.1+544716, was detected by eROSITA at the very beginning of its all-sky survey on Dec. 10–11, 2019. This quasar, CFHQS J142952+544717 at z=6.2 (corresponding to an age of the Universe of just 900 million years), had never been observed in X-rays before. According to eROSITA, its X-ray luminosity is huge: $L_X \sim 3 \times 10^{46}$ erg/s (or $\sim 10^{13}$ times the bolometric luminosity of the Sun!), smashing the previous record for high-redshift quasars (Medvedev et al. 2020). An *XMM–Newton* follow-up observation confirmed the stability of its X-ray luminosity and revealed a surprisingly steep spectrum (photon index $\Gamma = 2.5$, Medvedev et al. 2021). Three months later, eROSITA found a new X-ray source, SRGE J170245.3+130104, which was photometrically identified as a quasar candidate at $z \sim 5.5$. Follow-up optical spectroscopy at the 6m BTA telescope in the North Caucasus pinpointed the redshift at 5.466. This quasar turned out to be at least as luminous in X-rays as CFHQS J142952+544717 (Khorunzhev et al. 2021). Interestingly, both CFHQS J142952+544717 and SRGE J170245.3+130104 are radio-loud quasars, which represent a minority of quasars in the Universe. A substantial part of their enormous X-ray luminosity might be produced by inverse Compton scattering of cosmic microwave background photons off relativistic electrons in jets emanating from the supermassive black hole. SRG/eROSITA might find many more such objects during its ongoing all-sky survey.

Quasi-Periodic Eruptions (QPEs) are extreme high-amplitude bursts of X-ray radiation recurring every few hours and originating near the central supermassive black holes in galactic nuclei. It is currently unknown what triggers these events, how long they last and how they are connected to the physical properties of the inner accretion flows. Previously, only two such sources were known, found either serendipitously or in archival data, with emission lines in their optical spectra classifying their nuclei as hosting an actively accreting supermassive black hole. During the course of the first two all-sky surveys, an eROSITA blind and systematic search over half of the X-ray sky identified QPEs in two more galaxies. The optical spectra of these galaxies show no signature of black hole activity, indicating that a pre-existing accretion flow typical of active nuclei is not required to trigger these events.

The periods, amplitudes and profiles of the newly discovered QPEs are inconsistent with current models that invoke radiation-pressure driven accretion disk instabilities. Instead, the eROSITA observations suggest that QPEs might be driven by an orbiting compact object which would need to be much smaller than the central black hole. Future X-ray observations may constrain possible changes in the period due to orbital evolution. This scenario could make QPEs a viable candidate for the electromagnetic counterparts of the so-called extreme mass ratio inspirals, with considerable implications for multi-messenger astrophysics and cosmology.

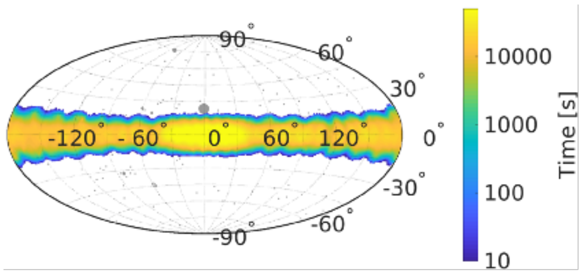


Example of QPE discovered by eROSITA: Top left panel: eROSITA light curve in the 0.2-0.6 keV and 0.6-2.3 keV energy bands (circles and squares, respectively), with red and orange highlighting faint and bright observations, respectively. Top right panel: eROSITA X-ray spectra of the bright and faint states in orange and red, respectively. Bottom panel: background subtracted XMM-Newton X-ray light curves with 500s bins for EPIC PN (dark gray), MOS1 (green) and MOS2 (red) in the energy band shown in the legend. XMM-Newton optical and UV fluxes are shown in the lower sub-panels (units of erg cm^{-2} s^{-1}), with non-detections shown as upper limits. The mean (and related dispersion) of the rise-to-decay duration is $\sim$27 minutes ($\sim$3 minutes), with a peak-to-peak separation of $\sim$2.4 hours ($\sim$5 minutes). Credit: Arcodia et al. (2021)

Insight-HXMT

Shijie Zheng, Shuangnan Zhang (IHEP, CAS)

The *Insight-Hard X-ray Modulation Telescope (Insight-HXMT)* mission is China's first X-ray astronomy satellite. It was launched on June 15, 2017 and is currently operating smoothly. There are three main payloads onboard *Insight-HXMT*: the high energy X-ray telescope (20 – 250 keV, 5100 cm^2, Liu et al., 2020), the medium energy X-ray telescope (8 – 35 keV, 952 cm^2, Cao et al., 2020), and the low energy X- ray telescope (1 – 12 keV, 384 cm^2, Chen et al., 2020). *Insight-HXMT* is expected to operate through June 15 2021, and a two-year extended mission has been approved by CNSA & CAS. For more details about the mission, please see the *Insight-HXMT* AO-04 white book.



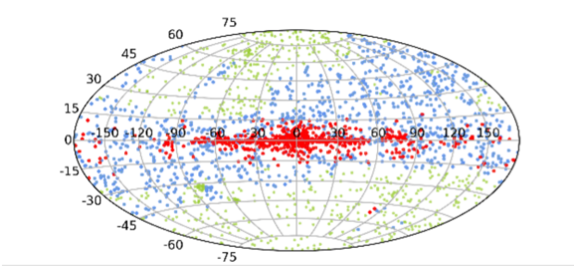
Exposure map of the Galactic plane survey (up to Dec 31, 2020). Credit:Insight-HXMT

The main scientific objectives of *Insight-HXMT* are to:

1. scan the Galactic Plane to find new transient sources and monitor known variable sources;
2. observe X-ray binaries to study the dynamics and emission mechanism in strong gravitational or magnetic fields;
3. monitor and study Gamma-Ray Bursts (GRBs) and Gravitational Wave Electromagnetic counterparts (GWEM).

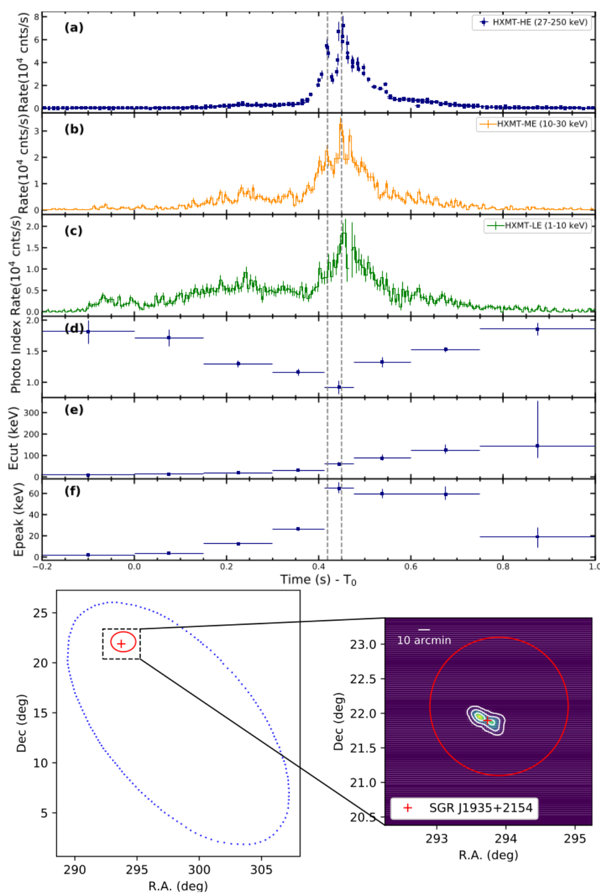
Insight-HXMT has two observation modes: a pointing mode, in which the observatory is directed to a certain sky position in inertial space for a specified duration; and a small sky area scan mode, to scan specific small sky areas to achieve a full coverage of a 7° — 10° half cone of sky.

More than 1/6 of *Insight-HXMT*'s observation time has been used to the scan the Galactic plane, to find new high energy transients and detect new activity from known sources. More than 800 known sources have been monitored. Many new source candidates have been detected, and some were confirmed to be known sources that have just undergone outbursts.



Distribution of known sources monitored by Insight-HXMT. The red dots indicate SNR >3, the blue dots indicate SNR $\leq$ 3, and the green dots indicate the catalog sources from Swift & Integral & MAXI. Credit: Insight-HXMT

In more than 3-years of operations, *Insight-HXMT* has observed almost 100 sources, including pulsars, NS binaries, BH binaries, magnetars, galaxy clusters, etc. A list of observed sources and exposure times is publicly available from the *Insight-HXMT* website. During this time *Insight-HXMT* has provided many important new science results. *Insight-HXMT* has detected the highest-energy fundamental cyclotron resonance scattering feature in the spectrum of GRO J1008-57 (Ge et al, 2020); detected the highest energy (above 200 keV) low frequency QPO (which can be modeled as precession of a relativistic jet, Ma et al. 2021); studied the jet-like corona near the black hole in the new black hole X-ray binary MAXI J1820+070 during the X-ray hard state (You et al. 2021); observed the decrease of hard X-ray emission in the spectrum of a single type I burst on a time scale of seconds (Chen et al, 2018); and demonstrated in-orbit X-ray pulsar navigation with high precision (Zheng et al, 2019). In 2020, *Insight-HXMT* discovered the first X-ray burst associated with a fast radio burst and identified it as coming from the Galactic magnetar SGR J1935+2154. It also found that the two pulses of the X-ray burst are coincident with the two peaks of the radio burst, a result which was key to identifying the magnetar origin of the FRB (Li et al. 2021). Please visit Insight-HXMT's publication list for more details on these results and other exciting *Insight-HXMT* science.



Top: Observations of FRB 200428 by Insight-HXMT and other telescopes. These observations show that the FRB originates from the magnetar SGR J1935+2154 (bottom). Credit: Li et al. (2021)

Insight-HXMT has participated many space- and ground-based coordinated and follow-up observations. By agreement, *Insight-HXMT* has joined the international campaign to follow-up gravitational wave events, and contributed to the multi-wavelength follow-up observations of GW170817, obtaining an upper limit on the emission of the counterpart in the MeV band (Abbott et al, 2017). *Insight-HXMT* searched for electromagnetic counterparts of high energy neutrinos seen with the IceCube Neutrino Observatory. *Insight-HXMT* has performed several joint observations with optical (Lijiang and Xinglong optical telescopes, China), radio (Xinjiang Nanshan radio telescope, FAST, et al.) and X-ray and Gamma-ray (*NuSTAR*, *INTEGRAL*, and *Fermi*) observatories, along with GECAM (Gravitational wave high energy Electromagnetic Counterpart All-sky Monitor), a Chinese satellite observatory which was launched in December 2020. Joint *Insight-HXMT* and GECAM observations have helped localize bursts and study terrestrial gamma-ray flashes.

The AO-03 observing cycle will be finished on July 31, 2021 and the call for proposals of Cycle 4 observations was issued to the whole international scientific community; proposals were due Apr. 30, 2021. The ratio of allocated observation time for core proposals and guest proposals is 2:3. In Cycle 3, 298 observations of 31 submitted proposals have been approved, coming from institutes and universities in China, Germany, France, Spain, Italy and Greece, and other countries. Significant amount of Director's Discretionary Time has been reserved for ad hoc ToO observations, the data from which are usually completely public and released immediately.

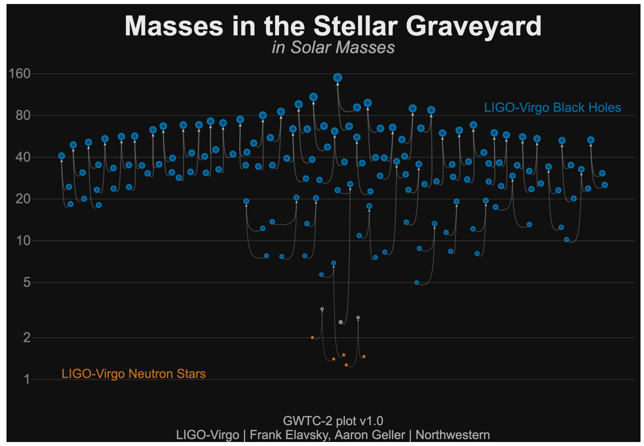
The *Insight-HXMT* Data Analysis Software (HXMTDAS) and the *Insight-HXMT* CALDB have been frequently updated and the latest version (V2.04) was released in November, 2020. To facilitate the analysis of the GRB data, the *Insight-HXMT* GRB Data Analysis software (beta 1.4) has also been released. To date, over 50 TB of Level-1 data products have been generated. Non-proprietary data can be downloaded from the *Insight-HXMT* data archive. More information (in Chinese & English) about the *Insight-HXMT*, user support and results can be found at the *Insight-HXMT* website.

LIGO-Virgo-KAGRA Collaborations

P. R. BRADY (U. WISCONSIN-MILWAUKEE)

Analysis of data from the third *LIGO-Virgo-KAGRA* observing run (O3) has been proceeding well. The release of the second gravitational-wave transient catalog (GWTC-2) at the end of October 2020 added 39 gravitational-wave events to the 11 events identified in O1 and O2. Papers describing the analysis of the data, the estimation of the source parameters, the implications for compact binary merger rate estimates and populations, tests of general relativity, and searches for associations with gamma-ray bursts that occurred during O3a were all released simultaneously.

A search was also carried out for lensing signatures in the gravitational-wave signals identified in GWTC-2. Several of the detected compact binary signals resemble each other closely as expected for lensed signals. When the sample is analyzed under realistic population assumptions, however, there is no support for the lensing of any of the current signals.



The masses of black holes (blue), neutron stars (orange), and compact objects of uncertain nature (gray) detected through gravitational waves. Each compact binary merger corresponds to three compact objects: the two coalescing objects and the final merger remnant. Credit: LIGO Virgo Collaboration / Frank Elavsky, Aaron Geller / Northwestern

Searches for gravitational waves from other sources of gravitational waves have also been reported. Together with the *NICER* team, the LVK constrained gravitational-wave emission from PSR J0537-6910. The gravitational ellipticity of the pulsar is constrained to be below 3×10^{-5} at 95% confidence. This implies that less than 14% of the star's spindown luminosity is associated with gravitational waves. A separate analysis also placed constraints on gravitational-wave emission from r-modes from this neutron star.

Other searches have placed limits on the gravitational-wave background, cosmic strings, and continuous waves from pulsars in binary systems.

On 30 April 2021, the *LIGO* and *Virgo* collaborations released bulk strain data taken during the first six months of O3. This is the O3a data release. It includes data taken between Aprila, 2019 and September 30, 2019. The data is available from the Gravitational Wave Open Science Center which also hosts tutorials and links to various tools for analyzing the data. The remaining strain data from O3 will be released later in 2021.

Earlier this year, the IEEE (Institute for Electrical and Electronics Engineers) bestowed Milestone awards on the *LIGO* and *Virgo* observatories. These awards recognize "technological innovation and excellence for the benefit of humanity found in unique products, services, seminal papers and patents." More than 160 IEEE Milestones have been awarded to a range of projects, including historical breakthroughs such as Benjamin Franklin's work on electricity and the electrical telegraph. *LIGO* and *Virgo* were honored for their gravitational-wave antennas and the first detections of gravitational waves.

Work is under way at *LIGO* Hanford, *LIGO* Livingston, *Virgo*, and *KAGRA* to improve the detectors for the next observing run O4. At the *LIGO* sites, this includes construction projects to house the filter cavities needed to support frequency dependent squeezing. The O4 observing run is projected not to begin before June 2022, due to both key procurement delays and COVID-19-related delays. The collaboration is reviewing the status of detector improvements and will provide updates on the run schedule in the next few months.

As we enter a new decade, physicists and astronomers are considering the future paths for gravitational-wave detectors. The *LIGO-Virgo-KAGRA* Collaboration are working to establish the International Gravitational Wave Network (IGWN) which is conceived as an organization to facilitate coordination among gravitational-wave detector projects across the globe. The initial effort is being invested in establishing a unified computing plan under the IGWN umbrella to introduce efficiencies by sharing common infrastructure and tools. The A+ and AdV+ projects involve significant upgrades to the detectors in the *LIGO* and *Virgo* facilities that will be completed for O5 which is anticipated to start around 2025. The *LIGO*-India project is also under way and should join the international network in the middle of the decade. Work has continued to ramp up on next generation facilities featuring detectors with arm lengths of 10km to 40km that could begin operations in the early to mid-2030s. Einstein Telescope is being pursued in Europe as an underground facility to house multiple detectors in triangular configuration. Cosmic Explorer is being pursued in the US as an above ground facility with interferometers at different locations. Specialized detectors, such as the Australian NEMO concept, are also being proposed to pursue specific science goals. Both *LIGO* and *Virgo* have initiated studies to consider options for upgrades in the existing facilities that would dovetail with the constructions and operations of next generation facilities. Watch for workshops to seek community input over the summer and in the fall of 2021.

IceCube Neutrino Observatory

Madeleine O'Keefe (University of Wisconsin–Madison)

On May 13, 2021, the IceCube Collaboration celebrated the 10th anniversary of the start of IceCube's first fully configured physics run. It also marked the kickoff of five months of festivities in honor of IceCube's "First Decade of Discovery," a mostly virtual celebration of IceCube's first 10 years of full operation. Leading up to IceCube's fall collaboration meeting in mid-September, we will share memories and history as well as hopes and goals for the future of the detector on IceCube's website and social media (Twitter, Facebook, Instagram, and YouTube).

One of the more exciting of IceCube's recent results was announced on March 10, 2021: The IceCube Collaboration reported the detection of an electron antineutrino via a Glashow resonance event on December 8, 2016. This phenomenon occurs when an astrophysical electron antineutrino carrying 6.3 PeV of energy interacts with electron and produces a W^- boson that quickly decays into a shower of secondary particles. With this detection, physicists provided another confirmation of the Standard Model of particle physics. It also further demonstrates the ability of IceCube to do fundamental physics. The result was published in *Nature*.

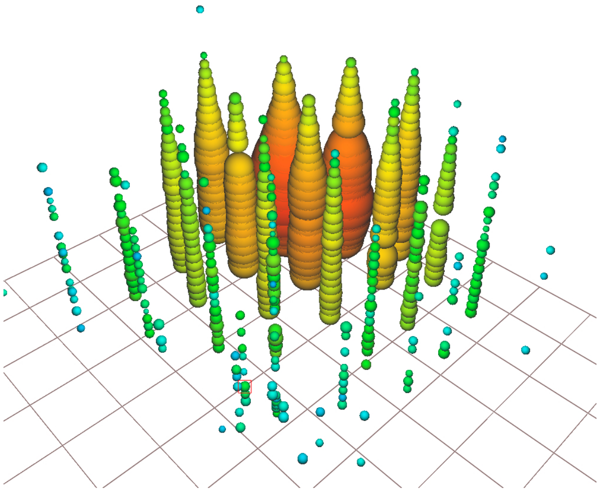
Sheldon Glashow first proposed his eponymous resonance in 1960 when he was a postdoctoral researcher at what is today the Niels Bohr Institute in Copenhagen, Denmark. There, he wrote a paper in which he predicted that an antineutrino (a neutrino's antimatter twin) could interact with an electron to produce an as-yet undiscovered particle—if the antineutrino had just the right energy—through a process known as resonance.

When the proposed particle, the W^- boson, was finally discovered in 1983, it turned out to be much heavier than what Glashow and his colleagues had expected back in 1960. The Glashow resonance would require a neutrino with an energy of 6.3 PeV, almost 1,000 times more energetic than what CERN's Large Hadron Collider is capable of producing. In fact, no human-made particle accelerator on Earth, current or planned, could create a neutrino with that much energy.

But what about a natural accelerator—in space? The enormous energies of supermassive black holes at the centers of galaxies and other extreme cosmic events can generate particles with energies impossible to create on Earth. Such a phenomenon was likely responsible for the 6.3 PeV antineutrino that reached IceCube in 2016.

The Glashow resonance event is noteworthy for a number of reasons. Its energy is remarkably high, and it is only the third event detected by IceCube with an energy greater than 5 PeV. The result also opens up a new chapter of neutrino astronomy because it starts to disentangle neutrinos from antineutrinos. Previous measurements have not been sensitive to the difference between neutrinos and antineutrinos, so this result is the first direct measurement of an antineutrino component of the astrophysical neutrino flux. There are a number of properties of the astrophysical neutrinos' sources that we cannot measure, like the physical size of the accelerator and the magnetic field strength in the acceleration region. If we can determine the neutrino-to-antineutrino ratio, we can directly investigate these properties.

To confirm the detection and make a decisive measurement of the neutrino-to-antineutrino ratio, the IceCube Collaboration wants to see more Glashow resonances. A proposed expansion of the IceCube detector, IceCube-Gen2, would enable the scientists to make such measurements in a statistically significant way. In 2019, the collaboration announced an upgrade of the detector that will be implemented over the next few years, the first step toward IceCube-Gen2.



A visualization of the Glashow event recorded by IceCube. Each colored circle shows an IceCube sensor that was triggered by the event; red circles indicate sensors triggered earlier in time, and green-blue circles indicate sensors triggered later. This event was nicknamed "Hydrangea." Credit: IceCube

This result demonstrates the value of international collaboration. IceCube is operated by over 400 scientists, engineers, and staff from 53 institutions in 12 countries, together known as the IceCube Collaboration. The main analyzers on this paper worked together across Asia, North America, and Europe.

The Chandra X-ray Observatory

Edward Mattison (SAO), Martin C. Weisskopf (NASA/MSFC)

The *Chandra* X-ray Observatory has carried out more than 21 years of highly successful and productive science operations. *Chandra* 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 Project is looking forward to many more years of scientific productivity. In recognition of *Chandra*'s important role in high-energy astrophysics, NASA has chosen to continue the mission and extend the contract to operate the *Chandra* X-ray Observatory, with science observing potentially through September 2027.

Dr. Edward Mattison has been appointed Manager of the *Chandra* X-ray Center (CXC), succeeding Dr. Roger Brissenden, who transitioned to a senior advisory role with the CXC and the Smithsonian Institution. Dr. Mattison had been Deputy CXC Manager since before *Chandra*'s 1999 launch. Prior to his work on the *Chandra* project, Dr. Mattison carried out research at SAO on hydrogen maser frequency standards, including as part of the 1976 Gravity Probe-A team that used a rocket-borne maser to test Einstein's theory of general relativity. Dr. Mattison began as CXC Manager on February 5 of this year.

Dr. Brissenden has been with the *Chandra* program (initially called AXAF) since 1990, and served as CXC Manager since 1993. In addition to his original charge of overseeing the establishment of the AXAF Science Center, he took on the development and implementation of the Operations Control Center when NASA assigned that role to the Smithsonian Astrophysical Observatory in the mid-1990's, and also served as one of the original *Chandra* Flight Directors. He has taken on many other significant managerial and advisory roles, including Associate Director of the High Energy Astrophysics Division of the Center for Astrophysics Harvard and Smithsonian (CfA), Deputy Director of the CfA, and more recently Acting Under Secretary for Science & Research for the Smithsonian Institution. He has served on many high-level committees for Smithsonian, NASA and other agencies. We will miss him, but are fortunate to have continued access to his wisdom and advice.

Roger Brissenden. Credit: CfA

Since March 2020, *Chandra* science and mission operations staff have successfully adapted to the challenges of the corona virus pandemic. Our primary goals are ensuring the health of the staff and maintaining the continued normal operation of *Chandra*. Protocols and schedules are in place to minimize the number of staff at the Operations Control Center and to keep operators physically separated. In the next phase of response to the pandemic, procedures have been instituted to increase the number of staff in phases, maintaining reduced occupancy and physical separation.

Normal operation of the spacecraft, as well as processing and distribution of data and support of the scientific community, have continued unabated. The High Resolution Camera (HRC) has returned to full service following a hardware anomaly in August. After careful analysis, planning and review, staff swapped the HRC's control electronics to its redundant circuits. (*Chandra* is equipped with duplicate sets of electronics and hardware for many functions.) Following thorough checkout, HRC resumed normal science observations in November.

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 call for proposals for Cycle 23 observations, issued in December 2020, resulted in 517 proposals, including 418 proposals for observing and 99 for archive and theory research. 15 Msec of observing time was requested, for an oversubscription rate of 5.1. The Cycle 23 peer review will be held remotely in June 2021.

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 from the *Chandra* website. As always, more information about the *Chandra* Observatory and the *Chandra* X-ray Center can be found on the *Chandra* website as well.

XMM–Newton

Lynne Valencic (JHU/NASA) and Kim Weaver (NASA)

Successful submissions from the Twentieth Call for Proposals for XMM-Newton were announced in December 2020, and observations will begin in May. Successful U.S. PIs will be invited to submit a budget proposal via NSPIRES between April 9 and June 4.

The Twenty-first Call for Proposals will open August 17, and the final date to submit proposals will be October 8. The final approved program will be announced in mid-December.

The SOC is holding a virtual workshop from May 24-28 on the theme of "A high-energy view of exoplanets and their environments". It will cover such topics as exoplanetary atmospheres, stellar high-energy irradiation, exoplanet formation, and interactions between stars and exoplanets. Registration is free, and the deadline is May 20. The link to the virtual registration site is available at the workshop website.

The Neil Gehrels Swift Observatory

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

The Neil Gehrels *Swift* Observatory continues to operate flawlessly. It supports five 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 requests accepted and variety of sources observed.

In April 2019, *Swift* began to track the X-ray, optical and ultraviolet light of a newly discovered tidal disruption event, AT2019dsg. A few months later, in October 2019, the IceCube Neutrino Observatory detected a high-energy neutrino called IC191001A from the same location in the sky. These are incredibly rare phenomena and the probability of a chance alignment between AT2019dsg and IC191001A is only 1 in 500, as reported in Stein., et al., Nat. Astron., 2021. This is only the second time a high-energy neutrino has been tied to a source beyond our galaxy.

Tidal disruption events occur when a star strays too close to a black hole. Gravitational forces create intense tides that break the star apart into a stream of gas. The trailing part of the stream escapes the system, while the leading part swings back around, surrounding the black hole with a disk of debris. Scientists hypothesized that tidal disruptions would produce high-energy neutrinos within such particle jets. They also expected the events would produce neutrinos early in their evolution, at peak brightness. Because the IceCube detection of a neutrino came about five months after *Swift* observed the light to peak, the combination of these unique datasets prompted scientists to re-think how tidal disruptions might produce high-energy neutrinos.

Swift's contribution to the science of tidal disruption events also includes the continued monitoring of ASASSN-14ko, currently our best example of periodic variability in an active galaxy. Using measurements from *Swift* and other NASA observatories, including *TESS*, *NuSTAR*, and *XMM–Newton*, scientists studied 20 repeated outbursts from this source (Payne et al., 2021, ApJ, 910, 125). A likely explanation for this periodic activity is a partial tidal disruption event, in which the galaxy's supermassive black holes, one having a mass of about 78 million Suns, only partially disrupts an orbiting giant star. The star's orbit is eccentric, and each time it passes close to the black hole, it bulges outward, shedding mass but not completely breaking apart. Every encounter strips away an amount of gas equal to about three times the mass of Jupiter. We don't know how long the flares will persist, but the next ones are predicted to happen between April and August 2021.

The *Swift* Guest Investigator (GI) program will continue to solicit proposals in GRB and non-GRB research during Cycle 18. NASA's Research Opportunities in Space and Earth Sciences (ROSES) 2021 and the *Swift* Appendix were released on February 12, 2021. All science proposals will be evaluated following a dual-anonymous peer review process. Updates on the Cycle 18 GI Program and the deadline for proposal submission will be posted on the *Swift* Proposals web page.

The Neutron Star Interior Composition Explorer

Keith Gendreau & Zaven Arzoumanian (NASA/GSFC)

NICER mission operations continue during telework circumstances instituted in response to 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 (ISS), and manage pipeline processing of data from their homes.

Data collection for Cycle 3 of *NICER*'s Guest Observer (GO) program began on March 1, 2021. For this Cycle, 8 Ms of science observing time was allocated for a combination of successful GO proposals, approved multi-cycle investigations from GO Cycle 2, and Cycle 2 investigations that were coordinated with other observatories but not carried out as a result of COVID-19 impacts at those facilities. Time was also allocated for *NICER*'s Legacy Science program of neutron star studies and for unanticipated ToO observation requests from users worldwide. Details of successful GO proposals and ToO requests, the ToO request submission form, and the mission's short-term observing schedule are available at *NICER*'s HEASARC website.

A *NICER* Users Group (NUG) has recently been formed, consisting of ten members with substantial expertise relevant to *NICER* science and instrumentation. Edward Cackett of Wayne State University is the inaugural Chair. The NUG is expected to meet, independently of *NICER* mission leadership, in spring and fall each year. The community is encouraged to contact the NUG with comments and suggestions; contact information, the NUG Charter, and meeting information can be found at the *NICER* User's Group webpage.

The *NICER* team is making progress toward implementing enhanced ToO capabilities. Currently, prompt (within hours) response to urgent ToO requests is available during regular business hours, when operations staff members are on duty; off-hours requests are handled on a reasonable-effort basis. (Scheduling of observations is always contingent on target visibility afforded by *NICER*'s ISS environment.) A *NICER* flight-software update in late 2020 enabled automated raster scanning with the X-ray Timing Instrument over moderately large ($\sim 1°$) localization error regions, comparable to those expected from the Japan Aerospace Exploration Agency's Monitor of All-sky X-ray Image (*MAXI*) payload onboard ISS. Within a year, *NICER* observations will be triggered directly, without ground intervention, by *MAXI*. This effort, dubbed "OHMAN" (the On-orbit Hookup of *MAXI* And *NICER*), promises trigger responses on several-minute timescales or less, delivering prompt observations of fleeting phenomena with approximately 15 times the effective area of *Swift*'s X-ray Telescope. While technical components of the OHMAN capability will be ready in October 2021, ISS processes for integration of OHMAN will enable full operation beginning in March-April of 2022.

NICER held its first public Data Analysis and Science Workshop during the week of May, 10, 2021; over 300 participants registered to attend. The workshop included data-analysis tutorials by the NICER science team, as well as 28 science presentations from members of the broader community.

Some recent notable *NICER* science results:

- At the 2021 APS April Meeting, the *NICER* team announced its latest neutron-star radius results and their implications for the equation of state (EOS) of cold, ultradense matter. In a special session, Thomas Riley and Cole Miller presented independent analyses of the 2.08 $M_\odot$ pulsar J0740+6620, inferring a radius of $\simeq 13$ km, similar to that determined for PSR J0030+0451 from an earlier *NICER* measurement. The result is surprising given the $\sim 50\%$ higher mass of J0740 over J0030, and strongly disfavors "soft" EOS models for the interior composition of neutron stars.
- Arcodia et al. (2021; Nature 592, 704) describe the discovery, by eROSITA with *NICER* and *XMM–Newton* followup, of quasi-periodic eruptions (QPEs) from two previously quiescent galaxies; *NICER* confirmed the longest-period QPE yet observed. The paper discusses the possibility that these QPEs result from a compact object's orbit around each galaxy's central supermassive black hole. If confirmed, this model would make QPEs a viable candidate for the electromagnetic counterparts of so-called extreme mass-ratio inspirals (EMRIs) expected to be detectable by the Laser Interferometer Space Array (*LISA*) gravitational-wave observatory, with important implications for multi-messenger astrophysics.
- Enoto et al. (2021; Science 372, 187) report enhanced X-ray emission coinciding with giant radio pulses (GRPs) from the Crab Pulsar. GRPs—sporadic bursts lasting microseconds but hundreds to thousands of times brighter than normal radio pulses—are known from just a handful of young neutron stars. Previously, associated emission enhancement outside the radio band had been seen only as a weak excess at optical wavelengths. The new result finds a 3.8% flux increase in soft X-rays coinciding with GRPs, a modest increment that nevertheless implies the total emitted energy during GRPs is 10–100 times higher than previously thought. This finding disfavors proposed connections between GRPs and repeating extragalactic fast radio bursts (FRBs).

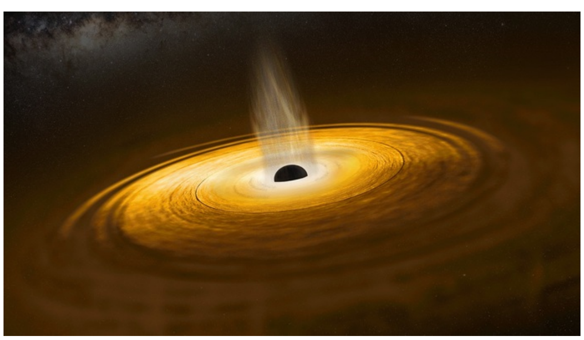
NuSTAR

DANIEL STERN (JPL), FIONA HARRISON (CALTECH)

The *NuSTAR* mission continues to operate nominally on orbit. With over 900 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 7 observations will begin on June 1, 2021, and are drawn from 196 submitted proposals with a factor of four oversubscription. This is a small increase from Cycle 6. With a factor of 5.5 oversubscription, Target of Opportunity (ToO) observations continue to be the most heavily oversubscribed proposal category, despite Cycle 7 doubling the ToO allocation compared to previous cycles. *NuSTAR* coordinated observing programs with the *Chandra*, *INTEGRAL*, *NICER*, *Swift*, and *XMM–Newton* observatories continue to be available through AOs for each of those facilities, with most of those facilities also providing time through the *NuSTAR* AO.

On the science front, the Caltech *NuSTAR* website did a News Release in March titled “A Tale of Two Coronae: Solving the Mystery of the Soft Excess” – though “solving” was a bit of an overstatement; the report highlighted the non-intuitive power of the *NuSTAR* high-energy, or hard, X-ray observatory to provide new insight into the mysterious low-energy “soft excess”.

The X-ray emission of actively accreting supermassive black holes (i.e., active galactic nuclei or AGN) is generally dominated by a power-law continuum due to thermal UV photons from the accretion disk up-scattered to X-ray energies by hot electrons in a plasma, or corona, near the black hole. However, a mysterious “soft excess” is often observed, consisting of a relatively strong, broad, and featureless spectral component at lower energies, below $\sim$1 keV. This component can overwhelm the characteristic power-law that dominates at higher energies, and the physical origin of the soft excess has been a matter of debate since its discovery in the early 1980s.



Artist’s impression of material spiraling into a black hole. Most of the material forms into a hot accretion disk, while some hot plasma forms an X-ray emitting "corona", illustrated here as vertical structure above the accretion disk. Using NuSTAR and soft X-ray observatories, astrophysicists are studying the mysterious low-energy, or soft X-ray emission seen from many black holes, which may be related to a second corona. Image credit: ESA

There are two main competing scenarios proposed to explain the soft excess. One explanation is a two-corona model, which postulates that in addition to the hot corona seen in most AGN, a second warm corona is seen in some AGN. X-rays in the less energetic corona repeatedly scatter and produce a lower energy, or softer, X-ray spectrum. The second scenario instead postulates that the soft excess results from X-rays from the hot corona shining back down and reflecting off of the accretion disk. In this case, the soft excess results from a forest of fluorescent emission lines from atoms in the disk, which are typically at low X-ray energies. The strong gravity of the black hole and the high speeds of the accretion disk then "blur" these lines into the observed soft excess.

Two recent *NuSTAR* papers came to opposite conclusions on this question. In a paper recently published in Astronomy & Astrophysics, Francesco Ursini and collaborators analyzed coordinated *NuSTAR* and *XMM–Newton* observations of the AGN in HE 1143-1810. *NuSTAR* constrained the AGN power-law emission, improving *XMM–Newton*’s ability to study the soft excess. Based on their modeling of the time variable spectrum of this source, Ursini and collaborators favor the two-corona origin over the relativistic reflection model. In contrast, studying the AGN in Mrk 509, Javier Garcia and collaborators came to the opposite conclusion in an earlier paper in the Astrophysical Journal. They showed that while both two-corona and relativistic reflection models produce statistically acceptable fits to their data, the latter is preferred on the basis of physics. Specifically, a warm corona is expected to produce very strong absorption features which are not observed. Ursini noted that more recent theoretical models show that these warm corona absorption lines can be avoided if the second corona has a source of internal heating, as might be the case if the warm corona is essentially a hot atmosphere to the accretion disk.

In summary, the mystery of the soft excess continues. Theory and observations are improving, and, ironically, the high-energy *NuSTAR* satellite plays a unique and very important role in these observations by constraining the underlying hot corona emission, enabling better modeling of the soft excess.

AstroSat

DIPANKAR BHATTACHARYA (IUCAA)

Ultraviolet colour-magnitude diagrams have been constructed for a number of open and globular star clusters. UVIT survey of six open clusters has enabled the identification of additional cluster members and classification of the stars into blue stragglers, main sequence and red giants (MNRAS 503, 236). UVIT observations have also revealed hot and luminous UV-bright stars including blue stragglers and Extreme Horizontal Branch stars in the globular clusters NGC 7492, NGC 1251, NGC 2808 and M67 (MNRAS 502, 313; MNRAS 501, 2140; ApJ 908, 66; JAA 41, 45).

A catalogue of variable far ultraviolet sources in M31 has been compiled. A higher fraction of variable FUV sources are found among the brighter objects and close to the spiral arms (AJ 161, 215)

A high resolution *AstroSat*/UVIT image of the Seyfert 1 galaxy IC 4329A has enabled the separation of the UV flux of the AGN from that of the host galaxy. This allows the location of the inner edge of the accretion disk around the supermassive black hole to be estimated, and it is found to lie 80–150 gravitational radii away from the black hole (MNRAS 504, 4015). Broadband spectral energy distributions have been constructed at different epochs for a number of Active Galactic Nuclei, revealing the emission processes and their variability (MNRAS 500, 1127; MNRAS 500, 3908; arXiv 2104.13472).

The Fermi Gamma-Ray Space Telescope

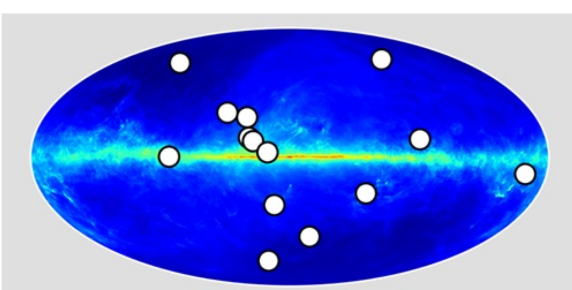
Elizabeth Hays, Chris Shrader, Dave Thompson, Judy Racusin, Julie McEnery (GSFC), Lynn Cominsky (Sonoma State U.)

The *Fermi* Gamma-ray Burst Monitor and Large Area Telescope continue to scan the gamma-ray sky. The Flight Operations Team and the Instrument Operations Teams manage the observatory and instruments, working remotely due to the COVID-19 pandemic.

Both the *Fermi* instruments were involved in a multi-wavelength study showing that a gamma-ray burst originated from a magnetar outburst in galaxy NGC 253.

Some theoretical modeling based on LAT data has suggested that dark matter is the most likely explanation for the excess gamma radiation seen in the Galactic Center region. Other analyses have suggested that the excess originates from sources such as millisecond pulsars.

A study of the more than 5000 gamma-ray sources in the most recent LAT catalog has found 14 of these sources that have properties consistent with being stars made of antimatter. Although none of these are likely to be antistars, the small number places strong constraints on the density of possible antistars.



Locations of the 14 possible "antistars" in the Fermi-LAT 4FGL-DR2 catalog. The background is the intensity map of the gamma-ray sky. Credit: S. Dupourque/IRAP

Did you miss the *Fermi* Tapas Talks at the January 2021 AAS meeting? You can find 4 short presentations on *Fermi* science and discussions with the experts.

The Ninth International Fermi Symposium happened virtually on April 12–17, almost one year later than originally planned. Plenaries and parallel sessions were held in many different time zones to accommodate participants from around the globe. The meeting hosted more than 500 registrants from two dozen countries. Recordings of the presentations along with presentations and posters are available on the Indico meeting site. The Tenth Symposium will be held in Johannesburg, South Africa. Watch for dates and details.

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 LAT team just released an update to the spacecraft position and history files. The spacecraft velocity has been added to support applications that can use the full state vector, such as pulsar timing analysis. The files were generated using an improved calculation of the spacecraft geodetic latitude and altitude and the latest International Geomagnetic Reference Field model (IGRF-13) for 2020 and 2021.

If you have job/research/degree opportunities relevant to the gamma-ray community, the LAT Collaboration has an Opportunity Board where those can be posted.

Cycle 14 Guest Investigator proposals were recently evaluated through a Dual Anonymous Peer-Review process. Additional information will be posted in the near future at the Fermi Science Support Center website.

The *Fermi* Summer School will be held virtually this year. Watch for an announcement through the Fermi Science Support Center.

The *Fermi*-LAT team has created a coloring book featuring the stained glass art posters that were created by Aurore Simonnet. The six pages of drawings include *Fermi* itself, the Milky Way in gamma rays, the *Fermi* bubbles, a supernova remnant, a blazar and a gamma-ray burst. The information accompanying the poster has been translated into 13 different languages ranging from Afrikaans to Urdu.

INTEGRAL

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

Since the introduction of the "Z-flip" observing strategy (in mid-July 2020), the spacecraft continues to operate nominally, without thruster usage or reaction wheel biasing. Science instruments also continue to operate nominally. With the aim of achieving higher time resolution spectral data with IBIS/PiCsIT from short duration transient events and intense flares of celestial sources, a test was performed to verify the possibility to use half of the integration time for its Spectral Timing Histograms (covering energies up to an MeV). Another test involved the "Compton Mode" in which off-axis high-energy photons (>300 keV) are registered when the IBIS shielding becomes transparent. This mode extends the IBIS Field-of-View and is important for the wide-field detection of transient events. The aim was to check if the Compton Mode sensitivity can be increased by slightly changing the time acceptance window applicable to this mode. The analysis of these tests are on-going.

The 36th SPI annealing took place in March. No SPI science operations were possible during that period. The instrument switch-on was performed smoothly with one of the detectors (#8) again showing somewhat worse performance. Compared to the relatively high level of degradation before the annealing ($\Delta E/E$ ~0.21% @1764 keV), the recovery is acceptable ($\Delta E/E$ ~0.19% @ 1764 keV). The recovered spectral resolution is slightly better than after annealing #35.

INTEGRAL's 19th Announcement of Opportunity (AO-19) call for proposals, for observations during 2022, closed on April 9, 2021. Forty-nine proposals were received requesting 58 Ms in total observing time, corresponding to an oversubscription in time by a factor of 2.8. The proposals request data rights for 311 sources with 11 proposals requesting joint time with *NuSTAR*, *Swift*, and/or *XMM–Newton*. The Time Assignment Committee (TAC) will meet virtually from May 18–20, 2021.

INTEGRAL User's Group (IUG) meeting #25 took place on November 24–25, 2020 to discuss the outcome of the SPC meeting. The IUG acknowledged the impressive work done at MOC and ISOC, and congratulated the teams for all the efforts invested to re-enable INTEGRAL science operations. Minutes of the meeting are being finalized.

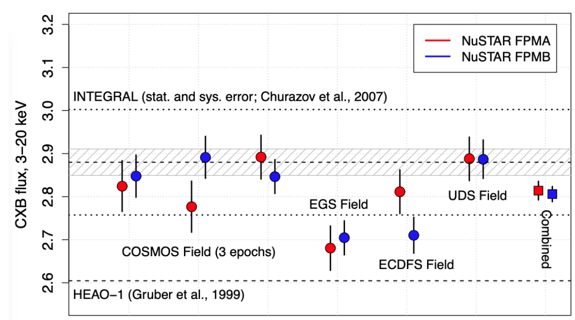
INTEGRAL has been asked to join the EHT (Event Horizon Telescope) multi-wavelength Working Group, intending to coordinate observations in late March/early April 2022. The IUG will be covered by the agreement.

Scientific observations during the reporting period followed the AO-17 and AO-18 long-term plans as much as possible given the Z-flip observing strategy. A coordinated observation between *INTEGRAL*, *XMM–Newton*, and MAGIC of the blazar Mrk 421 took place on December 12–15. *INTEGRAL* performed observations of the Fast Radio Burst FRB 180916.J0158+65 on January 12–13 and February 14–15, coordinated with radio facilities. Target-of-Opportunity (ToO) observations were performed on January 13–14 of the LMXB Cen X-4 (suggested to go into its 3rd ever outburst) and on April 3–5 of the accreting neutron star 4U 1728-34 (coordinated with the Australia Telescope Compact Array, ATCA). Since the last HEAD newsletter, four long gamma-ray bursts (GRB201214A, GRB210208A, GRB210312B, GRB210406A) were detected by the INTEGRAL Burst-Alert System (IBAS) in the main instruments Field-of-View.

A collaboration has been re-initiated to study the auroral-like activity that was seen by *INTEGRAL* and PROBA-2/LYRA in observations done in 2012. This is important for the upcoming *INTEGRAL*/Cluster/Swarm coordinated observations planned for later this year which will study the high-energy response on Earth to Solar flares.

INTEGRAL helped establish the source of the gamma-ray burst (initially named GRB 200415A) observed on April15 2020, was likely a magnetar in the nearby galaxy NGC 253 (Svinkin et al. 2021, Nature 589, 211). This finding confirms the long-held suspicions that some GRBs are in fact powerful flares from relatively close magnetars. Many space observatories were involved in this effort and the results triggered a NASA Press Release.

Using a unique technique of spatial modulation of the X-ray background on the detectors of NASA's *NuSTAR* orbiting telescope, it was possible to measure the cosmic X-ray background with an accuracy of <1% (Krivonos et al. 2021, MNRAS 502, 3966). These new measurements are consistent with *INTEGRAL* results (made via an Earth occultation maneuver), but about 8% higher than that measured with *HEAO-1*.



NuSTAR FPMA (red) and FPMB (blue) measurements of the CXB flux (in units of 10^{-11} erg s^{-1} cm^{-2} deg^{-2}) in the 3–20 keV band for individual datasets. The square points show the weighted average over all the datasets. The dashed lines show the CXB 3-20 keV fluxes measured by HEAO-1 (Gruber et al. 1999), RXTE (Revnivtsev et al. 2003), and INTEGRAL (Churazov et al. 2007). Note that the RXTE and INTEGRAL measurements become consistent with each other if corrected to the same spectral model for the Crab Nebula. The shaded areas show the statistical uncertainties for the RXTE and INTEGRAL measurements; the region between the dotted lines denotes the combined statistical and systematic uncertainty of the INTEGRAL measurement (Churazov et al. 2007). Credit: Krivonos et al. 2021

Cygnus X-3 was one of the first discovered X-ray binaries and the only bright compact binary system known to host a Wolf-Rayet star as a companion. The intense stellar wind created by this companion is one of the reasons why Cygnus X-3 exhibits a very peculiar spectral behaviour. It shows a wider variety of states than just the two canonical ones usually observed in other X-ray binaries. Despite being well studied, very little is known about this source's hard X-ray spectral behavior beyond 50 keV since the source is very faint at these energies. Thanks to *INTEGRAL*'s more than 16 years of observations, this source can now be detected up to 200 keV. A first phenomenological spectral fitting clearly reveals the presence of an additional component above 50 keV in addition to the component usually interpreted as thermal Comptonization. This non-thermal component can either be due to a non-thermalized population of electrons in a hot plasma very close to the compact object or synchrotron emission from the jets (Cangemi et al. 2021, A & A 645, A60).

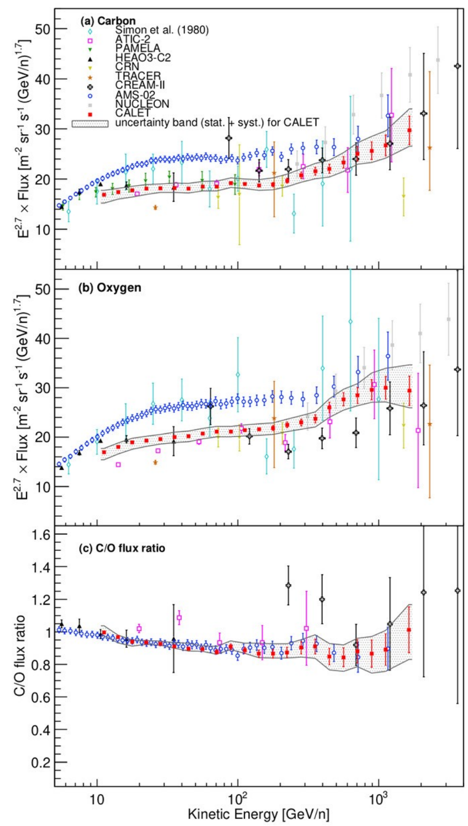
As of May 2, there are 1800 refereed publications since launch; of these, 36 have appeared in 2021. At NASA's High Energy Astrophysics Science Archive Research Center (*HEASARC*) there is an independent effort to compile publications per mission, including *INTEGRAL*, with a link to observation IDs. Work is underway to understand how papers are identified and matched with observation IDs.

Due to the ongoing COVID-19 pandemic, the *INTEGRAL* Conference "Towards the third decade of X and Gamma ray observations" is again postponed, now to autumn 2021 (close to the 19th launch anniversary). The venue, scope and objectives of the conference remain unchanged, but a hybrid model (in-person and remote attendance) is being considered; the exact dates will be announced later this spring.

CALET — John Wefel (LSU)

CALET (Calorimetric Electron Telescope), an international collaboration between Japan, Italy and the US on the International Space Station (ISS), has been measuring very high energy cosmic ray electrons, protons, and heavy nuclei plus high energy gamma rays and transient (burst) gamma ray events since late 2015. *CALET* has been approved for an extended mission phase through, at least, 2024. The main telescope (Cal) is a calorimetric instrument with a fully active calorimeter composed of lead tungstate scintillating bars preceded by an imaging calorimeter sub-system which is itself preceded by a charge measuring detector (CHD). The plastic scintillator-based CHD has a large dynamic range which allows particles up to about Zirconium (Z=40) to be studied. In addition to the Cal, the instrument complement includes the CGBM (*CALET* Gamma Burst Monitor) which records transient low energy gamma ray events as seen by two separate detectors.

In the past six months, the *CALET* team has completed the detailed analysis of the energy spectra of Carbon and Oxygen cosmic ray nuclei. These results are intriguing in several areas. While *CALET* spectra agree with a number of previous results, the absolute spectra fall about 27% below the results from AMS-02, also on the ISS. The origin of this effect is still not understood and is under investigation. However, if we normalize the C and O spectra to the AMS-02 results at low energy, the shapes of the spectra are in good agreement, as indicated in the bottom plot of the C/O ratio. Of most significance is the fact that *CALET* now confirms a hardening of both the C and O spectra at around 225 GeV/nucleon. Also, a fit to the C/O ratio above 25 GeV/nucleon gives a constant value of about 0.9, indicating that the spectral index change for C and O are the same – a value of 0.16 – within the uncertainties. More details can be found, soon, in a paper accepted for publication in Phys. Rev. Letters.



The flux of Carbon (top) and Oxygen (middle) as measured by CALET, multiplied by energy raised to the 2.7 power are shown as a function of kinetic energy and compared to previous balloon and satellite results. The gray band is the quadrature sum of statistical and systematic uncertainties. The lower plot shows the C/O ratio. Credit: CALET

CALET previously demonstrated a hardening in the proton spectrum. Preliminary results do not show any hardening for Fe. So, what is becoming clear is that the sources and/or interstellar transport for these very energetic cosmic rays are not the same as for their lower energy counterparts. All that, however, is for another report, another day.

VERITAS — Wystan Benbow (SAO)

In October 2020, *VERITAS* began its fourteenth season of full-scale operations. We are now $\sim 80\%$ through the 2020–21 season and the ~ 750 h of good-weather data acquired so far are of excellent technical quality and enable a variety science programs. Our successful experience in 2020–21 is particularly hard earned, as the impossibility of scientific travel required the conversion of

VERITAS into a remotely-operable facility. This was challenging since *VERITAS* was intentionally designed to be operated by an on-site crew of $\sim$3 visiting scientists, a concept that is effectively impossible during the ongoing pandemic. Indeed, prior to 2020, remote operations had never been attempted for any Cherenkov-telescope array. The deployment of VNC servers on *VERITAS* control machines and hardware/software upgrades to enable remote control of various sub-systems (e.g. high-voltage, shutters), now allow *VERITAS* to be operated by scientists located anywhere on the globe. These remote operations were successfully tested and phased in through Fall 2020. *VERITAS* is now remotely operated by (typically three) off-site observers assisted by a single local technician who prepares/shuts-down the system and responds to occasional technical issues. This innovation has enabled the *VERITAS* science program to proceed normally despite the pandemic, and the primary data yields are within a few percent of a typical season. The successful use of remote observing will likely enable the long-term operations model for *VERITAS* to evolve, improving access, sustainability and decreasing cost.

Some highlights from this season's remote operations include the detection of a new TeV blazar (B2 1811+31, see ATel #14104) and a flare of the extreme BL Lac H 1426+428 (see ATel #14501). There were also campaigns scheduled with *Swift* on 22 targets, and with *NuSTAR* on the blazars 3C 66A and H 1426+428. In addition to these programs and our other pre-planned observations, there were 24 Target of Opportunity (ToO) campaigns triggered with *VERITAS*, most including multi-wavelength partners. On the multi-wavelength and multi-messenger front, there were searches for gamma-ray and optical counterparts on 8 CHIME FRB repeaters, and follow-ups on 11 gamma-ray bursts, 3 IceCube neutrino alerts and a supernova.

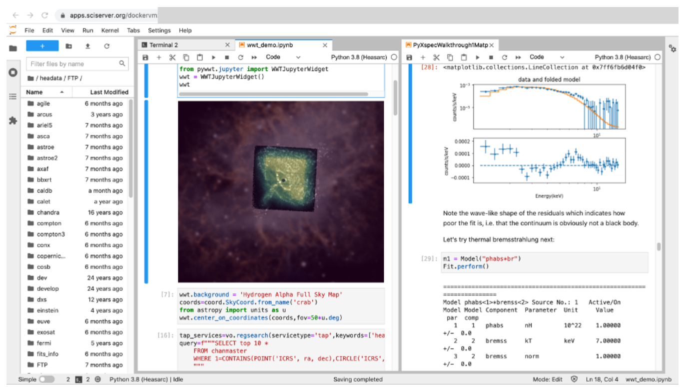
VERITAS is also leading a new effort in stellar intensity interferometry (SII) and its first results were published in Nature Astronomy in 2020. These SII data are taken around the full Moon, when gamma-ray observations are not normally acquired. Our goal this season is to generate a stellar-diameter catalog that is both improved and on similar scale to the last major (Narrabri) SII catalog from the 1970s. *VERITAS* is well on its way to this goal having observed 34 sources as of April 30. Throughout this season various hardware upgrades were also deployed improving the SII system's sensitivity to magnitude 4 targets, thereby increasing the number of observable sources from tens to hundreds, and enabling the system to operate for 6 consecutive nights without needing to stop and process the data.

The *VERITAS* collaboration's published highlights since Fall 2020 include: contributions to an unprecedented multi-wavelength observation campaign on M87, led by the Event Horizon Telescope collaboration, in 2017; and results from deep observations of the Galactic Center region.

The High Energy Astrophysics Science Archive Research Center

Lorella Angelini, Tess Jaffe & Alan Smale (NASA/GFC)

The *HEASARC* is excited to invite users to try out a new science platform hosted at SciServer.org, a collaborative environment for server-side analysis with extremely large datasets hosted by the Institute for Data Intensive Engineering and Science (IDIES) at Johns Hopkins University. For users familiar with the *HEASARC Hera* service, SciServer offers a more powerful and collaborative way to do data analysis in the cloud. With a few clicks in the browser, users can analyze the *HEASARC* data holdings without having to download a byte or install any software.



An example of a JupyterLab notebook running on SciServer and displayed in the user's web browser. On the far left is the file browser showing the HEASARC data available. The middle and right are two Jupyter notebooks being run. The first shows a visualization using the WorldWide Telescope (WWT) visualization software and a Chandra image of the Crab overplotted along with a catalog overlay of Chandra pointings (white dots). On the right is a `PyXspec` *tutorial notebook showing how to do everything from fitting to plotting in Python. Behind the WWT demo window is the hidden Terminal tab that allows you to work using a Linux command line. Credit: HEASARC*

After creating a personal account on SciServer users can create a Linux-based compute container that has all of the `HEASoft`, `Ciao`, and *XMM–Newton*-`SAS` software already built and a data volume populated with the full *HEASARC* archive. The container can be used through a Jupyter interface directly from your web browser. The simplest interface runs Jupyter notebooks written in, e.g., Python using the HEASoft's new Python wrapper package, `heasoftpy`. There are a few examples ready to demonstrate how users can interact with this interface, e.g., an `XSPEC` fitting in a Python notebook on SciServer, or an analysis of 15 years of *RXTE* light curves on your favorite source just by changing the source name at the top and running the prepared notebook.

Alternatively, SciServer allows you to use the more powerful JupyterLab interface that includes other applications such as a terminal window to work on the command line as though on the user's Linux desktop. If there are packages that have not been pre-installed, users have a conda environment to do the installations in the personal container. Users can let the *HEASARC* know of additional packages to include in the next update of the *HEASARC* software image by sending a request to the *HEASARC* help desk. We are working to add support for the Fermitools.

In the *HEASARC* data volume there are examples of notebooks already in place, and a HEASARC@SciServer userguide is available at the *HEASARC* SciServer website, demonstrating the current capabilities. HEASARC@SciServer was released in January 2021 and the *HEASARC* help desk will address any queries about data or software.

The *HEASARC* has a new portal to submit requests for data archiving. This portal is intended for new data that will be obtained from new missions/experiments or results from new data analysis, as well as for legacy data obtained from balloon or rocket flights or other high-level published legacy results that may be useful to the community. New missions and/or experiments proposed either under the Explorers opportunities (MIDEX, SMEX, MOO, etc) or the Astrophysics Research Program (ROSES elements PIONEER and APRA) are encouraged to submit their requests during the proposal preparation. These missions/experiments include CubeSats, SmallSats, ISS-attached payloads and suborbital projects, in addition to larger missions. Similarly, researchers writing ADAP or ATP proposals produce data or software tools are encouraged to contact the *HEASARC* prior their proposal submission. The portal includes descriptions of the *HEASARC* guidelines to archive data including guidelines on data format, software, calibration and cataloging as well as the *HEASARC* services applicable to upcoming missions. These guidelines are to ensure and maintain the capability of the multi-mission approach of the *HEASARC* archive, as described in the *HEASARC* charter.

In the last six months several new data sets were added to the *HEASARC* archive. These are:

- The *CALET* Gamma-ray Burst Monitoring (CGBM) data from the two Hard X-ray Monitor and Soft Gamma-Ray Monitor instruments, and their associated auxiliary data, available from the *HEASARC* and DARTS archives. The CGBM monitoring data consist of binned spectral data and are populated with the data processing outputs from Japan. This initial release includes all data from Oct 2015 up to Nov 2020 and will be updated routinely. Event data obtained when the instrument is triggered by a GRB or other events will be included at a later time.
- The BAT source monitoring lightcurves data generated by the BAT *Swift* team are now available from the *HEASARC* archive and will be updated every month.
- *HaloSat* reentered on Jan 4, 2021. The *HEASARC* data archive already had the data collected during the first year of operation. After the reentry the data from the second year were delivered to the *HEASARC* and made public.

Finally, the *HEASARC* is preparing Version 6.29 of the `HEASoft` analysis package to be released in May/June 2021. This release was largely driven by updates and improvements for the mission software packages *NICER*, *NuSTAR*, and *Swift*, and enhancements and bug fixes to libraries and other packages included in `HEASoft`.

Physics of the Cosmos News

Brian Williams (NASA/GSFC, Acting PCOS Chief 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.

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 the Comic-Ray SIG, the Gamma-Ray SIG, the Gravitational Wave SIG, and the X-Ray SIG. The PhysPAG provides for the PCOS community to regularly engage with the Program Office. 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.

In January, the PhysPAG EC welcomed three new members: Dr. Justin Finke (NRL), Dr. Vera Gluscevic (USC), and Dr. Andres Romero-Wolf (JPL). Five members rolled off of the committee, and we thank Dr. John Conklin, Dr. Sylvain Guiriec, Dr. James Rhoads, Dr. Abigail Vieregg, and Dr. Nicolas Yunes for their service over the past several years.

The PhysPAG has been busy in the past few months, organizing splinter sessions for the various SIGs at both the Winter 2021 AAS meeting and the April 2021 APS meeting. In addition to the SIG sessions, the AAS meeting saw a PhysPAG Town Hall meeting, a joint PAG session focusing on technology needs for upcoming missions, and a Cross-PAG meeting on "Enhancing the Participation of Minority Serving Institutions in Space Science."

The PCOS Program Office is currently soliciting community input on gaps between the current state of the art and technology needed for the strategic missions of the coming decades to achieve science goals. The next prioritization will take place in 2021. You can submit an entry for these technology gaps at the Astrophysics Technology Development website. Submissions are due by June 1st, 2021, OR three weeks after the release of the Astro2020 Decadal Survey.

On the personnel side, Dr. Valerie Connaughton has taken over as the PCOS Program Scientist at NASA HQ. We thank Dr. Dan Evans for his service in this role, and wish him the best in his future endeavors. Dr. Jacob Slutsky has taken over for Dr. Kim Weaver as part of the Acting PCOS Chief Scientist team at NASA GSFC.

We encourage anyone interested in PCOS science to join our email list, where we regularly highlight news items of interest to the PCOS community. See the PCOS website to join.

The X-ray Science Interest Group

Ryan Hickox (Dartmouth), Grant Tremblay (CfA), and Jillian Bellovary (CUNY/AMNH)

This year X-ray astronomy has seen more new and exciting science results, including new constraints on the neutron star equation of state by the *NICER* observatory in concert with *XMM–Newton*, the discovery by eROSITA of X-ray emission from the huge hot bubbles above and below the Milky Way disk, and the first detection of X-rays from Uranus by the *Chandra* X-ray Observatory.

The NASA PCOS X-ray Science Interest Group (XRSIG) continues to track and analyze science and mission development in X-ray astronomy, as well as provide a communication forum for the field. In the past six months we have held two sessions looking at the present and future of X-ray observations and exciting discoveries on fundamental physics.

The XRSIG session at the AAS Annual Meeting in January highlighted the science and accomplishments of current and future Explorer-class X-ray missions, including the Neil Gehrels *Swift* Observatory, *NuSTAR*, and *NICER*, as well as the upcoming Imaging X-ray Polarimetry Explorer (*IXPE*) and X-ray Imaging and Spectroscopy Mission (*XRISM*). At the APS April meeting, the XRSIG Minisymposium focused on X-ray constraints on fundamental physics, including the new *NICER* neutron star results, as well as X-ray constraints on axion-like particles from stellar observations with *NuSTAR*, and on sterile neutrino dark matter from archival *Chandra* observations.

In mission news, *IXPE* has now completed integration, and following environmental testing will be on schedule for launch this December. *XRISM*, a collaboration between the Japan Aerospace Exploration Agency (JAXA) and NASA, along with ESA, has released its Performance Verification phase targets and is continuing development toward launch in Japanese Fiscal Year 2022. 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

Marcos Santander (UA), Bindu Rani (AU), Justin Finke (NRL)

The Gamma-ray SIG welcomes Justin Finke (NRL) as new co-chair. The SIG thanks Sylvain Guiriec (George Washington University) who rotated off as co-chair.

The SIG co-organized (together with the Gravitational Wave and Cosmic Ray SIGs) a multi-messenger session at the 237th AAS Meeting in January The session was focused on the current status of multi-messenger astronomy and on how to maximize its scientific return.

The SIG also organized a mini-symposium at the virtual 2021 APS April meeting on the topic of time-domain astrophysics in the gamma-ray range. Four invited talks covered a range of topics in this field, including gamma-ray binaries, transients and novae, as well as opportunities to maximize the scientific return from time-domain studies. The SIG is currently organizing a session at the upcoming 238th summer AAS meeting on the topic of solar physics from a gamma-ray perspective.

The SIG will continue organizing events at different national and international meetings and invites members of the gamma-ray community to contact the current chairs (Justin Finke, Bindu Rani, and Marcos Santander) with any inquiries or feedback regarding the GR-SIG program.

The Cosmic Ray Science Interest Group

Marcos Santander (University of Alabama), Andrew Romero-Wolf (JPL)

The CR-SIG aims to act as a forum to discuss the current status of cosmic-ray and high-energy neutrino 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 CR-SIG welcomes Andrew Romero-Wolf (NASA JPL) as new co-chair. Andrew replaced Abigail Vieregg (University of Chicago) whose term expired in December 2020 and joined Marcos Santander (University of Alabama) who will continue to serve until December 2021.

Together with the gravitational wave and gamma ray SIGs, the CR-SIG co-organized a multi-messenger session at the 237th AAS Meeting in January. The CR-SIG also organized a mini-symposium at the virtual 2021 APS April meeting on the current status of ultra-high-energy cosmic ray and neutrino observations, with invited talks presenting an overview of ground-based results followed by presentations on the status of current and future space- and balloon-based missions such as *ZAP*, *PUEO*, *EUSO-SPB2*, and *POEMMA*. The CR-SIG is planning to host a series of webinars focused on the status of future CR/neutrino missions.

The CR-SIG chairs invite the members of the CR community to contact them directly via email to Andrew Romero-Wolf or Marcos Santander with any inquiries or feedback regarding the NASA cosmic ray program. People interested in the activities of the group are also invited to join our mailing list.

The Gravitational Wave Science Interest Group

JILLIAN BELLOVARY (CUNY/AMNH) AND SEAN MCWILLIAMS (WVU)

The GW SIG hosted a session at the January 2021 AAS meeting, which was held virtually. We enjoyed four talks, including Evan Goetz who gave a *LIGO* O3 results summary, Scott Ransom who talked about NANOGrav recent results and the impact of losing Arecibo, Ira Thorpe who gave an excellent *LISA* overview, and Zach Etienne who described novel numerical relativistic methods to simulate black hole mergers, which can be performed on a phone! The GW SIG did not convene a session at the April 2021 APS meeting, nor will there be a session at the Summer 2021 AAS meeting. We look forward to reconnecting with the community at the January AAS meeting in 2022. Further information about upcoming GW SIG meetings can be found on the PhysPAG website.

The Imaging X-ray Polarimetry Explorer

M. C. WEISSKOPF, BRIAN RAMSEY, & STEVE O'DELL (NASA/MSFC)

Despite COVID-19, the *IXPE* team is hard at work preparing the mission for launch in late 2021. Here we provide updates on the status of the mission since the previous Newsletter.

Significant events include the completion of the on-ground calibration of all 4 Detector Units (DUs)—3 flight units and a spare—and all 4 flight Mirror Module Assemblies (MMAs) —also 3 flight units and a spare. Calibration of the DUs occurred in Italy; calibration of the MMAs, at MSFC's Stray Light Test Facility. Recently upgraded for *IXPE* calibration, this 100-m facility now includes features—polarized and unpolarized sources, specialized support equipment, facility X-ray detectors, etc.—that simplify X-ray calibration. These calibrations revealed a small number of detector artifacts, which have both been accounted for and minimized by clocking the 3 flight detectors at 120° intervals and by dithering the observatory while taking data. In addition, an end-to-end telescope calibration, using the spare DU and spare MMA, was also performed at MSFC. There were no surprises from this calibration when comparing results from the telescope calibration to those from an analytical combination of the separate DU and MMA calibrations.

As noted in a previous newsletter, Ball Aerospace installed the 3 DUs and 3 MMAs onto the Observatory's "Payload" and accurately aligned them, such that the 3 telescopes (MMA + DU) will be co-aligned upon orbital deployment of the boom, which establishes the 4-m focal length of the X-ray telescopes. In addition, Ball has completed assembly and integration of the Observatory's "Spacecraft", which provides the non-mission-specific functions of the 3-axis-stabilized satellite. Now, Ball has integrated the Payload and the Spacecraft forming the Observatory and is nearly ready to perform observatory-level environmental testing—acoustic, shock, vibration, and thermal vacuum testing. Proceeding into these tests has been delayed by two issues: (1) repair of a broken lanyard in the boom assembly and (2) investigation of an anomaly with the Tip-Tilt-Rotate (TTR) mechanism (as used on NuSTAR), which will be used to make on-orbit MMA/DU alignment corrections if necessary.

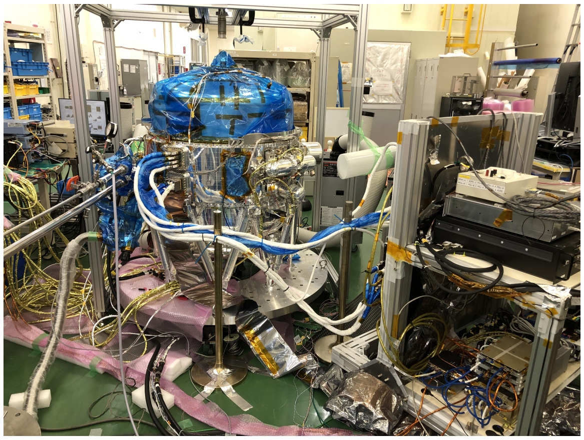
Turning to the ground system, a number of radio-frequency compatibility tests have been successfully completed and a required certification approved. An end-to-end test from the Observatory to a Malindi ground-station simulator, to the Mission Operations Center (MOC), and then to the Science Operations Center (SOC) was successful.

Finally, the SOC has been extremely busy developing and testing various software modules to process the data. The SOC has successfully passed potential target lists to the MOC, which, in turn, has converted these to the appropriate command loads and uploaded these to the Observatory. Finally, in addition to preparing the standard analysis, the SOC has purchased hardware to implement Neural Network (NN) processing and is running tests with an early version of the *IXPE* NN software developed at Stanford. Meanwhile, the Italian Instrument Team has begun extensive validation of the NN technique against calibration data. However, we may not have the NN analysis in place at launch, as the possibility of this enhancement occurred late in the program.

The X-ray Imaging and Spectroscopy Mission

RICHARD KELLEY (NASA GSFC); BRIAN WILLIAMS (NASA GSFC)

Development continues on the *X-ray Imaging and Spectroscopy Mission* (*XRISM*). NASA personnel have been able to continue to support the integration and testing of the Resolve instrument both virtually and in-person. The in-person support, in particular, has happened as a result of extraordinary efforts on the part of both the NASA and JAXA project management teams. Travelers to Japan continue to face the most strenuous tasks of all with the requirement to quarantine for two weeks upon arrival before beginning work on the instrument. At GSFC, work continues on the testing and calibration of the two identical X-ray mirror assemblies (one for the Resolve instrument, one for the Xtend instrument). These mirrors are expected to be delivered to Japan in early 2022. The mission remains on track for a launch in Japanese Fiscal Year 2022, with a target launch date of February 2023.



The XRISM/Resolve instrument undergoing cryogenic and performance tests in May at Sumitomo Heavy Industries in Japan prior to delivery to the JAXA Tsukuba Space Center in summer 2021. Credit: NASA/JAXA

The targets for the Performance Verification (PV) phase of the mission have been selected, and the list released. The PV phase of the mission will last approximately 6 months (following the checkout and initial calibration phases), during which the performance of the instruments will be verified through observations of a wide variety of celestial targets, including (but not limited to): X-ray binaries, active galactic nuclei, clusters of galaxies, stars, and supernova remnants. The list of targets can be viewed on our newly redesigned NASA *XRISM* website. It is anticipated that a Call for Proposals will come out later in 2021 for the *XRISM* Guest Scientist Program, under which astronomers who are not part of the *XRISM* Science Team can become involved in analysis of the PV phase data for specific targets. As a reminder, once the PV phase of the mission is concluded, the mission will enter the General Observer phase, in which it will remain for the duration of the mission. Yearly calls for observing proposals will be issued, and funding will be available through NASA for successful proposers based at US institutions.

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 the data once they get it. 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.

Athena: Revealing the Hot and Energetic Universe

Randall Smith & Laura Brenneman (CfA), Kristin Madsen (NASA/GSFC & UMBC), and Jon Miller (U. Michigan)

The *Athena* Study, currently in Phase B1, recently passed another important milestone: the Spacecraft Intermediate Review, aiming at freezing the global architecture of the mission by consolidating the interfaces under ESA responsibility. In the framework of this review, ESA has concurred with the request by the *Athena* Science Study Team (ASST) to switch the orbit to the Lagrangian Point L1, due to its better characterized and possibly more benign soft proton environment with respect to the baseline assumed so far (L2).

The next Study milestone is the Science Instrument Module Intermediate Review, scheduled to start in mid-May, with completion expected before the summer break. It shall confirm the maturity level of the Science Instrument Module (SIM), most importantly of the first consolidated designs of the X-IFU cryostat by two industrial Primes.

ESA has announced that the Adoption of *Athena* in the ESA Science Program is now scheduled for the November 2022 meeting of the Science Program Committee. The Mission Adoption Review should be held in the summer of 2022. The ASST will need to deliver the Definition Study Report (a.k.a. as "The Red Book") by the end of August 2022. The estimated duration of the implementation phase is about 10.5 years.

In light of this programmatic update, the ASST has decided to postpone the kick-off of the preparation of the Red Book to early 2022. With key technology development activities in full swing over the next ∼18 months, the ASST considers it crucial to ensure that the mission profile for the Red Book is based on state-of-the-art experimental demonstrations of key scientific performance, most notably that of the optics (see later), while ensuring sufficient time for the ASST to gather and compile well-thought and -prepared inputs from the science community. The deadline for the submission of the papers for the Special Issue on Astronomy & Astrophysics will correspondingly be shifted to the second half of 2022. Spring 2022 will be a very busy period for the *Athena* community worldwide!

The ASST has been carefully monitoring the evolution of the Study, in particular as far as the ultimate scientific performance is concerned. The latest estimates of the mirror area and of the instrument efficiencies indicate that the effective area requirement at 1 keV should be achievable by Adoption. On the other hand, the risk exists of a 20–40% shortfall in effective area at 7 keV. In order to mitigate this risk, at its last meeting (#24, March 2021) the ASST adopted a recommendation encouraging ESA to plan a specific activity to increase the Technology Readiness Level of multi-layer coating options as a possible alternative to the current bi-layer baseline. This recommendation has been implemented by ESA in the latest version of the corresponding technology plan.

The development program of the optics proceeds according to plan, with good progress over the whole range of activities. A significantly improved performance has been achieved in both half-energy-width (HEW) and effective area. The HEW now well below $10''$ over 100% of the area, and an average improvement of $1''$ at all areas with respect to the average of the prior generation measurements. This can be compared to the results reported in the Spring 2020 HEAD newsletter, describing the production of the first high-quality 34-plates stack for an outer radius achieved 10″ HEW over only 70% of the area. The changes include moving to a wider rib pitch and reduced membrane thickness, increasing the geometric throughput, which have now been partially demonstrated with ongoing work in 2021.

Multiple coating studies are underway for *Athena*, including qualification, coating design & characterization and study of the longterm stability. Recent preliminary results suggest that both Ir and Ir/C coating layers are stable against post-lift-off and cleaning; further tests on flight-like plates are in process, as are studies of both SiC and B_4C coatings. This work would primarily enhance the low-energy mirror response. One way to improve the harder X-ray area would be multilayer coatings (Della Monica Ferreira+2017), with a multilayer located underneath a bi-layer such as Ir/SiC. Additional studies are now underway to investigate this option in practice.

The ACO has been established by the ASST to support its role as "focal point of interests of the broad scientific community". Since 2016, the ACO has managed ASST's communication with the *Athena* community, including the web page, urgent or important notifications via bimonthly Brief News emails, the document repository, and $\sim$yearly calls for membership (now numbering more than 1000 scientists worldwide).

The office publishes the *Athena* scientific and technical nuggets (the 52nd and latest published in April 2021) and the *Athena* Newsletter (number 8 published in November 2020). It has also kept an active profile on Facebook and Twitter @AthenaXobs, and created a YouTube channel, where videos produced for the International Day of Women and Girls in Science and European Researchers' Night are kept. Additionally, the ACO produces and shares other *Athena*-related outreach material.

Last, but not least, the ACO provides scientific support to the ASST and the Community, by assisting in the synergy exercises with other ground-based and space observatories (so far with ESO and SKA, and two more coming in the next few months with multi-messenger observatories and the Vera Rubin Observatory), compiling a list of publications relevant for the observatory (please, inform us about your related publications), maintaining the gallery of up-to-date figures, images and artistic impressions. The office also performs and facilitates simulations of *Athena* observations, and offers links to simulation tools.

The Cherenkov Telescope Array

DAVID WILLIAMS (UCSC)

The CTA Observatory and CTA Consortium continue to work towards establishing the European Research Infrastructure Consortium (ERIC) which will define the initial scope of the CTA Observatory and provide the organizational framework for its construction and operation. The remaining steps are expected to be completed this year. At the same time, telescope designs for CTA are being tested and fine-tuned. One such design is the Schwarzschild-Couder Telescope (SCT) which has been prototyped in the U.S.

The SCT optical design was first conceptualized by U.S. members of CTA in 2006, and the construction of the prototype SCT (pSCT) was funded in 2012. Preparation of the pSCT site co-located with VERITAS at the F.L. Whipple Observatory near Amado, AZ, began in late 2014, and the steel structure was assembled on site in 2016. The installation of the pSCT's 9.7-m primary mirror surface — consisting of 48 aspheric mirror panels — occurred in early 2018 and was followed by the camera installation in May 2018 and the 5.4-m secondary mirror surface installation — consisting of 24 aspheric mirror panels — in August 2018. Scientists opened the telescope's optical surfaces and observed first light in January 2019. The SCT is based on a 116-year-old two-mirror optical system first proposed by Karl Schwarzschild in 1905, but only recently became possible to construct as a result of essential research and development progress made at the Brera Astronomical Observatory, the Media Lario Technologies Incorporated and the Istituto Nazionale di Fisica Nucleare, all located in Italy. pSCT operations are funded by the National Science Foundation and the Smithsonian Institution.

In early 2020, just before operations at the Whipple Observatory were temporarily suspended because of COVID-19, the pSCT was used to observe the Crab Nebula. The detection of the Crab Nebula, published now in Astroparticle Physics 128 (2021) 102562 (also arXiv:2012.08448), is an end-to-end validation of the telescope design. Preliminary results were presented in June 2020 at the AAS meeting. Operations at the observatory resumed in June, and commissioning work to understand and improve the pSCT performance resumed last fall.

Two new webinar series were launched by the CTA Observatory in April this year. For researchers, the "Synergies in the Exploration of the Extreme Universe" webinar series, co-organized with the CTA Multi-Wavelength Task Force, is focused on the various multi-wavelength (MWL) and multi-messenger (MM) synergies of CTA's scientific goals. Webinars will take place on the fourth Thursday of every month via Zoom, alternating the time for each webinar (17:00 UTC or 09:00 UTC) to make the live connection more accessible to scientists in different time zones. Participation is open and free to all researchers who subscribe to the series. Information about the next seminar and the access for each month's webinar will be shared via email to all subscribers. David Thompson from NASA's Goddard Space Flight Center presented the inaugural webinar on April 29. His topic was "AGN Multiwavelength Research Strategies: The Fermi Large Area Telescope Experience." More information, including how to subscribe, can be found at the webinar web page.

A second webinar series, for everyday astronomy fans, is "Journey through the Extreme Universe." It will take participants on a series of exciting "missions" to explore the Universe via the science cases and technology of CTA. It will be livestreamed via the CTA YouTube and Facebook feeds every month on a Wednesday at 17:00 UTC. The series launched on 28 April with an introductory talk about the CTA Observatory, after which different "mission commanders" will cover topics like cosmic rays, dark matter, and star-forming regions. For further details, please see the webinar web page.

LISA

I. Thorpe (NASA/GSFC); G. Mueller (U. Florida); M. Vallisneri (JPL/Caltech); S. Barke (U. Florida)

The European Space Agency (ESA)-led *LISA* project is nearing the completion of Phase A, in which the fundamental features of the mission are defined. A pair of industrial contractors are developing independent designs for spacecraft and payload systems which meet the mission requirements and accommodate the expected instrument contributions from ESA member states and NASA. ESA, NASA, and the teams within the *LISA* Consortium are also collaborating on studies of critical system-wide aspects of the *LISA* measurement such as performance models, operational scenarios, risk registers, and approaches to calibration. The goal of this phase is to demonstrate the feasibility of the mission requirements, address any perceived show-stoppers, and define the payload interfaces and requirements so that technology development can progress through its final stages. Work is also progressing on early definition of the *LISA* ground segment including identification of the likely data products and the requirements for the analysis pipelines needed to produce them. ESA's Mission Formulation Review (MFR) in Fall of 2021 will conclude *LISA* Phase A. Phase B1 will follow immediately afterward, where detailed designs will be developed leading to a cost and technical evaluation ahead of Mission Adoption in 2024.

In addition to supporting systems engineering and ground segment definition work, NASA continues to push technology development activities for its anticipated *LISA* payload contributions. L3Harris, NASA's industrial partner for telescope technology development, began fabrication of the first structural and thermal model (STM) this Spring. The STM will be used to validate the telescope design against key environmental requirements. Engineering Development Units (EDUs) with functional optics will follow the STM and will be used to validate the design against *LISA*'s unique optical performance requirements. The University of Florida is developing a specialized facility to test the stability of the EDUs at picometer level in the *LISA* measurement band and at micron level over longer timescales. The laser team at NASA Goddard Space Flight Center delivered a TRL4 prototype of the *LISA* laser system to ESA for performance testing by an ESA contractor. Development of the TRL5 laser is already well underway. The University of Florida was awarded a contract to develop a TRL6 Charge Management Device for LISA and completed their Systems Requirement Review in late April. NASA's long-running efforts in phase measurement systems and electric micropropulsion, both conducted at JPL, will be phased out of the *LISA* program in FY22 as they are not anticipated to lead to NASA contributions to an ESA-led gravitational wave mission. Both of these technologies have had proven success on flight programs and it is likely that they will be applied in future NASA missions.

The science working groups within the *LISA* Consortium continue to build bridges between many different astrophysics groups, foster collaborative research and create communities around *LISA*'s science topics. These groups have between 300 and 500 members from many different countries ranging from young students to very senior scientists. So far the working groups were organized as open forums to collect science opportunities and expertise in all areas relevant to *LISA*. The groups are currently generating white papers which will present research roadmaps to help guide future activities to prepare for *LISA* data. Following the release of the "open-forum" white papers, the groups plan to organize collaborative projects targeting sub-areas or specific problems. The hope is that the working groups will be able to transition between open-forum formals and collaborative projects organized by smaller sub-groups as needed.

New LISA Logo Credit: Davide DalBosco, the University of Trento

On a lighter note, the *LISA* consortium organized a design competition for the new *LISA* Consortium logo. More than 90 designs were submitted from which a panel selected 11 logos. These logos were slightly edited for clarity and visibility under different print and projection scenarios by the advocacy and outreach group. Each *LISA* Consortium member was then asked to select his/her favorite three logos. The top three vote getters were then presented to the board which made the final selection. And the winner and new *LISA* logo is a design from Davide DalBosco from the University of Trento group.

AstroPoetry Corner

Sonnet 18

Edmund Hodges-Kluck (NASA/GSFC)

Shall I compare thee to midsummer days?
Thou probe that which is hotter still by far;
And glows or bursts forth in the soft X-rays,
As from the crust of yonder neutron star;
Sometimes hot spots like eyes of heaven shine,
Thou glimpse their lighthouse beacons in the night;
And as thou watch tempestuous flares decline,
The myst'ries of the bursts are brought to light;
But greater still: from pulse shapes comes the mass,
And radius of the whirling potentate;
Into the inner sanctum thou wilt pass,
And find within Equation of its State;
    And though the Hubble no-one can forget,
    Thou must be known as even *NICER* yet

Encounter

Rodolfo Montez, Jr. (CXC)

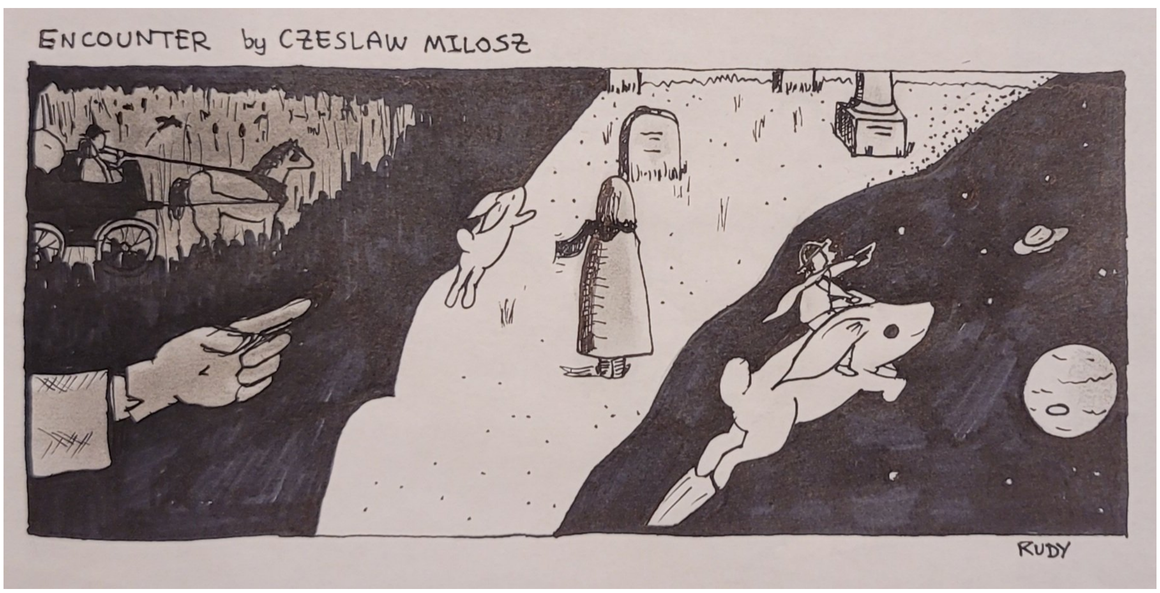


Illustration inspired by the short poem, "Encounter", by Czeslaw Milosz.