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March 13, 2026

The Honorable Brian Stone
Acting Director and Chief of Staff, U.S. National Science Foundation
Alexandria, VA 22314

The Honorable Jared Isaacman
Administrator, National Aeronautics and Space Administration
NASA Headquarters
Washington, DC 20546-0001

The Honorable Chris Wright
Secretary, U.S. Department of Energy
1000 Independence Avenue SW
Washington, DC 20585

The Honorable Brian Babin
Chairman, Committee on Science, Space and Technology
United States House of Representatives
Washington, DC 20515

The Honorable Ted Cruz
Chairman, Committee on Commerce, Science and Transportation
United States Senate
Washington, DC 20510

The Honorable Bill Cassidy
Chairman, Committee on Health, Education, Labor & Pensions
United States Senate Washington, DC 20510

Dear Director Stone, Administrator Isaacman, Secretary Wright, Chairman Babin, Chairman Cruz, and Chairman Cassidy:

We are pleased to transmit to you the annual report of the Astronomy and Astrophysics Advisory Committee for 2025-2026.

The Astronomy and Astrophysics Advisory Committee (AAAC) is a Federal Advisory Committee that was established by the U.S. Congress under the National Science Foundation Authorization Act of 2002 to provide independent assessments and recommendations regarding the coordination of astronomy and astrophysics programs of the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), and the Department of Energy (DOE). As part of its founding charge, the AAAC specifically evaluates the agencies' progress toward the priorities outlined in the National Research Council's decadal surveys in astronomy and astrophysics and transmits its findings and recommendations to the agencies and Congress no later than March 15 of each year.

The attached document is the twenty-second such report, which has been carefully considered and prepared by our committee in full compliance with our congressional charter and requirements of the Federal Advisory Committee Act. Attached below you will find an executive summary, followed by our report, with findings and recommendations for NSF, NASA, and DOE regarding their support of the nation's astronomy and astrophysics research enterprise, along with detailed recommendations concerning specific projects and programs. The report is also being sent to other Congressional Committees of Jurisdiction.

We would be glad to provide you with a personal briefing if desired.

Sincerely yours, on behalf of the Committee,



Dr. Alyson Brooks
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Cc:

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The Honorable Maria Cantwell, Ranking Member, Committee on Commerce, Science, and Transportation, United States Senate

The Honorable Bernie Sanders, Ranking Member, Committee on Health, Education, Labor, and Pensions, United States Senate

The Honorable Jerry Moran, Chair, Subcommittee on Commerce, Justice, Science, and Related Agencies, Committee on Appropriations, United States Senate

The Honorable Chris Van Hollen, Ranking Member, Subcommittee on Commerce, Justice, Science, and Related Agencies, Committee on Appropriations, United States Senate

The Honorable Mike Lee, Chairman, Committee on Energy & Natural Resources, United States Senate

The Honorable Martin Heinrich, Ranking Member, Committee on Energy & Natural Resources, United States Senate

The Honorable Bob Latta, Chairman, Subcommittee on Energy, Committee on Energy and Commerce, United States House of Representatives

The Honorable Kathy Castor, Ranking Member, Subcommittee on Energy, Committee on Energy and Commerce, United States House of Representatives

The Honorable Hal Rogers, Chairman, Subcommittee on Commerce, Justice, Science and Related Agencies, Committee on Appropriations, United States House of Representatives

The Honorable Grace Meng, Ranking Member, Subcommittee on Commerce, Justice, Science and Related Agencies, Committee on Appropriations, United States House of Representatives

The Honorable John Kennedy, Chair, Subcommittee on Energy and Water Development, Committee on Appropriations, United States Senate

The Honorable Patty Murray, Ranking Member, Subcommittee on Energy and Water Development, Committee on Appropriations, United States Senate

The Honorable Chuck Fleischmann, Chairman, Subcommittee on Energy and Water Development, Committee on Appropriations, United States House of Representatives

The Honorable Marcy Kaptur, Ranking Member, Subcommittee on Energy and Water Development, and Related Agencies, Committee on Appropriations, United States House of Representatives

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Mr. Robert Moller, Office Head, Office of the Director/Office of Legislative and Public Affairs, U.S. National Science Foundation

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Dr. Steven Boggs, UC San Diego

Dr. Alyson Brooks (Co-Chair), Rutgers University

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Dr. Lara Arielle Phillips, University of Notre Dame

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Dr. David Trilling, Northern Arizona University

Dr. Anja von der Linden, Stonybrook University

Conflict of Interest Disclosure

The AAAC is an independent advisory committee with members who are scientists working in the field of astronomy and astrophysics. The AAAC is committed to ensuring that our annual report is both fair and balanced. For this reason, it is obligatory to identify and disclose any potential conflicts of interest (COIs) that could influence the perspectives and judgments, whether they be personal or institutional. To maintain the integrity of our analysis and the trust of our audience, the content on each major topic in our report was reviewed and approved by one or more members of the AAAC Committee who have no personal or institutional conflict. Below, we provide a detailed summary of the potential conflicts of interest identified among our members.

Barron: Personal COI: Funded by awards from DOE and NSF, and a member of Cosmic Microwave Background Stage 4 (CMB-S4) collaboration. Institutional COI: Associated with an institution involved in the Next Generation Very Large Array (ngVLA).

Brooks: Personal COI: Funded by awards from both NSF and NASA. Institutional COI: Institution is a member of the LSST Discovery Alliance and the Simons Observatory.

Follette: Personal COI: Project Scientist for the Gemini Planet Imager 2.0 (GPI 2.0) Science Team. Co-Chair, American Astronomical Society Education Committee. Frequent user of NSF and NASA national facilities, and funded by awards from both NSF and NASA. Institutional COI: None.

Lundgren: Personal COI: Funded by awards from NSF and the LSST Discovery Alliance.

Seo: Personal COI: A member of the Dark Energy Spectroscopic Instrument (DESI) collaboration and co-chair of the DESI-II working group within DESI. A Co-I of the Nancy Grace Roman Space Telescope Galaxy Redshift Survey Project Infrastructure Team. Funded by awards from DOE and NASA. Institutional COI: None.

Trilling:

Personal COI: PI of the SNAPs broker, which ingests data from ZTF and LSST. Frequent user of NSF and NASA national facilities, and funded by awards from both NSF and NASA.

Institutional COI: None

By making this disclosure, we hope to ensure that the insights and conclusions presented in the AAAC report are informed by an objective and comprehensive analysis and not influenced by personal or institutional biases.

Astronomy and Astrophysics Advisory Committee Annual Report for 2025-2026

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Summary

The strategic direction of astronomy and astrophysics in the United States is fundamentally shaped by decadal surveys. These consensus reports, produced every ten years by the National Academies, identify the highest-priority scientific questions, describe the missions and facilities required to answer them, and examine the health of critical foundations that enable scientific progress, from investments in theory to broad support for workforce development efforts. The Astronomy and Astrophysics Advisory Committee (AAAC) is a statutory committee tasked with assessing and advising on the implementation of decadal priorities across the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF). This is accomplished through meetings where the committee interfaces with stakeholders and staff at the agencies, especially those within the divisions of the agencies most active in carrying out decadal priorities: the DOE Office of Science, Office of High Energy Physics; NASA's Astrophysics Division; and NSF's Section of Astronomical Sciences. The committee issues a report each year based on material presented in these meetings and other public information, with findings and recommendations related to interagency coordination and progress towards decadal priorities.

This year's report is organized into five sections:

1. **Agency and Science Highlights:** Updates on activities at and across DOE, NASA, and NSF, along with highlights of scientific discoveries in the past year
2. **Workforce Development:** A report on developments of the past year that impact the training of the future STEM workforce powered by astronomers, astrophysicists and educators
3. **State of the Profession:** An assessment of the dramatic changes to the research funding landscape in the past year, and its impacts on professional astronomers and scientific leadership
4. **Updates on Major Facilities for Astronomy and Astrophysics:** Progress reports on flagship projects, including the beginning of operations with the Rubin Observatory, and the slow and sometimes halting progress of the facilities prioritized in *Astro2020*
5. **Cross-Cutting Decadal Priorities:** Reviews of progress in areas of high priority and activity for astronomy and astrophysics that also extend far into other fields, including artificial intelligence, protection of dark and quiet skies, time domain and multi-messenger astrophysics, and laboratory astrophysics

This document reports on progress towards the priorities of the most recent decadal survey, Pathways to Discovery in Astronomy and Astrophysics for the 2020s, *Astro2020*, as we prepare for the mid-decadal assessment. With this timing, we point to this process as the path to engage the community in areas of significant disruption since *Astro2020*, from the cancellation of CMB-S4 to the dramatic increase in capabilities and usage of artificial intelligence tools. Recommendations throughout this report are aimed at the astronomical community and the agencies to work together in the mid-decadal to determine the best path forward.

This report also serves to document the roller coaster of the past year for the astronomical community. While flat budgets and rising facilities costs have long been a concern, steep budget cuts threatened even minor investments with outsized impact like NASA's ballooning program and NSF's Research Experience for Undergraduates (REU) program. Even with science budgets stabilized by the

passage of the January 2026 CJS Minibus, the long-standing processes and programs that produce high-quality science and highly trained scientists are still under threat, along with the future of major facilities for astronomical discovery. These challenging topics are covered in Section 2 on Workforce Development, Section 3 on the State of the Profession, and Section 4 on Major Facilities for Astronomy and Astrophysics.

Our report concludes with Section 5, which covers important cross-cutting areas of activity where astronomers and astrophysicists bring valuable expertise to address current challenges and opportunities. These are areas where the primary needs are better coordination, both within and between agencies and disciplines, which can require Congressional action to fully facilitate.

Our committee emphasizes the need for a renewed commitment to the strategic vision outlined by *Astro2020*, and a rigorous reassessment of priorities in the mid-decadal, to ensure the continued excellence of the U.S. astronomical enterprise. Global leadership in astronomy and astrophysics is at risk, and maintaining it will require not just funding stability but growth, protection of the scientific merit review process, and commitments to sustaining the educational pathways that make up the STEM workforce pipeline.

1. Agency and Science Highlights

1.1. Interagency Highlights

An important highlight of the past year was the successful completion of the joint NSF-DOE Vera C. Rubin Observatory. This major facility was first conceived in 1995, and was the top-ranked large ground-based project in the 2010 Decadal Survey. Construction began in 2014 and was completed in October 2025. Rubin presented two of its first science-grade images to the public at its “First Look” event on June 23rd, 2025, demonstrating the spectacular capabilities of the observatory. The Observatory recently started its “Alert Stream”, sending out millions of notifications of all transient events per night, and is about to commence the Legacy Survey of Space and Time (LSST), creating a 10-year movie of the entire southern night sky. The Observatory and its leadership have received broad recognition, including being recognized as one of the Best Inventions of 2025 by Time Magazine, and the project’s Chief Scientist Tony Tyson being named to Nature’s 10 (December 8, 2025). Further details on this major facility coming online are given in Section 4, Updates on Major Facilities for Astronomy and Astrophysics.

An important area of interagency collaboration in astronomy and astrophysics is in the Antarctic, where NSF’s Office of Polar Programs (OPP) supports all science activities. The 2025/2026 Long Duration Balloon Antarctica Campaign had successful flights by two science payloads (GAPS, PUEO, described further in Section 3.2), as well as two calibration sondes, HiCal A and HiCal B. Another science payload, GUSTO, was recovered from the ice two years after its flight. These NASA missions relied on the unique conditions of flights above Antarctica, including its exceptionally deep ice sheet, and their flights and recovery relied on the infrastructure and resources supported by NSF OPP, including Arctic Trucks that can traverse routes inaccessible to fixed wing aircraft.

Another exciting interagency collaboration is LuSEE-Night, a partnership between DOE’s Brookhaven National Lab, UC Berkeley’s Space Sciences Laboratory, and NASA’s Science Mission Directorate. This pathfinder is a radio spectrometer to be installed in the radio-quiet Shielded Zone of the Moon (SZM). The instrument aims to impose the tightest constraints on the Dark Ages of the Universe,

before the emergence of the first stars. LuSEE-Night is also indirectly supported by NSF through their Electromagnetic Spectrum Management Coordination group, which continues to work to protect spectrum access for radio astronomy in the Shielded Zone of the Moon. The instrument successfully completed environmental testing at Space Dynamics Lab in Utah and was delivered to Firefly Aerospace last November in 2025, preparing for launch in early 2027. Firefly is contracted under the NASA Commercial Lunar Payload Services (CLPS) program to deliver an orbiter and two surface payloads to the moon.

On January 22, 2026, the NSF-DOE Dark Energy Survey marked its completion with the release of its final cosmology results, based on its six-year imaging survey of galaxies and supernovae conducted on NSF NOIRLab's Blanco Telescope at Cerro Tololo in Chile. These results mark the first time that all four DES cosmological probes were combined. The DES data are fully public, marking a treasure trove of data for a broad range of science investigations. These results are highlighted further in Section 1.5.4.

1.2. NASA Astrophysics Division

While the future of NASA and many of its missions were highly uncertain in 2025, the enacted FY26 budget maintained NASA's ability to continue to pursue cutting-edge astronomy and astrophysics research across all wavelengths. A major upcoming milestone for NASA is the launch of the next major astrophysics flagship mission, the Nancy Grace Roman Space Telescope. More details on this upcoming launch are described in Section 4, Updates on Major Facilities for Astronomy and Astrophysics. Here we describe the exciting progress made on numerous other missions that NASA Astrophysics supports.

NASA's new SPHEREx (Spectro-Photometer for the History of the Universe, Epoch of Reionization and Ices Explorer) mission launched in March 2025. SPHEREx has carried out a comprehensive spectrophotometric survey of the entire sky in near infrared light, and will cover the sky three more times in its two-year operations lifetime.¹ This dataset will deepen our understanding of the cosmic dawn, galaxy evolution, and the processes that seed star and planet formation. SPHEREx's infrared spectral maps are fundamentally new data that complement other surveys and will be widely used across astrophysics.

NASA recently marked a significant achievement in its high-altitude scientific programs with the launch of two major balloon-borne missions: PUEO and GAPS. These missions represent a critical frontier in astrophysics, utilizing the unique vantage point of the upper atmosphere to probe the fundamental nature of the Universe. PUEO (Payload for Ultrahigh Energy Observations) is a mission within the NASA Pioneers program designed to investigate the nature and origins of the Universe's highest-energy particles. By detecting ultra-high-energy neutrinos, PUEO aims to identify the sources of these incredibly rare particles, providing a window into the most violent and energetic events in the cosmos. Understanding these "cosmic messengers" allows scientists to map out high-energy phenomena that are otherwise invisible to traditional telescopes. GAPS (General Antiparticle Spectrometer) is a precision instrument designed to search for low-energy cosmic-ray antiprotons and antideuterons, funded through NASA's Astrophysics Research and Analysis (APRA) program. This mission is particularly significant for its potential to provide major constraints on dark matter models. Since antideuterons are rarely produced through standard astrophysical processes, their detection would be a "smoking gun" for dark matter annihilation or decay. Additionally, GAPS aims to shed light on the existence of primordial black holes and improve our broader understanding of how cosmic rays are sourced and propagate through the interstellar medium.

¹ <https://www.jpl.nasa.gov/news/nasas-spherex-observatory-completes-first-cosmic-map-like-no-other>

Together, these balloon-borne missions exemplify NASA's commitment to “smaller and faster” projects that can provide parallel advancements in particle astrophysics and multi-messenger science. The Astrophysics balloon programs were targeted for elimination in the President’s FY26 budget request. The AAAC commends Congress for maintaining funding for balloon experiments, which allow critical science advancements for a cheaper cost.

Additionally, NASA recently launched the first experiments in their Pioneers Program, PUEO and Pandora. PUEO was described above, while Pandora is a small satellite designed to characterize exoplanet atmospheres and their host stars. The Pioneers Program, started in 2020, is intended to carry out compelling astrophysics science at a lower cost and using smaller hardware than missions in the Explorers Program. Current Pioneers missions include SmallSats, major Balloon payloads, and modest payloads attached to the International Space Station with a \$20M cost cap.²

1.3. NSF Section of Astronomical Sciences

The National Science Foundation (NSF) maintains its essential position in cultivating the country’s scientific talent pool. Through a combination of research fellowships, support for hands-on experiential training, facility and technology development, and grants for independent investigators, the NSF remains a primary engine for progress in astronomy and astrophysics, ensuring a steady pipeline of emerging researchers. The agency has notably expanded its commitment to the field over the last few years by funding major initiatives at the intersection of astronomy and astrophysics and artificial intelligence (AI), focusing on technological innovation and specialized professional development.

Modeling public–private partnership, the NSF has joined with the Simons Foundation to make significant investments in advancing AI and machine learning in astronomy and astrophysics. Their two \$20 million NSF–Simons AI Institutes, with equal funding from each partner, support cutting-edge, big-data astronomical research while also strengthening education and workforce development in this rapidly evolving field. The first of these centers, the Artificial Intelligence Institute for Cosmic Origins (CosmicAI), is researching the trustworthiness, efficiency, interpretability, and robustness of AI methods and filling an urgent need for formal, advanced AI training by developing a graduate certificate in Astrophysics-AI/ML in partnership with the University of Texas at Austin. The second center, the National AI Institute for the Sky (SkAI), is focused on advancing the AI technologies needed to maximize scientific discovery from the Rubin Observatory’s Legacy Survey of Space and Time (LSST) and other vast optical and near-infrared surveys.

NSF continues to sustain a vibrant, productive ecosystem of world-class astronomical facilities to meet the evolving needs of the research community. Through its stewardship of the National Radio Astronomy Observatory (NRAO), the National Solar Observatory (NSO), and the National Optical-Infrared Astronomy Research Laboratory (NOIRLab), NSF ensures broad public access to globally leading radio, solar, and optical-infrared observatories, along with the data infrastructure that enables cutting-edge discovery.

As the NSF-DOE Vera C. Rubin Observatory marked a major milestone with its construction completion, new instrumentation at other NSF-managed observatories has been developed to meet the need for spectroscopic follow-up of the millions of transients Rubin will detect. At the Southern Astrophysical Research (SOAR) Observatory at Cerro Pachon, Chile, a new high-resolution spectrometer, STELES, will be available beginning in late 2026, with additional capabilities forthcoming through the

² <https://science.nasa.gov/astrophysics/programs/astrophysics-pioneers/>

SAMOS adaptive optics multi-object spectrograph. At NSF’s International Gemini Observatory, integration and testing are underway for SCORPIO, an eight-channel optical/infrared imager and spectrograph designed specifically to efficiently characterize astronomical transients.

The Atacama Large Millimeter/submillimeter Array (ALMA) exceeded its Cycle 11 goal of 4,300 observing hours by delivering 4,500 hours, reflecting strong community demand. Meanwhile, Daniel K. Inouye Solar Telescope (DKIST) is advancing new capabilities with the addition of a Visible Tunable Filter, as Cycle 4 begins in March 2026.

1.4. DOE Office of Science, Office Of High Energy Physics

As the largest federal funder of fundamental research in the physical sciences, the Department of Energy (DOE) carries out much of its basic research at the ten Office of Science run DOE national research laboratories. The High Energy Physics (HEP) Cosmic Frontier subprogram pursues strategic plans aligned with discovery opportunities on cosmic acceleration, dark matter searches, neutrino properties, and new physics. A major accomplishment for DOE in 2025 was the transition to operations with the NSF-DOE Vera C. Rubin Observatory, as it prepares to begin its Legacy Survey of Space and Time (LSST). DOE built Rubin Observatory’s camera, LSSTCam, the largest digital camera ever constructed (3.2 Gigapixels), and is supporting Rubin Operations as well as the LSST Dark Energy Science Collaboration (DESC). Rubin Observatory is discussed in detail in Section 4, Updates on Major Facilities for Astronomy and Astrophysics.

A major announcement from the DOE was the Genesis Mission, launched in November 2025 and led by the DOE, which is a national effort to revolutionize scientific discovery through the power of artificial intelligence (AI). In February 2026, The DOE announced 26 Genesis Mission Science and Technology challenges. This includes “Unifying Physics from Quarks to the Cosmos,” which challenges teams to build AI reasoning models at an “unprecedented scale,” taking in experimental data along with theoretical knowledge, to accelerate discovery. The launch of Genesis presents a unique opportunity to address the data deluge from large-area sky surveys such as LSST, Euclid, DESI, and Roman. While the current DOE projects in the Cosmic Frontier, DESI and LSST DESC, already have a strong track record of developing AI/ML tools for the analysis of survey datasets, Genesis will significantly boost these efforts across all Cosmic Frontier projects, resulting in an accelerated pace of discovery and enabling a broader range of “Big Data” analyses not possible conventionally.

The Dark Energy Spectroscopic Instrument (DESI) is the world’s leading wide-field spectroscopic survey facility. Led and primarily funded by the U.S. Department of Energy, with Lawrence Berkeley National Laboratory (LBNL) as the lead laboratory, DESI operates on NSF’s Mayall 4-meter Telescope. In March 2025, the collaboration released the largest-ever public catalog of extragalactic redshifts, comprising more than 14 million galaxies/quasars observed during its first year. Following the first-year cosmology results in 2024, the collaboration released the three-year science results in March 2025. The original 5-year dark- and bright-time survey is nearing completion, on schedule and under budget, and has received a DOE Excellence Award. DESI operations have now been extended through 2028, expanding the footprint by 20% with substantially more overlap with Rubin LSST and CMB observations. DESI has already begun spectroscopic follow-up on Rubin LSST identified transients.

Building on the success of DESI, the community- and collaboration-proposed instrumentation upgrade and subsequent six-year DESI-II survey program (2029-2035) to study dark energy in the matter-dominated regime ($z > 2$), recommended by the 2023 High Energy Physics Advisory Panel’s P5

report,³ is under consideration by DOE. The survey will continue operations at the DESI facility at Kitt Peak, with targeted instrument upgrades, and will push program boundaries by tightening cosmological constraints, extending to earlier cosmic epochs and to higher density, advancing dark matter science, and enhancing synergies with Rubin Observatory.

In July 2025, DOE and NSF jointly decided not to continue to support CMB-S4, despite its designation as the top new priority in the 2023 P5 report. DOE HEP continues to support the South Pole Telescope and its latest SPT-3G instrument. SPT-3G (in partnership with NSF) has continued to operate with excellent, high observing efficiency and stable instrument performance. The 6-year main Survey (1500 square degrees of the sky) has been completed, and Y7 is scheduled to start in March 2026. HEP recently supported a major upgrade with the fabrication of the 16,000-detector focal plane, and is providing operations funding. With the cancellation of CMB-S4, DOE HEP has expanded its portfolio of cosmic microwave background science with research support for BICEP within the South Pole Observatory, and Simons Observatory. These telescopes aim at detecting gravitational waves from the inflationary era to directly confirm or refute the Λ CDM model of the Universe, though they will not achieve the same constraints that CMB-S4 would have enabled, as discussed in Section 4, Updates on Major Facilities for Astronomy and Astrophysics.

1.5. Science Highlights

1.5.1. Studying an Interstellar Visitor, 3I/ATLAS

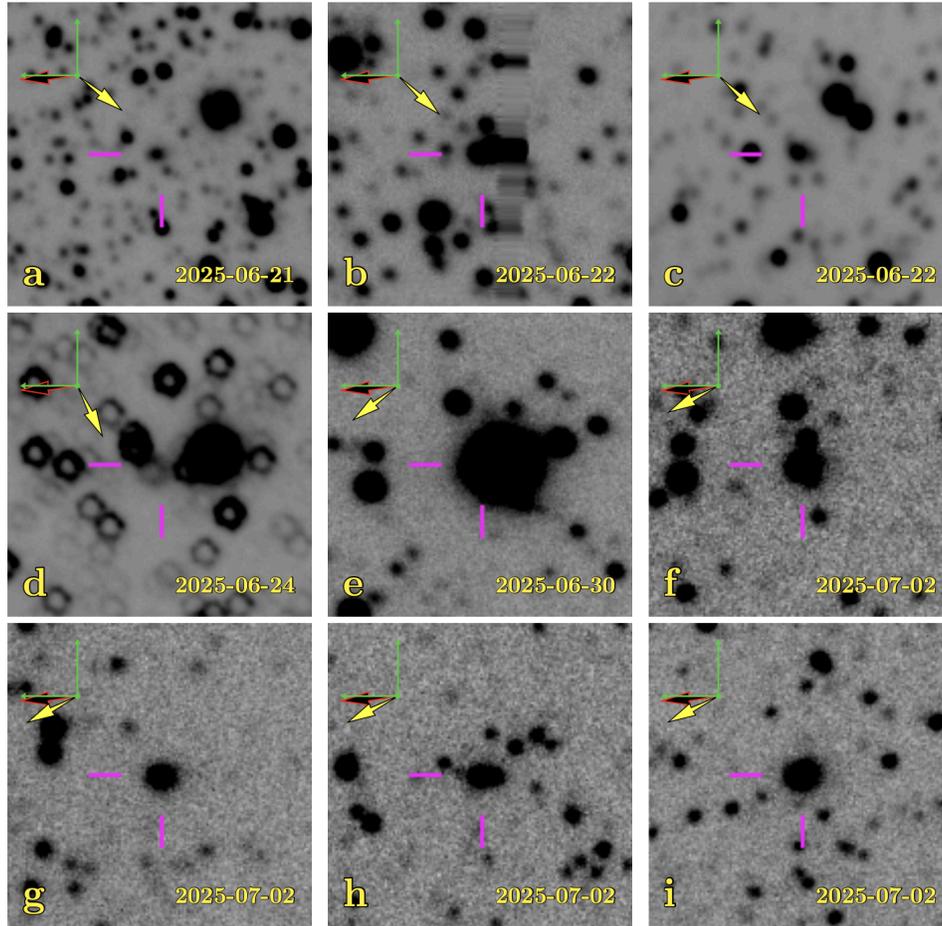
One of the biggest astronomical news stories of the year was the discovery of object 3I/ATLAS on July 1, 2025, by the ATLAS survey. It was also serendipitously observed by the Rubin Observatory in its commissioning phase⁴ (see figure below). 3I/ATLAS was confirmed as an interstellar object, only the third such body ever observed in our solar system. Its highly hyperbolic trajectory shows it is passing through and will leave the solar system, offering a once-in-a-lifetime opportunity for close-up study before it departs forever. NASA's observatories (including Hubble, JWST, and SPHEREx) have observed the object's size, composition, and physical characteristics, providing crucial insights into material originating from other star systems. Follow-up spectroscopic studies with JWST revealed an unusual mixture of volatile ices and gases, especially an enhanced CO₂/H₂O ratio, suggesting conditions in its origin environment or long exposure to cosmic radiation. Observations of this interstellar visitor help scientists learn how other planetary systems form and evolve, and whether their building blocks differ significantly from those in our solar system.

The below images show the interstellar object 3I/ATLAS obtained by the Vera C. Rubin Observatory in mid-2025. All images are 30"×30" and have been reprojected so that North appears up, and East to the left (green arrows). The anti-solar (yellow, black-outlined arrow) and anti-motion (black, red-outlined arrow) directions are indicated. By good fortune, 3I/ATLAS appeared serendipitously in these early Rubin images, providing both an opportunity for early Rubin science and a real-world test of

³ <https://www.usparticlephysics.org/2023-p5-report/index.html>

⁴ <https://arxiv.org/abs/2507.13409>

Rubin image processing and Solar System object observations. This figure is from Chandler et al. (2026, in press)⁵ – one of the first papers to report science results from Rubin.

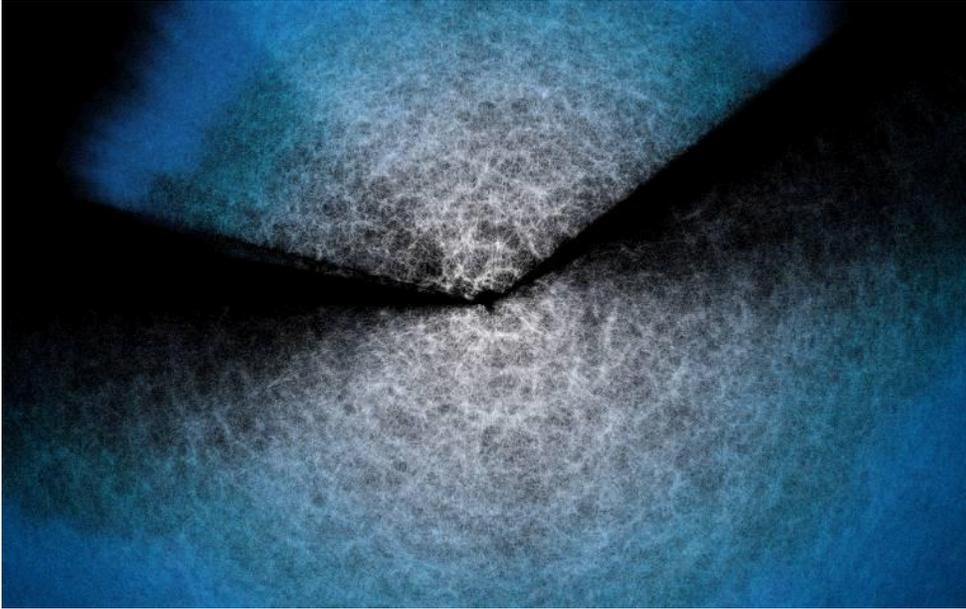


1.5.2. Precise 3D Maps of the Universe with DESI

In March 2025, the Dark Energy Spectroscopic Instrument (DESI) released cosmological results from its second data release (DR2), based on three years of observations. By detecting baryon acoustic oscillations in a three-dimensional map of 14 million galaxies, quasars, and Lyman-alpha absorbers, DESI delivered the most precise measurement to date of the cosmic expansion history over 11 billion years of cosmic time. Among its many significant findings, the collaboration's latest analysis⁶ confirmed and strengthened its 2024 result, indicating a strong hint of dynamical dark energy, continuing to challenge the standard Λ CDM cosmological model. To date, the collaboration has published over 800 papers and recently received the Lancelot M. Berkeley-New York Community Trust Prize at the 2026 January AAS meeting. Its results have generated 1,522 press articles in 35 languages, and its flagship cosmology publications in 2024 and 2025 rank among the most cited High Energy Physics papers of those years.

⁵ <https://arxiv.org/pdf/2507.13409>

⁶ <https://journals.aps.org/prd/abstract/10.1103/tr6y-kpc6>



The above image shows a slice through the 3D map generated using precise distances to 15 million galaxies and quasars from three years of the DESI data. The Earth is at the center of the fan-shaped detections. The “cosmic web,” the filamentary structure created by galaxies in our Universe, is obvious in this map. (Credit: DESI collaboration and KPNO/NOIRLab/NSF/AURA/R. Proctor)

1.5.3. Constraining Cosmic Evolution with DES

The Dark Energy Survey (DES) collaboration released its final cosmology results on January 22, 2026, summarizing its six-year imaging survey of galaxies and supernovae⁷. For the first time, the analysis combined all four DES cosmological probes, delivering some of the tightest constraints to date on the growth of cosmic structure and the expansion history of the Universe. The results test the time dependence of dark energy and find consistency with the standard Λ CDM model within the constant equation-of-state extension, in agreement with DESI. An upcoming release will explore more general dynamical dark energy models to further test potential deviations from Λ CDM, as suggested by DESI.

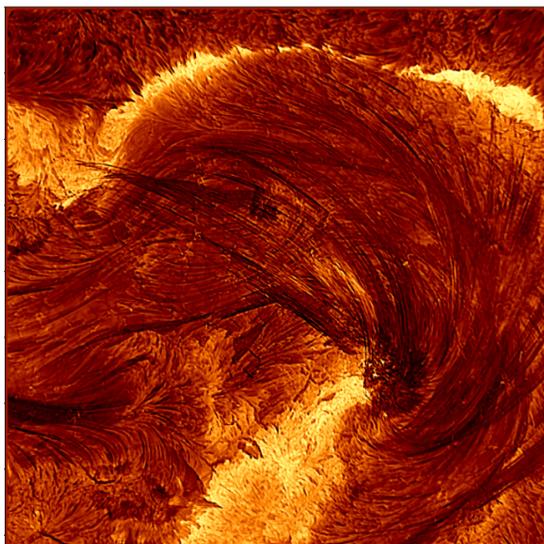
1.5.4. Imaging a Nearby Exoplanet with JWST

Using the James Webb Space Telescope (JWST), astronomers and astrophysicists have obtained the strongest evidence yet of a candidate giant exoplanet orbiting Alpha Centauri A, the nearest Sun-like star roughly four light-years away from Earth. Observations from JWST’s Mid-Infrared Instrument sought to block out the glare of the bright star and revealed a faint source that may be a gas giant with a mass comparable to Saturn at a separation roughly twice Earth’s distance from the Sun. If confirmed, this would be the closest exoplanet directly imaged around a Sun-like star and a major step forward for exoplanet imaging. It would offer an unprecedented opportunity for detailed atmospheric characterization

⁷ <https://www.darkenergysurvey.org/des-y6-cosmology-results-papers/>

and dynamical study. Such a world in the nearest stellar system would serve as a prime target for future telescopes and missions seeking to understand planetary system architectures and habitability.

1.5.5. Observing an X-Class Solar Flare with DKIST

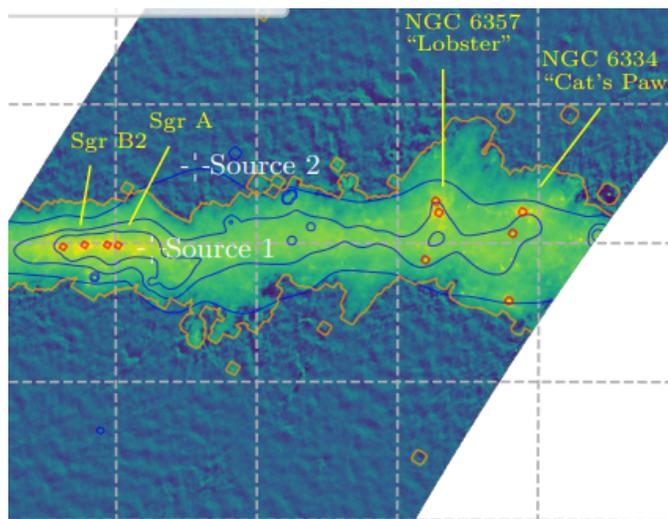


In August of 2024 the Daniel K. Inouye Solar Telescope (DKIST) made its first observations of a large solar flare (shown at left) – its first flare in the highest flare class: X. After a thorough analysis of this ground-breaking data, a team from the National Solar Observatory and the University of Colorado discovered flare emission from magnetic loops as narrow as 24 km (15 miles). Magnetic fields have been known to power solar flares, and it has recently become clear that the magnetic processes at work might be occurring at small spatial scales. These new observations, and the scientific analysis they enabled, confirm the workings of processes on extremely small spatial scales – indeed smaller than ever before observed. The observation also demonstrates the capability of DKIST to obtain

measurements at the limits of its design, and to make them rapidly enough to capture the extremely dynamic phenomena present in solar flares.

1.5.6. Characterizing our Universe with the South Pole Telescope

In June 2025, the South Pole Telescope collaboration released cosmology results from Data Set 1 of their third generation instrument, SPT-3G, supported in partnership between DOE and NSF. This analysis of CMB temperature and E-mode polarization demonstrated the strong constraining power of ground-based CMB experiments and, in combination with ACT, achieved precision surpassing that of the Planck satellite⁸. The release also reported the discovery of energetic, short-lived stellar flares near the center of the Milky Way from two known accreting white dwarf systems (shown at right)⁹, highlighting the capability of wide-field millimeter surveys to capture rare and extreme transient events.



⁸ <https://arxiv.org/abs/2506.20707>

⁹ <https://arxiv.org/abs/2509.08962>

2. Workforce Development

Astronomy acts as a “gateway” to science, leveraging natural curiosity about the night sky to inspire and motivate students to pursue STEM careers. Educational efforts in astronomy and astrophysics range from public engagement and outreach to formal graduate education in highly valued technical skills. Introductory astronomy courses reach hundreds of thousands of students each year at universities and community colleges. The number of college students majoring in astrophysics has seen record growth over the last twenty-five years, with 500% growth in the number of bachelor’s degrees conferred. Recent years have continued this trend: In the 2023-24 academic year, U.S. institutions awarded 982 astronomy/astrophysics bachelor’s degrees, the highest number on record.¹⁰ Roughly half of those students go on to seek advanced degrees, with 30% entering physics or astronomy graduate programs and the other 20% pursuing fields like engineering or law, and the other half entering the workforce.

Astronomy and astrophysics majors develop strong transferable skills in computing, data analysis, and problem-solving, leading to careers in data science, software engineering, aerospace, and education.^{11,12} Many astronomy and astrophysics programs have developed more flexible curriculum pathways, allowing more students with a variety of academic backgrounds to complete a high-level STEM degree. Astronomy and astrophysics students also regularly use AI, and a number of majors are going into the field of AI development.¹³

However, this pipeline bringing students into the STEM workforce is in jeopardy. As outlined below, we may be facing a situation where the U.S. is ceding its leadership role in this science field, and reducing the overall number of technically-advanced workers that it is training.

Finding: The suspension and postponement of federal science funding initiatives have adversely affected the professional growth and instruction of entry-level researchers. These disruptions have specifically curtailed the availability of summer research internships, which serve as an essential cornerstone for the development of STEM undergraduates.¹⁴ Given the limited timeframe in which these students are eligible to participate, such missed opportunities represent a significant loss in their foundational career training.

Finding: A survey of the astronomy and astrophysics workforce conducted by the American Astronomical Society (AAS) in 2025 identified a key concern in the field to be the disruption of education funding for research experiences for undergraduates (REUs) which could imperil the pipeline of excellent American undergraduate students into the field. This could disproportionately impact American students from institutions with more limited local access to research.

Finding: As of this writing, review of REU site proposals at NSF has been completed. However, no new awards can be made until the budget process is final, which is a minimum of 30 days after the appropriations bill was finalized in January. Since the timeline for REU applications is usually in mid- to

¹⁰ <https://aip.brightspotcdn.com/a8/d3/b1eeca3047aba3a542f79ed06df4/astroster-24.pdf>

¹¹

<https://www.aip.org/statistics/scientific-and-technical-knowledge-and-skills-used-by-exiting-physics-masters-degree-recipients-from-academic-years-2021-22-2022-23-and-2023-24>

¹²

<https://www.aip.org/statistics/interpersonal-and-management-skills-used-by-exiting-physics-masters-degree-recipients-from-academic-years-2021-22-2022-23-and-2023-24>

¹³ <https://www.aps.org/apsnews/2025/09/aip-report-recent-grads-ai>

¹⁴ <https://www.aip.org/fyi/funding-cuts-hit-stem-career-pipelines>

late-January, with placements finalized in March, it may not be possible for REUs to be spun up in time for summer 2026, reducing the number of opportunities available.

Finding: A similar situation applies to the NSF Astronomy and Astrophysics Postdoctoral Fellowship. While the consensus in astronomy and astrophysics is to make postdoctoral offers by Feb 15, the delay due to budget finalizations means that no offers have yet been made.

Finding: The NSF Graduate Research Fellowship Program (GRFP) made a last-minute change in its delayed call this past year that essentially froze out a whole year of graduate students for funding by eliminating eligibility for 2nd year Ph.D. students without prior warning.

Finding: As of this writing, the solicitation for the NASA FINESST graduate fellowship has not been announced. The deadline has generally been in February annually. Given the delay, it is likely that at least one academic year will lapse without FINESST support.

Finding: The NSF EDU directorate will have its budget cut by 20% in FY26. This directorate funds numerous impactful programs supporting educational pathways into astronomy and astrophysics, including the GRFP. It also funds STEM education research, a vibrant and essential research discipline that supports improvement and innovation in astronomy education, research mentorship, and public outreach. Cuts to EDU directorate can be expected to lead to even less support for graduate students and STEM education researchers.

Finding: The DOE's Office of Science supports workforce development through its Workforce Development for Teachers and Scientists (WDTS) program. This includes Science Undergraduate Laboratory Internships (SULI), Community College Internships (CCI), and the Office of Science Graduate Student Research (SCGSR) programs. The President's Budget Request would have reduced the WDTS budget by 20%, but the final enacted FY26 budget included \$32 million for these programs, a slight increase above FY25.

Recommendation WD.1: The agencies should prioritize stabilizing and sustaining funding initiatives that support and broaden the pool of early-career astronomers and astrophysicists, including bridge programs, REUs, and graduate and postdoctoral fellowships, to foster the next generation of innovative leaders in the field.

Recommendation WD.2: The agencies should consider consistently aligning the application and selection timelines with student timelines so that opportunities have maximal impact. For example, the last call for the NASA FINESST fellowship had a start of funding on Nov 1, not aligned with the start of the academic year. Likewise, awarding of REU sites early in the calendar year, as has traditionally been done, makes it difficult to start or continue an REU program that year given the work required to get the program going, advertise, recruit, and make offers.

Recommendation WD.3: Congress could protect workforce development programs by appropriating specific levels of funding to such programs in order to ensure consistent availability to students.

Overall, large-scale continued uncertainty in funding and funding cycles will have significant impact on the astrophysics community's ability to carry out projects of various scales, and will have a particularly acute negative impact on junior members of the community. As discussed in the next section, funding uncertainty leads to a situation where academic departments are unable to support the numbers of students that they have historically, reducing their ability to admit and train graduate students. Early-career researchers may leave the field (or never join) if opportunities to support them do not exist, or the uncertainties of funding are so great as to outweigh the excitement of working in our field. Thus, even just a few years of unpredictability may have a generational impact on the astronomy and astrophysics community.

3. State of the Profession

The astronomy and astrophysics profession entered 2025 facing a period of unprecedented uncertainty, reflected in our committee's 2025 report. That uncertainty turned into an existential crisis once dramatic cuts were proposed to the budgets of all three science agencies, threatening to upend careers and mothball astronomy's premier observational facilities. This short period of extreme uncertainty wrought havoc on long-term planning, forcing universities and national laboratories to cut admissions, freeze hiring, pause critical research efforts, and brace for budget "triage." The eventual passage of the January 2026 CJS Minibus was a testament to the longstanding bipartisan recognition of science as a cornerstone of national competitiveness. Congress was able to deliver a full, enacted budget that ensured stable funding to NSF, NASA, DOE, and other science agencies, and stopped the cycle of continuing resolutions without clear guidance.

However, the restoration of funding for FY2026 did not repair the damage inflicted during the preceding months of reorganization and instability. Highly specialized teams have fragmented, long-term international partnerships have been strained, and a generation of students and early-career researchers have been shaken by the sudden precariousness of the field. Moreover, while top-line budgets have been restored, the overall funding levels decreased at NSF and NASA by a few percent. Reductions that do not keep pace with inflation create an untenable situation for maintaining workforce development and achieving the vision of U.S. astrophysics leadership outlined in *Astro2020*.

Finding: There is ongoing reorganization, adjustment, and postponement of solicitations for grant proposals. This is immediately obvious in the delay of ROSES-26 by NASA, but the National Science Board (NSB) has also announced that there will be at least a 50% reduction in the number of NSF solicitations agency-wide. These developments have introduced significant instability for researchers currently managing or drafting proposals, causing logistical interruptions that impede their ability to organize long-term projects and execute their scientific goals effectively.

Finding: New post-review notifications to comply with executive orders are slowing the process from review panels to selection of awards for NASA ROSES.

Finding: Reflecting these funding stability concerns by faculty and department chairs, admissions to graduate programs in physics and astronomy saw a reduction of almost 10% for fall 2025.¹⁵

¹⁵ <https://www.aip.org/statistics/estimated-decline-in-new-graduate-physics-program-enrollments-fall-2025>

Finding: While the admissions process is currently ongoing at the time of this report writing, evidence from this year suggests that graduate admissions will be significantly reduced for fall 2026 as well. A survey conducted by the American Astronomical Society found that many programs are aiming for a reduced class size, and some programs have even cancelled admissions entirely.¹⁶

Finding: The decadal survey placed an emphasis on expanding funding for individual research grants, recognizing their fundamental importance to scientific breakthroughs. However, federal agencies have not yet fully realized this objective.

Finding: Federal immigration actions are imperiling the astronomy and astrophysics community's ability to recruit international talent to U.S. higher-education, postdoc, and faculty positions. This could impact the U.S.'s continued pre-eminence in the field.

Finding: The number of staff at NSF has decreased by over 30% in the past year, the most significant job losses of any science agency.¹⁷ Additionally, key astronomy personnel have been on extended administrative leave, overburdening other staff less specialized for those roles and straining the management of major investments including Rubin Observatory. A survey of the astronomy and astrophysics workforce conducted by the American Astronomical Society found the reduction of staff at key agencies that service the community to be a major concern.

Finding: A planned 50% reduction in agency-wide solicitations announced by NSF leadership at the February 25, 2026¹⁸ meeting of the National Science Board aims to increase efficiency and reduce complexity at the agency. Fewer distinct funding lines could reduce the administrative burden on program officers, many of whom must currently manage, publicize, and respond to inquiries for multiple separate solicitations.

Comment: While the reduction in solicitations has a goal of reducing complexity at NSF, broadening the scope of the remaining programs may introduce a different challenge: evaluating and selecting among a more heterogeneous and less directly comparable pool of proposals. Narrowing the range of supported projects could also limit opportunities for innovation, and make the field more vulnerable to the failure or underperformance of a small range of award types. By contrast, the current diversity of solicitations within the directorates sustains a broad spectrum of approaches and investigators, aligning with the wide-ranging goals of the U.S. astronomy and astrophysics community, as articulated in *Astro2020*.

Finding: A decision was made to relocate the NSF from their headquarters in Alexandria, VA, and the agency has operated on a fully remote basis since December 12, 2025. The previous NSF headquarters were completed in 2017 and were purpose-built to support the management of NSF's programs, including rooms for the numerous panel meetings necessary to carry out their mission, and areas with robust security procedures. A return-to-office date at the new NSF headquarters on the U.S. Patent and Trademark Office campus has not been set.

¹⁶

https://docs.google.com/spreadsheets/d/1n4ZCoZpJ44TID_jnQFICJ5d4PXVYh36ce6ZQqCoVo_E/edit?gid=0#gid=0

¹⁷ <https://www.aip.org/fyi/federal-science-workforce-declines-sharply-under-trump?mcid=8544d52c91>

¹⁸ <https://www.nsf.gov/nsb/updates/national-science-board-meets-february-25-washington-dc>

Comment: Scientific leadership and stewardship depend on sustained communication, informal exchange of ideas, and close collaboration among program officers and staff. The extended absence of shared physical space limits opportunities for spontaneous consultation, cross-disciplinary coordination, and the relationship-building that underpins effective program management and are essential to NSF’s mission.

Finding: While the top-line NSF budget remained relatively flat in the FY26 enacted budget, the Agency Operations and Award Management budget was cut by 20%.

Finding: In December 2025, NSF leadership announced significant changes to the agency’s merit review process, citing the need for additional flexibility in light of staffing reductions and time lost during the government shutdown. Although the guidance affirms that “external review is a tenet of Gold Standard Science,” the NSF Proposal and Award Policies and Procedures Guide has now been amended to allow “an internal review [to] substitute for one of the two required [external] reviews,” – with three reviews being the previous minimum standard. The rule change is based on the premise that NSF Program Officers generally possess the technical knowledge and expertise necessary to make unilateral funding recommendations; however, fewer than 60% of NSF staff surveyed in the National Science Board’s 2025 report on Merit Review agreed that NSF staff “represent a sufficiently representative range of individual and institutional characteristics to achieve the goals of the Merit Review process.”¹⁹ Moreover, a survey conducted by the American Astronomical Society found the prospect of the minimization of scientific expertise in decision making to be a concern of the astronomy and astrophysics workforce.

Recommendation SoP.1: In-person panels composed of external reviewers remain the most effective and efficient mechanism for ensuring the rigor and integrity of the NSF’s merit review process. As NSF works to recover to normal operations, it should prioritize a return to normal review panel processes as well.

Recommendation SoP.2: Reducing the role of external reviewers places a greater burden of responsibility on a shrinking pool of Program Officers at NSF, narrows the range of scientific perspectives brought to bear on funding decisions, and introduces opportunities for individual bias in proposal evaluation. Astronomy spans a wide array of subfields, from theory and instrumentation to laboratory astrophysics and data-intensive observational surveys, each with distinct methodologies and rapidly evolving frontiers. Diminishing the breadth of expertise in the review process could inadvertently overlook emerging areas and destabilize progress across a field whose strength depends on rigorous evaluation by such a wide range of expert practitioners. The AAAC concurs with the 2025 National Science Board report on Merit Review, which urged NSF to engage more, not fewer, outside experts who can provide “a wider range of perspectives and expertise” to identify the most compelling scientific questions.

Recommendation SoP.3: Congress should work to restore agency budgets that at minimum keep pace with inflation to avoid overall shrinking of programs that have ensured scientific excellence, but optimally work to achieve the goals outlined in *Astro2020* to maintain U.S. leadership in astronomy and astrophysics.

¹⁹ <https://nsf.gov-resources.nsf.gov/files/Merit-Review-Changing-Landscape-2025.pdf>

Recommendation SoP.4: Since it is clear that the agencies will continue to face reorganization of grant solicitations, they should work to ensure (1) that a broad range of science is supported and (2) that gap years in funding are not introduced. Even a lapse of funding for a single year has detrimental consequences on support for junior researchers that can impact the field for years or decades.

Recommendation SoP.5: Exacerbating the dramatic reduction in the NSF Astronomy team staffing in the past year is an unusual situation where two senior personnel with key expertise on major facilities have been on extended administrative leave with no updates or timeline for resolution since late 2025. The AAAC recommends that this situation be resolved as quickly as possible to prevent further disruption to the NSF Astronomy team's ability to carry out its mission.

4. Updates on Major Facilities for Astronomy and Astrophysics

Modern astronomy and astrophysics relies on shared national research facilities, and decadal surveys have served as a roadmap for these priorities for decades. These large, strategic investments take the place of funding for numerous individual laboratories and research facilities seen in many other fields of science. In 2026, the U.S. astronomy and astrophysics community is eagerly anticipating a new era of science enabled by strategic, multi-decade investments as two flagship facilities, the Vera C. Rubin Observatory and the Nancy Grace Roman Space Telescope, prepare to carry out definitive surveys of our Universe. These facilities represent the successful realization of previous decadal priorities, poised to deliver unprecedented data on dark energy, dark matter, exoplanets, and the transient sky.

However, as these new facilities come online, progress on many of the next-generation efforts prioritized by *Astro2020* has slowed or stalled. *Astro2020* endorsed the U.S. Extremely Large Telescope (US-ELT) Program as the highest-ranking priority for major facilities projects. The second highest priority puts equal weight toward two other facilities, the Next-Generation Very Large Array (ngVLA) and the Cosmic Microwave Background Stage 4 (CMB-S4), a ground-based cosmic microwave background experiment. While the decadal surveys lay out an ambitious vision that does not always fully come to fruition, we are now facing the situation where multiple mature projects recommended in *Astro2020* may fail to achieve the community's science goals.

Along with the 2018 the National Science Board (NSB) report "Study of Operations and Maintenance Costs for NSF Facilities" (NSB-2018-17),²⁰ *Astro2020* warned that the rising costs of operation and maintenance of new flagship facilities (including ngVLA and Rubin) would threaten the individual research grants that power scientific discovery, unless budgets are increased or a new model for funding facilities operations is developed. At the end of 2025, NSF announced a major agency-wide restructuring that included the creation of a centralized office of the Chief Officer for Research Facilities. Facilities formerly managed under NSF's Division of Astronomical Sciences will be managed by this new office. At the same time, the three Federally Funded Research and Development Centers (FFRDCs) are in the middle of a Portfolio Prioritization Process, developing a "Plan for the 2030s" that will solicit community input. Full details of the NSF re-organization and implications for astronomical facilities and operations budgets are not yet known. The mid-decadal process has excellent timing to give input to NSF

²⁰ <https://nsf.gov-resources.nsf.gov/files/nsb201817.pdf>

on this new organization, and update or emphasize the numerous recommendations from *Astro2020* related to a balanced portfolio.

We also note that of this writing, NASA has paused all activities that would create new financial commitments on 17 science projects. The projects include the Habitable Worlds Observatory Technology Maturation Program, the Chandra X-ray observatory, the Physics of the Cosmos SR&T, and the Astrophysics Probes Future Missions. While these holds, enacted on February 11, were initially set to expire after 10 days, the pause will be extended until signed apportionment is received from OMB. We note that most of these projects were slated for elimination in the President's FY26 Budget Request. The restriction is a new practice, but part of an overall delaying of budget implementations by OMB, according to reporting from Nature.²¹

4.1. Operations Begin with NSF-DOE Vera C. Rubin Observatory

The past year has been momentous for the NSF-DOE Vera C. Rubin Observatory, jointly funded by the U.S. National Science Foundation and the U.S. Department of Energy, Office of Science. Rubin construction was officially completed in late October 2025, marking the successful realization of the top-ranked priority for ground-based facilities in the 2010 Decadal Survey, and exemplifying a successful NSF-DOE partnership.

Even earlier, Rubin celebrated its "First Look" event on June 23rd, 2025, presenting two of its first science-grade images. Demonstrating the spectacular capabilities of the observatory, the event was a tremendous media success, with "watch parties" and news coverage around the world, including five dedicated pages in the New York Times. Multiple news outlets referred to Rubin as the "greatest astronomy discovery machine ever built."

With the transition to the operations phase, Rubin Observatory has been working to fine-tune the instrumentation to consistently deliver the highest image quality possible, anticipating the start of the ambitious Legacy Survey of Space and Time (LSST), which will capture a 10-year timelapse movie of the southern sky by scanning the observable night sky once every three nights, at full resolution. On February 24, 2026, Rubin launched its "Alert Stream", sending out global notifications of all transient events within two minutes of their observation. On the night of Feb. 24th, Rubin sent out 800,000 alerts, a number which is expected to increase to 7 million per night. The full LSST is expected to commence in March or April 2026.

Already, data taken as part of Rubin's commissioning process have led to scientific discoveries and publications. For instance, Rubin discovered 2000 new asteroids, including the fastest spinning main-belt asteroids observed to-date²², and serendipitously observed the interstellar object 3I/ATLAS before its discovery.²³

After more than 20 years of development for this project, it is tremendously exciting to have reached this stage. The entire project, NSF and DOE should be congratulated for bringing us to the cusp of this transformational facility.

²¹ <https://www.nature.com/articles/d41586-026-00601-0>

²² <https://iopscience.iop.org/article/10.3847/2041-8213/ae2a30>

²³ <https://arxiv.org/abs/2507.13409>

4.2. Roman Space Telescope Prepares To Launch

NASA's Nancy Grace Roman Space Telescope, the next major astrophysics flagship mission, has completed integration and assembly of its major systems and is progressing toward launch in Fall 2026, with final testing and launch preparations underway. Teams are on track to meet both schedule and budget targets, an achievement notable given the complexity and scale of the mission. Roman will carry wide-field infrared instruments that can survey large swaths of the sky, enabling transformative studies of dark energy, exoplanets, and the large-scale structure of the Universe. Its wide field of view is over 100 times larger than Hubble's, allowing surveys of billions of galaxies and the discovery of thousands of exoplanets that other telescopes cannot efficiently detect.

Proposals for Cycle 1 of Roman are due on March 17, 2026. Proposals for Roman observations are not similar to those for JWST or other individual investigator observations. Only five calls for proposals are expected during the five year prime mission, and only three of those will solicit new observations. Roman is a unique survey that focuses primarily on community-designed surveys of the sky, and all data is immediately made public. Hence, the Cycle 1 call is bringing together large groups of scientists aiming to optimize the science return of Roman.

4.3. Progress Towards Major Facilities Prioritized in *Astro2020*

4.3.1. Ground Based Facilities

CMB-S4 Next Generation CMB Experiment

In addition to being the second-highest ranked ground-based project in *Astro2020*, the 2023 High Energy Physics Advisory Panel's P5 report²⁴ identified CMB-S4 as the highest priority among new projects. The reports identified observations from both Chile and the South Pole as critical for achieving the outlined science goals, which reinforced the need for CMB-S4 to be a major interagency effort.

Finding: In July 2025, the NSF and DOE announced the cancellation of the CMB-S4 project. This came six years after CMB-S4 received CD-0 status from DOE, which was the official start of the planning and funding for the project, and 12 years after CMB-S4 was first conceived in the 2013 Snowmass process. Before cancellation, approximately \$50 million was spent on design and preliminary engineering work for the CMB-S4 project, funded by NSF and DOE. The effort was led by a project office at Lawrence Berkeley Lab and supported by a collaboration of over 500 scientists and engineers. The major impediment toward achieving the project is the status of infrastructure at NSF's Amundsen-Scott South Pole Station.

Finding: NSF posted a draft of the South Pole Master Plan for comment in the Federal Register in June 2024.²⁵ While a final draft was expected in 2025, it has yet to be announced.

Finding: The current LC-130H fleet provides critical logistical support for the South Pole Station and other polar science activities, but has had rapidly declining reliability after over fifty years in service. The

²⁴ <https://www.usparticlephysics.org/2023-p5-report/index.html>

²⁵ <https://nsf.gov-resources.nsf.gov/files/SPSMP-Fed-Reg-Draft-NSF.pdf>

FY26 Defense Appropriations Act signed into law included funding support for engineering efforts and procurement of one initial LC-130J “ski bird” plane. The bill also includes language directing the Air Force to provide a report within 90 days including “a program schedule that delineates key engineering and production milestones.”

Comment: The AAAC commends Congress for its continuing support of U.S. polar activities, and its funding for the initial “ski bird” plane to recapitalize our polar airlift capacities. The mandated report on the program schedule will be a valuable input to planning of polar scientific activities.

Finding: NSF and DOE continue to support CMB research through other programs. Through continuing support of projects such as the CLASS experiment, and upgrades to existing instruments such as Advanced Simons Observatory (ASO) in Chile, and SPT and BICEP at the South Pole Observatory, progress towards many of the science goals of CMB-S4 can continue.

Finding: The completion of ASO was threatened this past year when NSF’s construction funding (including MSRI-2 funding for ASO) was cut off. NSF’s Major Research Equipment and Facilities Construction (MREFC) account had been finalized as emergency funding in FY24. Under the continuing resolution in FY25, President Trump revoked some of the items listed under the emergency spending, including the MREFC.

Finding: Upgrades of existing instruments cannot achieve the sensitivity and precision that CMB-S4 would have achieved in the search for a signature for primordial gravitational waves from inflation. Near-term progress on inflation science is the primary loss from the cancellation of CMB-S4, as well as the loss of talented early-career students and scientists working on cutting-edge instrumentation and analysis techniques in this field. The reduced capabilities of upgraded instruments compared to CMB-S4 will also reduce the ability to study variability and astrophysical transients at millimeter wavelengths.

Finding: A major feature of CMB-S4 was the platform it provided to bring CMB results together for more powerful joint data analysis for cosmological results, as well as its broad engagement of astronomers and astrophysicists beyond the CMB community in multi-wavelength and transient science. This platform and community engagement are also major losses in the cancellation of CMB-S4 as it is replaced by support for smaller independent projects.

Recommendation CMB-S4.1: Infrastructure upgrades are critical for the U.S. South Pole Station to survive and support current and future scientific endeavors. NSF’s Office of Polar Programs should work to release the updated South Pole Master Plan in a timely fashion, so that the scientific community can have a clear timeline of anticipated infrastructure work and a timeline for the capacity for the station to support current and future scientific projects.

Recommendation CMB-S4.2: Without the enhanced capabilities of CMB-S4, U.S. leadership in CMB science can continue and progress can still be made with continued funding for existing instruments, including upgrades, operations, and analysis. We recommend that the mid-decadal process engage the broader community on the best path forward, including identifying critical gaps left behind in the absence of CMB-S4.

United States Extremely Large Telescope Program (US-ELT)

The ELT program was the top-ranked ground-based major project recommended in *Astro2020*. Two consortia are vying for inclusion in the US-ELT Program: the Giant Magellan Telescope (GMT) and the Thirty Meter Telescope (TMT), both of which seek to construct a 30-m class optical telescope in the coming decade. The GMT is being built at Las Campanas in Chile, and the TMT aims to build on one of two potential sites in the northern hemisphere, either Maunakea in Hawaii or Spain's Canary Islands. A 39-meter aperture European ELT is already under construction in Chile's Atacama Desert, with first light expected in 2029. Without access to facilities of a similar scale in the near and long term, the U.S. astronomy and astrophysics community will be unable to lead discovery in nearly all the key science priorities of *Astro2020*.

Finding: Every committee asked to examine the question has concluded that two telescopes, one in each hemisphere, would maximize the science return of the ELTs and make the U.S. a leader in discovery. ELT access in both hemispheres would maximize support for discoveries from JWST and future space telescopes, the Rubin Observatory, the Square Kilometer Array (SKA), ngVLA, and other emerging science cases. The two-hemisphere approach has been endorsed by all entities that have been asked to evaluate it, including the original decadal, an NSF MPS blue ribbon panel in June 2023, and an external panel in December 2024 that was commissioned by the NSF Director.

Finding: Congress has repeatedly demonstrated support to achieve the US-ELT program, providing \$30 million in FY23, FY24, and FY26 to achieve the decadal priorities, and specifically endorsing the two-hemisphere plan in the FY25 budget requests.

Finding: The GMT was advanced to the NSF's Major Facilities Final Design Phase in June 2025.

Finding: The report accompanying the FY26 appropriations bill states that both US-ELT projects should be advanced to the final design review, but at no cost to the federal government. A plan from NSF is to be submitted to Congress shortly before the submission of this report.

Finding: All activity on Maunakea is paused while the Kuo o Wakea consortium, established by the Maunakea Stewardship and Oversight Authority, determines site capacity and works on a vision for the future.

Finding: The Spanish Ministry of Science has offered €400M to support the construction of TMT in the Canary Islands.²⁶

Recommendation ELT.1: While the AAAC applauds the continued Congressional support for a two-hemisphere US-ELT project, we strongly recommend that funding be provided to support the planning and final design of both telescopes.

As has been discussed in previous AAAC reports (e.g., see the report published in March 2024²⁷), U.S. observational astronomy operates under a model in which the community utilizes large projects and establishes large databases for equitable distribution and access. This is contrary to other sciences in

²⁶ <https://www.tmt.org/news/708>

²⁷ <https://nsf.gov-resources.nsf.gov/files/aaac-2024-report-r.pdf>

which a lab model for individual investigators might be the common operating model. Because of this structure, there are significant operating costs for astronomical projects, even after construction is completed. Should these costs be borne by the astronomy section of NSF, it would result in catastrophic impacts to the individual grants programs and other facilities. The 2018 NSB report “Study of Operations and Maintenance Costs for NSF Facilities” (NSB-2018-17)²⁸ recognized this conundrum, leading to the implementation of the Facilities Operation Transition (FOT) program. FOT will “partially support initial O&M of new facilities so that the full O&M costs can be gradually absorbed into the managing division or directorate.”²⁹ In FY25, the Senate proposed budget encouraged the continued use of FOT, and asked NSF to begin providing five-year estimates of maintenance and operations costs for projects that have graduated from MREFC. As discussed at the start of Section 4, the NSF is also undergoing a restructuring that includes a new centralized office of the Chief Officer for Research Facilities. How these changes impact O&M is yet unknown.

Recommendation ELT.2: The pilot FOT program should continue in some form indefinitely. The AAAC welcomes Congressional support of the FOT program.

Recommendation ELT.3: The AAAC recommends that NSF proceed with all due deliberate speed toward a funding decision of the U.S. ELT Program, consistent with internal review policies, and consistent with the recommendations of *Astro2020*.

Recommendation ELT.4: Given the budgetary uncertainty around major facilities, the AAAC recommends that the mid-decadal review be executed swiftly. While the process has begun, it is behind schedule and lacking transparency. As emphasized above, research supported by the astronomy section (and physics section to a lesser extent) of NSF MPS is heavily dependent on the use of large, shared facilities; this model is less so in many other disciplines. For this reason, community input in the form of a decadal survey is central to developing consensus around the highest priority initiatives on a multi-year timescale and in a constrained budget scenario in which we are unlikely to achieve the full goals of *Astro2020*.

Next Generation Very Large Array (ngVLA)

The second-highest ground-based priority of *Astro2020* for this decade (alongside CMB-S4) is proceeding at a slow but steady pace. Although it will not be completed until the 2030s, the ngVLA will surpass existing radio facilities in sensitivity and spatial resolution by more than an order of magnitude. Current plans are for more than 250 ngVLA antennas to be deployed across roughly ten U.S. states and territories and Mexico, with accompanying investments in economic infrastructure including transportation, energy, and communications.

Finding: The NSF awarded a \$21M grant to advance the ngVLA design in 2024-2026. These developments demonstrate the project’s strong scientific and technical promise and NSF’s continued commitment to U.S. leadership in radio astronomy.

²⁸ <https://nsf.gov-resources.nsf.gov/files/nsb201817.pdf>

²⁹ https://nsf.gov-resources.nsf.gov/about/budget/fy2023/pdf/39_fy2023.pdf

Finding: In September 2024, the ngVLA project successfully passed its NSF Conceptual Design Review. The ngVLA is now ready to be considered for entry into the Preliminary Design Review.

Findings: A prototype antenna for the ngVLA was delivered to NRAO in April 2025. The antenna is located near the existing VLA site in New Mexico. Scientists and engineers are busy with testing the antenna, a process that is expected to take roughly a year.

Finding: The ngVLA project office is continuing discussions with international and domestic organizations and agencies about collaborations, including partnerships related to funding the construction and operations, but there have been no major funding partners identified yet.

Recommendation ngVLA.1: As construction costs are estimated to be of order \$2.5B and operation costs in the range of \$100M/year, the findings and recommendations related to the financial hurdles for the U.S. ELT program apply to financing the ngVLA as well, i.e., Facilities Operation Transition (FOT) or a related fund must be established to support operations costs to avoid detrimental impacts to other areas of the NSF astronomy portfolio.

4.3.2. Space Initiatives

Habitable Worlds Observatory and the Great Observatories Maturation Program

Astro2020's top priority for flagship space initiatives is a large (roughly 6 meter aperture) infrared/optical/ultraviolet telescope that is capable of both a range of broad astrophysical observations as well as observing habitable exoplanets. This mission is expected to launch no sooner than the late 2030s, and likely in the early 2040s. The project is now referred to as the Habitable Worlds Observatory (HWO).

Finding: The HWO Technology Maturation Project Office (HTMPO) was established in August 2024. The new project office adopts a Concept Maturity Level framework in order to advance the architecture, technology and science of the mission.³⁰

Finding: The establishment of HTMPO aligns with another *Astro2020* recommendation, the establishment of a Great Observatories Maturation Program. NASA has clearly embraced this recommendation. The activities coordinated under such programs help to ensure the scope of all future flagship missions are clearly defined and will advance technologies to deliver revolutionary science.

Finding: In June 2025, NASA established the HWO Community Science and Instrument Team (CSIT), a body that will exist through Mission Concept Review (MCR). NASA solicited self-nominations to form the CSIT. The CSIT will work with the HTMPO to mature the technologies and mission concept ahead of the MCR.

Finding: NASA ROSES 2024 included a call for proposals from industry to advance the technology and architecture of HWO through the System Technology Demonstrations and Mission Architecture Studies program.

³⁰ <https://arxiv.org/pdf/2601.11803>

Finding: The HTMPO is one of the 17 science projects that is currently on pause until signed apportionments are received from OMB.

Comment: The AAAC commends NASA's advancement of this major project.

A Panchromatic Fleet

The remaining high priority space initiatives supported by the *Astro2020* Decadal Survey focus on sustaining a broad wavelength coverage in order to support Time Domain and Multi-Messenger (TDAMM) science. TDAMM investigates the Universe through synchronized observations across various wavelengths over time. To succeed, researchers need concurrent access to the entire electromagnetic spectrum. Only NASA can achieve the science goals in wavelengths not accessible from the ground.

Astro2020 highlighted that traditional "Flagship" missions—which often take decades to develop and launch sequentially—cannot meet the needs of TDAMM science. Instead, this field demands a more agile approach with smaller, rapidly developed projects built in parallel. Consequently, the survey assigned equal priority to two specific concepts: a high-resolution X-ray observatory and a far-infrared imaging and spectroscopy mission, both suggested to have a budget ceiling of approximately \$1.5 billion.

Finding: NASA has acted on these recommendations by establishing a "Probe Explorer" category within its existing Explorer Program. The Explorer Program is highly responsive to new knowledge, new technology, and updated scientific priorities by launching smaller missions formulated and executed in a relatively short development cycle. In 2024, the agency announced the advancement of two missions under this class, each with a \$1 billion cost cap: the Probe far-Infrared Mission for Astrophysics (PRIMA) and the Advanced X-ray Imaging Satellite (AXIS).

Finding: Selection of future missions will prioritize the wavelength not covered in the selected Probe Explorer and HWO, i.e., it would prioritize far-IR if AXIS is chosen, or X-ray if PRIMA is chosen.

Finding: In November 2024, the AXIS team began a 12-month Phase A Study to advance the mission concept. In March 2026 the AXIS team was notified by NASA that the project was no longer eligible for selection due to insufficient costing, thereby ending the review of its Concept Study Report. This decision was programmatic, with no basis in the scientific or technical concerns. The project leads pointed to three major disruptions at NASA that contributed to their inability to complete the cost-design iteration process within the limited study period, even with a 6-week extension to the deadline: numerous key project personnel being lost to NASA's Deferred Resignation Program, a reprioritization of other personnel at NASA's Goddard Space Flight Center to align with the FY2026 President's Budget Request, which eliminated the Probe program, and a nearly seven week pause on critical work during the government shutdown.

Finding: The primary obstacle to realizing NASA's TDAMM network is the current ambiguity surrounding space communications. NASA is transitioning away from its proprietary Tracking and Data Relay Satellite System (TDRSS) in favor of commercial near-Earth services. While TDRSS currently supports nearly all of NASA's low-Earth orbit operations, upcoming missions are restricted from using it in their design phases. This has created a critical information gap regarding how future telescopes will transmit data. For TDAMM science to thrive, the subsequent communication infrastructure must be

high-speed, flexible enough to link multiple observatories simultaneously, and backward-compatible with legacy missions still in operation. We discuss this further in Section 5.3.

5. Progress Towards Cross-Cutting Decadal Priorities

5.1. Investments in Artificial Intelligence and Machine Learning

Astronomers and astrophysicists have been using artificial intelligence and machine learning techniques (abbreviated here as AI/ML) for decades and are some of the earliest adopters and developers of the technology. The field’s rich datasets and culture of non-proprietary data have made it particularly well suited to drive more recent innovation and development of AI/ML tools, launching a new era of Astronomy + AI/ML progress. Due to the timing of its rapid rise in functionality and adoption, AI/ML was not a major topic in *Astro2020*. It is now clear, however, that the associated technologies will be major players in advancing the science envisioned in *Astro2020*.

Finding: An NSF Workshop on the Future of Artificial Intelligence (AI) and the Mathematical and Physics Sciences (MPS) was held in March 2025. This effort to understand “how the MPS domains (Astronomy, Chemistry, Materials Research, Mathematical Sciences, and Physics) can best capitalize on, and contribute to, the future of AI” resulted in a published summary of the MPS community’s perspective.³¹ This document includes recommendations that agencies prioritize activities that enable AI+MPS research in both directions, build up an interdisciplinary community of AI+MPS researchers, and foster education and workforce development in AI for MPS researchers and students. These would serve to support the authors’ strategic vision of “building a mutually beneficial bridge between MPS and AI research” and more specifically the coming era of Astronomy + AI/ML.

Finding: Recommendations included in the AI+MPS report also align with the findings released in the White House’s *Winning the Race: America’s AI Action Plan*,³² in particular its recommendations to Encourage Open-Source and Open-Weight AI (Sec. 2.3), Empower American Workers in the Age of AI (Sec. 2.7), Invest in AI-Enabled Science (Secs. 2.1, 2.5, 2.6, and 3), Build World-Class Scientific Datasets (Sec. 2.3), Advance the Science of AI (Sec. 2.2), Invest in AI Interpretability, Control, and Robustness Breakthroughs (Sec. 2.2), and Build an AI Evaluations Ecosystem (Sec. 2.3).³³

Finding: The recent rise of AI/ML, including the start of the Genesis Mission run by DOE, coincides with an imminent “data deluge” in astronomy and astrophysics, driven by the large-sky surveys from Rubin, Euclid, DESI, and Roman (see e.g., DESC AI/ML White Paper³³). The adaptation and development of AI/ML tools will play a significant role in the scientific analysis of these vast datasets.

Finding: The augmentation of AI/ML-based classifiers using Citizen Science volunteers could uniquely improve the performance of these campaigns (e.g., Rubin Comet Catchers³⁴).

³¹ <https://arxiv.org/pdf/2509.02661>

³² <https://www.whitehouse.gov/wp-content/uploads/2025/07/Americas-AI-Action-Plan.pdf>

³³ <https://arxiv.org/abs/2601.14235>

³⁴ <https://ui.adsabs.harvard.edu/abs/2025epsc.conf.1189C/abstract>

Finding: Two new AI institutes jointly supported by NSF and the Simons Foundation, CosmicAI (focused on star formation, and the radio realm) and SkAI (driven by large astronomical survey needs), represent a triumph of public/private partnerships. Their focus on building trustworthy applications of AI, workforce developments plans, and interdisciplinary research is largely separate from and complementary to on-going commercial efforts.

Finding: NASA is establishing a new AI/ML Science and Technology Interest Group (STIG) under the Cosmic Origins Program Analysis Group (COPAG).³⁵

Finding: Basic research funding levels for AI/ML within DOE's Office of High Energy Physics have grown by more than a factor of four since 2020 (from roughly \$15M in 2020 to roughly \$70M in 2026). With many funding opportunities now welcoming the incorporation of AI into proposed work, proposals tend to focus either on very fundamental work or very limited, specific applications of AI. Bridging the two regimes is a goal that the agency is currently working on.

Finding: A recent American Astronomical Society survey on AI opportunities and concerns revealed the astronomy and astrophysics workforce's awareness of potential negative impacts of AI on the creative process, scientific literacy, reproducibility, assessment, and plagiarism, of inequity in access to AI, of unethical uses of AI, and the environmental impact of AI's carbon footprint.

Finding: Science + AI research is done by people. Research points to the importance of subject matter experts in fulfilling the promise of AI use in the field while ensuring that the widespread adoption of AI/ML tools does not artificially narrow the research scope of the field. A recent study conducted blind reviews of research ideas generated by large language models (LLMs) with those generated by researchers in the field, and found that LLM-generated ideas were judged as more novel but less feasible.³⁶ The astronomical and astrophysical community is building a community of subject matter experts who can shape the future of Astrophysics + AI research, develop training opportunities for the community (both for workforce development and retooling by more senior scientists), and explore and build interdisciplinary collaborations.

Comment: The following four recommendations related to AI/ML for astronomy and astrophysics might be best considered within the context of the mid-decadal process, where the agencies and the community can engage in the development of best practices and the best path forward.

Recommendation AI.1: Agencies should consider prioritizing funding opportunities targeted at interdisciplinary and interagency research, including for the joint analysis of available datasets. Collaboration between agencies would further the development of AI/ML for astronomy and astrophysics. The agencies are encouraged to develop pathways for broad collaborations, such as between the NSF-Simons AI institutes and the DOE-run Genesis Mission.

Recommendation AI.2: Agencies should emphasize rigorous validation and building trustworthy tools to build a mutually beneficial bridge between astronomy and astrophysics and AI. Agencies should continue

³⁵ <https://science.nasa.gov/astrophysics/programs/cosmic-origins/science-groups/>

³⁶ <https://arxiv.org/pdf/2409.04109>

to work towards a consistent set of AI guidelines for creating and evaluating scientific content fairly, ethically, and accurately.

Recommendation AI.3: As the agencies receive more proposals incorporating AI/ML, they should develop metrics to prioritize projects that would minimize or offset the energy costs of computing requirements, in alignment with the sustainability goals of *Astro2020*.

Recommendation AI.4: Many federal astronomy and astrophysics investments in AI extend into education and workforce development. Current efforts include the CosmicAI Graduate AI certificate program and AI bootcamp, the recommendations advanced in the AI+MPS report on workforce development, SkAI efforts in high school and undergraduate research-intensive summer programs, and the Satellite Early Education for Discovery (SEED) Program. Developing and propagating best practices for workforce development to tackle future Astronomy + AI challenges should engage subject matter experts in astronomy and astrophysics education as well as disciplinary societies (AAS, AIP, APS) in the conversation and efforts. This is especially true for materials or recommendations for primary and secondary education that should be explicitly informed by, or developed in collaboration with, education researchers and practitioners. Such experts can provide needed guidance for faculty, researchers, and students employing AI technologies in undergraduate and graduate education.

5.2. Protecting Dark and Quiet Skies

Ground-based observatories remain the engines of cutting-edge scientific discoveries. *Astro2020* identified the increasing challenge posed by very large satellite constellations to ground-based astronomical observations, both in the optical due to reflected sunlight and in the radio due to the increase in both licensed use of satellite service transmissions and unintentional radio frequency interference (RFI). In addition to the sky brightness contributions from satellites and space debris, terrestrial light pollution continues to increase globally. While advances in energy- and cost-efficient lighting technologies benefit society, their deployment has had the unintended consequence of further brightening the night sky, thereby limiting the dark skies essential for astronomical discovery. Addressing these competing priorities will require coordinated efforts among stakeholders, including industry, policymakers, and the scientific community, to develop balanced and sustainable solutions.

Finding: Light pollution is increasing globally at an estimated rate of 2-10% per year, reducing darkness everywhere, even at remote sites of major observatories. The energy- and cost-effective LED increasingly poses a threat to astronomy, owing to its more efficient light scattering and its ability to cause skyglow in the blue and green regions of the spectrum, compared with earlier light technologies.

Finding: Controls at the level of individual light fixtures are likely feasible, such as limiting the blue and green glows or the extent of light spill. Cross-disciplinary research is critically needed to develop regional lighting master plans that balance outdoor lighting safety with astronomical requirements at critical dark-sky sites of major ground-based observatories.

Finding: Existing global lighting protocols have become obsolete as ambient light levels at even the most remote observation sites continue to rise. To protect the integrity of these locations, we must implement

modernized standards that mandate comprehensive shielding and low color temperatures. Furthermore, adopting 'cap-and-trade' frameworks to regulate aggregate luminous flux could help to curtail surplus light pollution near critical astronomical facilities.

Finding: Satellite trails are currently affecting a small percentage of the exposures obtained by Rubin Observatory and are not yet hindering the science goals of LSST. However, a factor of 10 or more increase in the number of satellites could cause a significant impact to the scientific output of the project.

Finding: Satellite trails also impact space observatories including the Hubble Space Telescope³⁷, with impacts similarly increasing with the population of satellites.

Finding: There are growing challenges posed by exponentially increasing numbers of Earth-orbiting satellites, which can significantly affect the entire electromagnetic spectrum, including radio and optical astronomy. Last year, the number of active satellites doubled, and recent commercial filings to the Federal Communications Commission (FCC) have requested permission to deploy one million new satellite data centers to low Earth orbit (a 70-fold increase to their current satellite population).

Finding: As satellites are becoming more numerous, they are also becoming significantly larger to provide direct-to-cellular service, to facilitate faster downlink speeds over a wider footprint on Earth, and to generate enough solar power for their energy needs. This larger surface area equates to higher brightness. One company's planned space mirror lighting-on-demand satellites represent an extreme in this regard, with a surface area more than 10 times larger than SpaceX's largest satellites (model V3).

Finding: In September 2025, the American Astronomical Society formally urged³⁸ the FCC to clarify that satellite and space-based communications operations with foreseeable domestic environmental impacts remain within the scope of review of the National Environmental Policy Act.

Finding: In October 2025, the FCC released a Notice of Proposed Rulemaking (NPRM) titled "Space Modernization for the 21st Century," which proposes overhauling the rules for licensing space and earth stations.³⁹

Finding: In February 2026, the House Science, Space, and Technology Committee Chairman Brian Babin and Ranking Member Zoe Lofgren sent a letter⁴⁰ to the FCC raising concerns that the FCC's recent NPRM "Space Modernization for the 21st Century" included provisions related to space traffic management and safety that exceed the FCC's statutory authority.

Finding: The International Astronomical Union's Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference (IAU-CPS) was established in 2022 following a series of

³⁷ <https://www.nature.com/articles/s41586-025-09759-5>

³⁸ <https://compass.aas.org/aas-comments-on-proposed-fcc-rule-excluding-satellite-ops-from-environmental-review/>

³⁹ <https://www.fcc.gov/document/space-modernization-21st-century-nprm>

⁴⁰

https://republicans-science.house.gov/_cache/files/a/6/a668ae60-5b49-4c53-b8b7-6a1bdfd8ac34/742991E8C328C631D7315F22A966B3E5D88D5C804B3550CB284A72671EA5BD2A.house-science-committee---letter-to-fcc-chairman-carr.pdf

community workshops on measurements of impacts from satellite constellations and possible recommendations for mitigation. The IAU-CPS is co-hosted by NSF's NOIRLab and the SKA Observatory. This organization aims to coordinate efforts of the global astronomical community towards Dark and Quiet Skies, and plans to collect, produce, and freely disseminate relevant information and resources.

Finding: NASA and NSF coordinate on spectrum management at the national level via the Interdepartment Radio Advisory Committee (IRAC), and at the international level through the United Nations Committee on the Peaceful Uses of Outer Space and the International Telecommunications Union Radiocommunications Sector.

Finding: NASA has an intra-agency liaison between the Science Mission Directorate and the Space Communications and Navigation (SCaN) office working to minimize impacts on science missions from new commercial communications providers (discussed further in Section 5).

Recommendation DQS.1: The impacts of satellite constellations on astronomy and astrophysics are rapidly evolving. NASA and NSF have each brokered effective coordination agreements with major satellite constellation operators to limit emissions (NSF) and avoid collisions with space-based observatories (NASA). Many scientists and researchers funded by NSF, NASA, and DOE and supporting the major astronomical facilities and missions of these agencies are independently developing hardware and analysis mitigation techniques, and collaborating through professional societies. More explicit coordination and information sharing between NSF and NASA on their work addressing the evolving challenges posed by satellite constellations, and the scientists and researchers measuring and working to mitigate impacts, may help to better identify emerging risks, streamline the process of coordinating future agreements, and inform future regulations.

Finding: Science agencies, satellite operators, and regulators still lack sufficient data for determining the “threshold for harm” from satellite constellations to major investments in ground-based astronomy. A pressing need exists for better data on satellite ephemerides, the scientific loss per pixel per unit time to astronomy facilities, measurements of reflectivity and materials research to develop better anti-reflective coatings, as well as the impact of heavy metal contamination in the upper-atmosphere from launch and reentry, which may deplete the ozone layer and seed cloud formation that can further hinder ground-based observations.

Recommendation DQS.2: Data-informed international regulations on the brightness of satellites at both optical and radio wavelengths are imminently needed. The agencies should support interdisciplinary research that generates the evidence needed to develop policies supporting the coexistence of satellite constellations and ground-based astronomy. This research should also inform the development and refinement of regulations governing satellite constellations by the FCC and ITU.

Finding: The NSF has successfully negotiated agreements with leading satellite operators to facilitate the coexistence of large satellite constellations and ground-based astronomy. However, in such a rapidly growing and diversifying industry, individualized agreements with each operator are unlikely to be a sustainable mitigation strategy.

Finding: The satellite operator market and the astronomy community both have an international footprint (e.g., U.S. astronomy has a major presence in Chile), requiring treaty-level coordination agreements and regulations to protect U.S. astronomy facilities from satellite reflections and RFI emissions.

Finding: The bipartisan Dark and Quiet Skies Act has been reintroduced in the Senate, with a goal of preserving the night from unintentional light and radio interference. The bill would establish a Center of Excellence to develop best practices to reduce interference. The Under Secretary of Commerce for Standards and Technology would be tasked with ensuring the coordination of activities of this center with DOE, NASA, NOAA, NSF, and NTIA efforts.

Comment: The AAAC commends the progress and bipartisan cooperation on developing the Dark and Quiet Skies Act, and looks forward to its passage.

5.3. A New Era in Time Domain and Multi-Messenger (TDAMM) Astrophysics

One of the major themes of *Astro2020* is the advancement of Time Domain and Multi-Messenger (TDAMM) astrophysics. This is a particularly opportune moment for TDAMM with the Vera C. Rubin Observatory coming online, repeatedly scanning the visible sky with a cadence of a few days. In February 2026, Rubin began issuing alerts for potential transients, and is expected to produce millions of alerts each night. It is crucial that the astronomy and astrophysics community is capable of taking full advantage of this scientific opportunity. Covering the wavelength ranges not observable from the ground falls to NASA.

Finding: As noted in the Progress toward Major Facilities, NASA’s selection of future missions will prioritize the wavelength not covered by either the selected Probe Explorer (either X-ray or far-infrared) and HWO. X-ray and far-IR were recognized in *Astro2020* as the priority wavelengths where coverage is required to accomplish TDAMM science. NASA plans to mature the wavelength not selected in the Probe mission via directed technology maturation activities.

Finding: To maintain gamma-ray coverage, NASA will “boost” the Swift Observatory in Spring 2026. Due to increased solar drag, Swift has been de-orbiting faster than anticipated. An analysis found that boosting its orbit is the most cost-effective way to preserve coverage at these gamma-ray wavelengths. The boost is funded via an SBIR program.

Finding: NASA is partnering with ESA to support the LISA gravitational wave mission. A Systems Requirements Review has been completed, and a ROSES-26 call is expected to support LISA preparation.

Finding: NASA is working toward mission adoption of the ESA-led Athena X-ray mission by 2027.

Finding: The 3rd TDAMM Workshop “Multidisciplinary Science in the Multi-Messenger Era” was held in Baton Rouge, LA in September 2024, and a report from this workshop was published in February 2025.⁴¹ NASA and NSF have hosted this series of workshops to support community-led development of

⁴¹ <https://arxiv.org/abs/2502.03577>

TDAMM science optimization. The 3rd workshop on multidisciplinary science focused on TDAMM advances that are relevant for both physics and national strategic priorities, and discussed strategies to coordinate efforts across agencies including DOE’s National Nuclear Security Administration (NNSA).

Finding: The scientific return of TDAMM science could be enhanced by adopting the “end-to-end” techniques used by the NNSA, using broad coordinated resources to fully understand a problem and all of its steps, rather than developing approximate models. These would not require additional funding but rather interagency coordination of efforts. The *Space Weather Research and Forecasting Act* was given as an example of what was needed for successful interagency coordination that led to significant advances in heliophysics.

Finding: Multidisciplinary fields such as High Energy Density Physics have been developed by the NNSA and have highly relevant techniques and resources for understanding TDAMM objects of interest, but remain mostly siloed from astrophysics, to the detriment of both sides.

Comment: The potential for scientific discovery in this era of TDAMM astrophysics extends far beyond astronomy and astrophysics, with these observations acting as a laboratory for better understanding multidisciplinary fields of national strategic interest, including nuclear astrophysics, radiation transport, and high energy density physics. Even the AAAC does not have a broad enough scope to fully advise on the breadth of TDAMM scientific interests and interagency coordination efforts.

Finding: The 4th TDAMM Workshop “Advancing Community Observing Plans for Rapid Follow-Up of Explosive Transients” was held in October 2025 in Huntsville, AL. The focus of the 4th workshop was on “community proposals,” and a white paper reporting recommendations is in progress.

Finding: As an outcome of the 1st TDAMM workshop, NASA has established the Astrophysics Cross-Observatory Science Support (ACROSS) initiative. ACROSS is currently working to support cross-observatory data access for space telescopes, though ultimately it hopes to expand to ground-based data and support. Ultimate goals include development of a single interface to support observing schedules, observing requests, observing tools, alert support and target-of-opportunity toolkits.

Recommendation TDAMM.1: A major recommendation of the 4th TDAMM workshop is to support pre-negotiated observations at critical facilities of high importance (i.e., very rare) events. Data from these observations would be immediately made public.

Recommendation TDAMM.2: NASA and NSF should coordinate on TDAMM proposals. This includes joint (cross-observatory) calls and community proposals.

Recommendation TDAMM.3: DOE should formalize plans to coordinate on TDAMM science using DESI-II for spectroscopic follow-up of TDAMM events.

As the above findings demonstrate, NASA’s fleet is critical to achieving TDAMM science. Critical to all missions is the ability to relay information between the ground and satellites. To preserve capacity for existing users of NASA’s Tracking and Data Relay Satellite System (TDRSS), NASA suspended new mission commitments for this service at the end of 2024. NASA is assessing whether TDRSS backwards compatible services are required for its commercial replacements, which are expected

to be available starting in 2031. The AAAC commends Congress for taking note of this crucial communication service in the proposed NASA Reauthorization Act of 2026, and requiring a report⁴² on the ability of future commercial partners to maintain the existing fleet and plan for future missions.

Finding: The Time-Domain and MultiMessenger Communications Science Analysis Group (TDAMMCommSAG) released its report in July 2024⁴³ on whether the current plan for the transition from NASA-operated space and ground relays to commercial services will adequately service NASA astrophysics missions studying the transient and variable Universe. Below, we highlight some of their recommendations.

Recommendation TDAMM.4: Many commercial providers are likely to focus on low Earth orbit (LEO), where many commercial satellites are located. However, NASA astrophysics has needs beyond LEO, including in the TDAMM suite (e.g., JWST and LISA). Special care needs to be paid to ensure that communications from non-LEO satellites are supported.

Recommendation TDAMM.5: Service providers must ensure the ability to download large datasets.

Recommendation TDAMM.6: Service providers must be able to accommodate communications on short notice, i.e., when target-of-opportunity observations occur for TDAMM observations.

Finding: Initial assessments for Fermi and Swift, both LEO satellites, indicated that at least one commercial provider could meet or exceed current TDRSS performance.

Finally, we note that the President's FY26 Budget Request (PBR) targeted TDAMM science in a way that would have reversed the decades of planning that have gone into optimizing this unique and emerging area. Specifically, the PBR sought to eliminate the U.S. contributions to the Laser Interferometer Space Antenna (LISA) and Ultraviolet Transient Astronomy Satellite (ULTRASAT) missions. It attempted to cancel the Physics of the Cosmos Supporting Research and Technology (PhysCOS SR&T), Euclid, Chandra, and Fermi. The PBR also wished to cancel the Explorers program including Contributions to Ariel Spectroscopy of Exoplanets (CASE), Compton Spectrometer and Imager (COSI), Astrophysics Probes Future Missions, Astrophysics Explorer Science, and the UltraViolet Explorer projects. It initiated closing of the XRISM mission in FY26, NICER and Swift after FY26, and funding for TESS, IXPE and NuStar was reduced. It also zeroed out the balloon program within Astrophysics Research, which often contributes to TDAMM science (e.g., PUEO highlighted above, which targets ultra high energy neutrinos). The AAAC commends Congress for sustaining the carefully crafted plan outlined in *Astro2020* that has been meticulously constructed to ensure high scientific return that keeps U.S. scientists at the forefront of discovery and advancement.

⁴²

https://republicans-science.house.gov/_cache/files/d/9/d9c64d82-e4d8-48b4-8755-a463a857a88a/0149CB10A1CBE5F741AA89F4B6858822405A3BF7B86835EBB49570532D97DD79.mcclmd-072-xml.pdf

⁴³ <https://arxiv.org/abs/2410.03980>

5.4. Continued Investments in Laboratory Astrophysics

The field of laboratory astrophysics, spanning experimental work such as kinetics and spectroscopy, as well as theoretical simulations, serves as the backbone of modern planetary science, astronomy, and astrophysics. By providing the fundamental physical data required to decode signals from across the electromagnetic spectrum, it acts as the essential “decoder ring” for the massive data streams currently being produced by premier facilities like the James Webb Space Telescope (JWST) and the Atacama Large Millimeter/submillimeter Array (ALMA).

However, laboratory astrophysics has historically faced a lack of formal recognition and strategic priority. This persistent undervaluation was documented in the 2000, 2010, and 2020 Decadal Surveys. The AAAC requested a TaskForce on laboratory astrophysics, which submitted a report⁴⁴ in February 2024, “Enabling Cosmic Discoveries: The Vital Role of Laboratory Astrophysics.” The report laid out tangible and cost-effective recommendations to be undertaken to strengthen the field and maximize the scientific return from current and proposed facilities and missions.

To ensure that our interpretative capabilities do not fall behind our observational power, consistent and increased investment is mandatory. Empowering this discipline allows the United States to maximize the scientific return on its multi-billion dollar investments in next-generation space missions and ground-based telescopes. Moreover, long-term funding is vital for human capital; it secures a pipeline for the next cohort of specialists. A robust laboratory astrophysics workforce is not only necessary for solving complex astrophysical problems but also for driving innovation in space exploration, planetary research, and the development of high-precision instrumentation, thereby ensuring continued U.S. preeminence in the global STEM landscape.

Finding: A workshop was held at the June 2025 American Astronomical Society (AAS) meeting, jointly funded by NSF and NASA, with a follow-up at the January 2026 AAS meeting. The workshop united key stakeholders to address challenges, set research priorities, and strengthen collaboration. A white paper discussing the outcomes and recommendations of the workshop is in progress, which will be used to inform the mid-decadal review and funding strategies. Such workshops were recommended in last year’s AAAC report.

Finding: The Astrophysics Research and Analysis Program (APRA) included in ROSES-25 included a solicitation for Laboratory Astrophysics proposals. The Cycle 1 call for the Nancy Grace Roman Space Telescope also highlights laboratory astrophysics as a potential area of interest. The AAAC previously recommended such solicitations from both NSF and NASA, including in last year’s report.

Recommendation LA.1: To maximize the impact of laboratory astrophysics, NSF, NASA, and DOE should explore the feasibility of a coordinated strategy that ensures sustained and synergistic support across agencies. This collaboration might include regular interagency meetings, joint funding initiatives, and shared infrastructure investments to prevent redundancy and optimize resource allocation. This coordination should include the DOE Office of Nuclear Physics which is highly involved in laboratory astrophysics efforts.

⁴⁴ <https://nsf.gov-resources.nsf.gov/files/latf-report-r.pdf>

Recommendation LA.2: To increase funding opportunities for laboratory astrophysics, NSF and NASA should broaden the scope of existing funding programs to explicitly include laboratory astrophysics research, and ensure that laboratory astrophysics proposals are fairly evaluated similar to observational and theoretical astrophysics research.

Comment: We applaud NASA for introducing the solicitation for Laboratory Astrophysics proposals in APRA.