AAAC ANNUAL REPORT 2023

Astronomy and Astrophysics Advisory Committee

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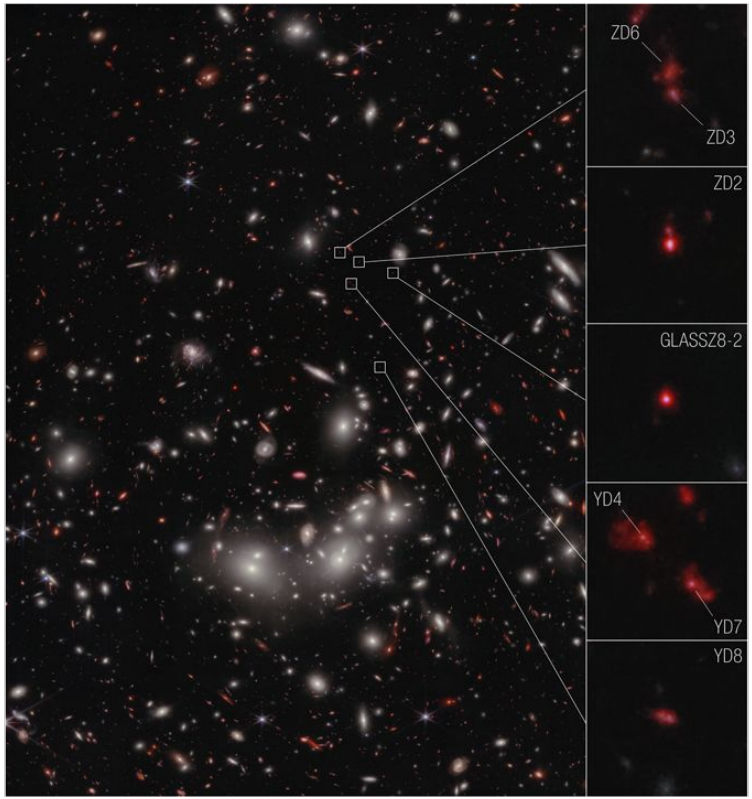
NASA Highlights of 2022 - 2023

- JWST is now in full science operations with an on-orbit performance exceeding mission requirements.
  - Detection of four of the most distant galaxies
  - Significant advances in exosolar planets

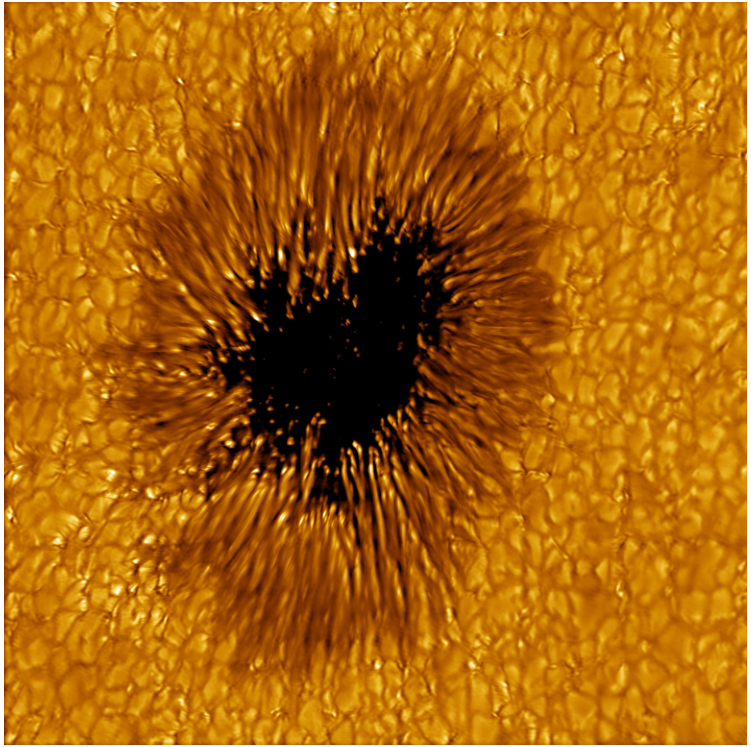
- Launch of the Nancy Grace Roman Space Telescope in 2027 remains on-schedule
  - Highest priority Large-Scale space facility from 2010 Decadal Survey



NSF Highlights of 2022 - 2023

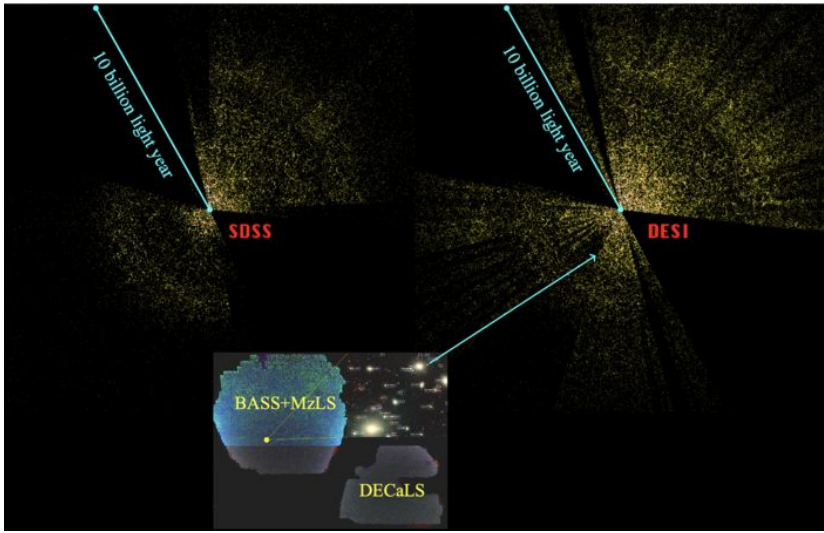
- Daniel K. Inouye Solar Telescope (DKIST), was inaugurated
  - World's most powerful solar telescope
  - Observations taken in conjunction with NASA's Parker Solar Probe, highlighting strength of inter-agency coordination

- Significant progress on high priority facilities from 2020 Decadal Survey
  - Preliminary Design Reviews for both the ELTs
  - ngVLA prototype antenna was completed in 2022



DOE Highlights of 2022 - 2023

- Joint partnerships between DOE and NSF performing superbly
  - Dark Energy Survey allowed astronomers to directly survey the distribution of dark matter on a scale never before possible
  - DESI is the world's premier multi-object spectrograph with 5,000 robotically-controlled fibers



- Full operations of the Vera C. Rubin Observatory expected in the second half of 2024
  - Highest priority Large-Scale, ground-based facility from 2010 Decadal Survey
  - Joint NSF/DOE endeavor

2020 Decadal Recommendations for Large Programs

Space-based

Create a Great Observatories Mission and Technology Maturation Program (TMP)

- First mission is to be a large (~6 m aperture) infrared/optical/ultraviolet (IR/O/UV) space telescope
- Commence TMP for both a far-IR and an X-ray large strategic mission

Ground-based

1. U.S. Extremely Large Telescope Program (ELT) program
2. CMB Stage 4 (CMB-S4) observatory (with support from NSF and DOE)
2. The Next Generation Very Large Array (ngVLA) using phased approach

2022 - 2023: Cross-agency Issues of Highest Priority

- Major ground-based facilities
  - The unprecedented science that will come from the highest-priority ground-based major facilities in the Decadal Survey (the US-ELTs) requires significant NSF support for construction, and thus ambitious and coordinated planning beyond the scope of historic MREFC funding levels.
  - Challenges related to Antarctic infrastructure need to be addressed through close coordination of NSF-OPP and the CMB-S4 project for DOE and NSF to complete construction of CMB-S4
- Dark/quiet skies
  - Number of commercial satellites operating in low Earth orbit is expected to increase by an order of magnitude or more in the next decade
  - Coordinated cross-agency effort is urgently needed to provide regulatory agencies and oversight organizations with quantifiable data and metrics to better shape policy
- Demographic data collection
  - Consistency is needed in the collection of demographic data for the scientific community to track progress towards building an equitable, diverse and inclusive community
  - Office of Science and Technology Policy (OSTP) and Office of Management and Budget (OMB) ideally positioned to establish minimal, consistent criteria for all data collection

Other Areas of Interest

- Time-Domain and Multi-Messenger Astrophysics
  - Agencies gathering community input through workshops
  - Excellent programs underway, but coordination between observatories remains challenge
- Data
  - Agencies gathering community input through workshops
  - The agencies and the AAAC should update the Principles for Access to Large Federally Funded Astrophysics Projects and Facilities
- Climate Change
  - NSF-AST is planning to make at least one observatory completely carbon neutral in the next two years and plans to reduce emissions of all NOIRLab facilities by roughly 50% in the next few years.
  - DOE has significant ongoing programs to address climate change, reduce energy usage, enhance energy resiliency and efficiencies and develop new energy sources and technologies that include industry and academic partnerships. Many DOE Cosmic Frontier experiments now have remote data-taking.

Extremely Large Telescopes

- The “survey’s priority for a frontier ground-based observatory is a significant U.S. investment in the Giant Magellan Telescope (GMT) and Thirty Meter Telescope (TMT) projects, ideally as components of a coordinated U.S. Extremely Large Telescope Program (ELT) program.”
- Design reviews are advancing, critical challenge is MREFC funding
  - The NSF MREFC funding line has historically been in the $120-200 M range per year. Of this amount, $60 M is nominally earmarked for Antarctic Infrastructure Recapitalization and $76.25 M is earmarked for Mid-Scale Research Infrastructure in future years.
  - Total construction investment is roughly $1.6 B
- Operations of NSF facilities presents critical challenge to NSF-AST budget
  - Roughly 75% of AST budget is dedicated to operations, ELT will raise this to ~85%
  - **AAAC has consistently recommended to Congress to provide appropriations to allow NSF to meet its strategic commitments to operations and maintenance of its major facilities**

Stage-IV Cosmic Microwave Background Experiment

- “Observations of the Cosmic Microwave Background (CMB) have been central to establishing the standard model of cosmology, and these measurements are increasingly important for science ranging from the study of galactic ecosystems to the formation of cosmic structure. NSF and DOE should jointly pursue the design and implementation of the next generation ground-based cosmic microwave background experiment (CMB-S4)”
- CMB-S4 is top priority for DOE based on remaining 2014 P5 recommendations; ELT is top priority for NSF based on 2020 Decadal Survey
- Direct costs to NSF
  - The $300 M construction of CMB-S4, over six years, fits into the preliminary MREFC budget
  - The NSF share of CMB-S4 operations is estimated to be roughly half the cost of the NSF share of ELT operations
- Direct costs to DOE
  - Primary constraint may be costs of LBNF Dune within DOE-HEP portfolio
  - Current P5 meeting to discuss budget scenarios, report in late 2023

CMB-S4 Challenges

- The South Pole is uniquely well-suited to enable CMB-S4 to discover a signal of cosmic inflation in the first fraction of a second after the Big Bang, and to discover the sources of astrophysical neutrinos with the NSF-PHY supported IceCube experiment.
- In the 2015 NAS report titled “A Strategic Vision for NSF Investments in Antarctic and Southern Ocean Research,” a next-generation Cosmic Microwave Background facility (which is now CMB-S4) was one of the three highest priorities across all fields of Antarctic science.
- In the 2022 mid-term assessment of progress on the 2015 Strategic Vision, it was noted that “Inadequate levels of funding and planning for logistical support pose a threat to the rate of progress of ongoing Antarctic CMB research and the pace of construction of the Antarctic CMB-S4 components.”
    - Aging LC-130 aircraft limits cargo and personnel movement on the ice: expanded traverse capabilities can reduce cost for science teams accessing South Pole
    - Power and lodging at South Pole limiting development of new facilities: NSF AIR (MREFC) includes infrastructure upgrades and maintenance at the South Pole, but under development

Protection of Dark and Quiet Skies

- "The NSF should work with the appropriate federal regulatory agencies to develop and implement a regulatory framework to control the impacts of satellite constellations on astronomy and on the human experience of the night sky. All stakeholders (U.S. astronomers, federal agencies, Congress, satellite manufacturers/operators, and citizens who care about the night sky) should be involved in this process. This is an international issue; therefore, international coordination is also vital."
- Satellites in 550 km orbits must be fainter than 7th magnitude in the G-band to avoid saturating the CCDs used to collect Rubin images
  - SpaceX reduced brightness to 5-6 magnitudes – roughly six times brighter than LSST requirements
  - As many as 430,000 satellites are may launch in the coming years
- NSF has been working with the professional astronomy community, industry leaders, regulating bodies, and the public to mitigate the impacts of satellite constellations
  - Reports have been presented to the U.S. Department of State, OSTP, DoD, and the FCC
  - Agreement signed January 2023 to reduce the brightness of Starlink satellites

State of the Profession

- "NASA, NSF, DOE, and professional societies should ensure that their scientific integrity policies address harassment and discrimination by individuals as forms of research/scientific misconduct."
  - The Head of NSF Office of Equity and Civil Rights (NSF OECR) has updated policies on harassment.
  - DOE Office of Science has established expectations for events and proposal requirements
- **NSF and DOE should report statistics to the AAAC on the number of instances of code of conduct investigations in award applications (NSF) or DOE-hosted conferences. NSF should also report challenges faced in implementation of the institutional reporting, for example, with regards to policies on privacy that vary from state to state.**
- **NASA and DOE should evaluate which aspects of the NSF OECR award policy on harassment can be adopted in their own processes.**

State of the Profession

- **Contrary to the Decadal Survey recommendation, NSF-AST, DOE Cosmic Frontier, and NASA should not set up a cross-agency task force, but should rather coordinate with the NSF Director's Office, OMB, and OSTP in establishing criteria for demographics data collection. Only through a joint effort with OSTP and OMB will a minimal set of requirements be established in a holistic way that spans federal agencies.**
  - The NIH collects demographic information from researchers in its external grants program and sets an example that other agencies can emulate.
  - Within NSF, DOE, and NASA, the astrophysics divisions are each subject to the policies on data collection established higher up within the agency.
  - Sec. 10502 of the CHIPS and Science Act requires each Federal research agency to collect comprehensive demographic data on recipients of Federal awards and to report this data to NSF for summary and publication. Sec. 10502 establishes that NSF shall establish and update a policy to ensure standardization of the data collected.
  - "Executive Order On Advancing Racial Equity and Support for Underserved Communities Through the Federal Government" requires the Director of the Office of Management and Budget (OMB) to partner with the heads of agencies to study methods for assessing equity and fairness in agency policies and actions.
  - OSTP has established a new team on science and society to broaden participation in STEM fields and strengthen the U.S. research infrastructure.

Recommendations (Large Facilities and NSF AAG)

- **To enable the transformative science of the highest-ranked Decadal recommendations for ground-based astronomy (US-ELT, followed by implementation of CMB-S4, and beginning design, cost studies, and prototyping for ngVLA, in ranked order), NSF should develop and communicate a multi-year roadmap in consultation with key stakeholders (e.g. DOE) and oversight bodies. The roadmap should incorporate appropriate contingencies and breakpoints.**
- **As recommended in the March 2021 AAAC report, Congress should provide sufficient appropriations to NSF to ensure that NSF's strategic commitments to operations and maintenance of its major facilities can be met, but not at the expense of the research and instrumentation funding portfolio within NSF-AST.**
- **NSF-AST should communicate cross cutting and NSF-wide opportunities to potential investigators that complement the AAG program.**
- **NSF-AST should consider how to support increased PI involvement during the planning and construction of large projects.**
- **Continue strategic, ambitious thinking, even considering restructuring or a developing a paradigm shift for life-cycle costs, to fulfill the spirit of Decadal Survey recommendations.**
- **NSF-OPP should engage directly with the CMB-S4 project to enable CMB-S4 to move forward. Coordination between NSF-OPP, NSF-AST, and DOE is critical to ensure the success of CMB-S4 and enable the world-leading science and exciting discoveries that will be achieved with the project.**
- **NSF-OPP should actively engage with Argonne and NREL to move forward on a renewable energy plan for the South Pole.**
- **NSF-OPP should actively engage with the science community in determining science support requirements and determining how to prioritize science at the South Pole, including working directly with researchers who have experience at the South Pole, and incorporating the extremely high priority given to CMB-S4 at the South Pole by the Astronomy decadal survey, the Particle Physics Project Prioritization Panel (P5), and the 2015 Antarctic Strategic Vision NAS report.**

Recommendations (Dark and Radio Quiet Skies)

- **NSF, NASA, and DOE should share information as broadly as possible to facilitate strong advocacy for domestic and international satellite brightness regulations.**
- **All three agencies should provide quantifiable data and sensitivity limits for existing and soon to be completed optical/infrared facilities in a coordinated and consistent fashion to better inform regulatory agencies and shape policy. Doing so will allow policy decisions to be appropriately quantitative and data-driven.**
- **NSF, NASA, and DOE should work with global partners to facilitate advocacy for treaty-level cooperation that will be essential for satellite brightness regulations to be effective.**
- **NASA should provide a report on how its missions are impacted by satellite contamination or confusion. The requested report should include a discussion of the effect of unmitigated satellite trails and debris on current and future Planetary Defense capabilities, including the Near Earth Object Observations Program. The committee would like to know if this critical monitoring program will be disrupted by the particularly bright reflections of these satellites during twilight – the only window to search for hazardous objects in the inner solar system. We also request reporting on the expected impacts of satellite constellations on NASA's observatories in low-Earth orbit, including the Hubble Space Telescope.**
- **We request that NSF provide quantifiable data and sensitivity limits for existing and soon to be completed facilities operating in the radio band in a coordinated and consistent fashion to better inform regulatory agencies and shape policy. Doing so will allow future policy decisions to be appropriately quantitative and data-driven.**

Recommendations (TDAMM, Data, Profession, Climate)

- **NASA and NSF should coordinate construction and operations for ground-based and space-based operations to maximize the scientific return of new space-based missions. NSF should also facilitate clear communication between LIGO and the community to allow maximal impact from future space-based missions.**
- **As requested in the 2020 AAAC report, the agencies and the AAAC should initiate a review of the 2014 Principles for Access to Large Federally Funded Astrophysics Projects and Facilities. Any findings and recommendations from the Flatiron workshop should be considered in updating the Principles for Access.**
- **NSF and DOE should report statistics to the AAAC on the number of instances of code of conduct investigations in award applications (NSF) or DOE-hosted conferences. NSF should also report challenges faced in implementation of the institutional reporting, for example, with regards to policies on privacy that vary from state to state.**
- **NASA and DOE should evaluate which aspects of the NSF OECR award policy on harassment can be adopted in their own processes.**
- **Contrary to the Decadal Survey recommendation, NSF-AST, DOE Cosmic Frontier, and NASA should not set up a cross-agency task force, but should rather coordinate with the NSF Director's Office, OMB, and OSTP in establishing criteria for demographics data collection. Only through a joint effort with OSTP and OMB will a minimal set of requirements be established in a holistic way that spans federal agencies.**
- **NSF should share their successful experience at the Gemini Observatory with other ground-based observatories of NSF and DOE to determine if this model can be implemented on a larger scale.**
- **NSF and DOE should develop programs specifically for supporting transitions to renewable power systems, given the operation budgets of observatories are generally not allowed for this kind of infrastructure upgrades. This specific funding should cover not only large observatories, such as the facilities in NOIRLab, but also mid-size and even small observatories.**