Outline of Analysis Studies Conducted by NASA Cosmic Origins Program Analysis Group Members During the Past 10 Years

Theme Areas: Star and Planet Formation; Stars and Stellar Evolution; Resolved Stellar Populations and their Environments; Galaxy Evolution

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An Informational White Paper for the NAS Astro2020
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Abstract

We outline several analysis studies that have been conducted by the NASA COPAG since the Astro2010 Decadal Survey was performed. These studies have been conducted by members of the Cosmic Origins community in support of decision making by Dr. Paul Hertz, Director of the Astrophysics Division at NASA SMD. The studies are intentionally free of advocacy and make every effort to lay out the current state of the discipline in each case (when written), and to use that information to assess possible options or strategic paths forward that NASA might choose to make, and the outcomes that such actions may yield. These reports have been in the public domain for several years and are summarized and presented together here for the information of the Astro2020 Decadal Survey Committee. We make no specific case or position statement in any of the reports, but merely provide information that may be of use to the Committee in their deliberations.

Overview

The COPAG serves as a community-based, interdisciplinary forum for soliciting and coordinating community analysis and input in support of Cosmic Origin objectives and of their implications for architecture planning and activity prioritization and for future exploration. It provides findings of analyses to the NASA Astrophysics Division Director.

The Cosmic Origins Program Analysis Group (COPAG) is constituted by the NASA Astrophysics Division Director to support community coordination and analysis of scientific and technological issues impacting NASA's Cosmic Origins (COR) Program (https://cor.gsfc.nasa.gov/copag/COPAG-Terms-Reference.pdf). In the past, the COPAG has supported analysis of technological priorities for potential future Cosmic Origins strategic missions, organized workshops on future missions' science goals, constituted Science Analysis Groups to identify ways to maximize COR science returns from future missions such as JWST and WFIRST, and explored ways for the US science community to pursue Spica-like science. The COPAG organizes open meetings and workshops for science community members.

All COPAG substantive activities—meetings, workshops, Science Analysis Groups (SAGs), Science Interest Groups (SIGs), telecons, or other core work—are open to participation by the community. The COPAG is coordinated by an Executive Committee, which meets biweekly by telecon.

Over the past decade the COPAG has formed several SAGs with specific tasks and areas of analysis defined so that their findings would be of specific interest and information to the deliberations of the NASA SMD leadership. This paper lays out what those groups were formed to do and to inform the NAS Astro2020 Decadal Survey Committee of the location of their final reports, which the Committee may choose to take into account when forming their decisions and priorities for the next decade. Three SAGs – numbers 1, 3 and 5 – were formed but did not complete their intended work and did not file a final report.

SAG #2 - 4-meter Space Telescope Design Concepts for a UVOIR / ExoPlanet Mission

This SAG was formed with the specific intent to study possible mission design concepts that were based on a 4m mirror form factor but that were focused on the specific goals and guidelines issued by the Astro2010 Decadal Survey report concerning what technologies would need to be developed to enable specific capabilities. The resulting report lays out several mission design concepts that were consistent with these goals and identified specific technologies that were critical for investment and development to allow the risk to be retired on any proposal that might be made using these designs. The resulting report informed strategic considerations for investment by technology opportunities through the regular NASA funding mechanisms.

Report: https://cor.gsfc.nasa.gov/docs/Lillie_SAG2.pdf

SAG #4 - Technologies for a future far-IR mission

Similar in many ways to the efforts of SAG #2, this SAG focused on the technologies necessary to enable a strategic plan for space-based astronomy in the FIR. It took as its starting point an original document developed by the community and input to the 2010 Decadal Survey, and broke out the details to identify specific technology investments that would allow such a plan to be executable. The report lays out the technologies themselves, the goals for development, the (then) state of the art, existing facilities that could be used, and identifies specific stakeholder groups and projects that would benefit from successful development.

Report: https://cor.gsfc.nasa.gov/docs/COPAG_SAG4_report_final_Nov2013.pdf

SAG #6 - Cosmic Origins Science Enabled by the WFIRST-AFTA Coronograph

The Wide-Field Infrared Survey Telescope (WFIRST) was the highest priority large space mission recommended by the 2010 Decadal Survey in Astronomy and Astrophysics. It was designed to perform wide-field imaging and slitless spectroscopic surveys of the visible to near-infrared sky. The Astrophysics Focused Telescope Assets (AFTA) study design of the mission made use of an existing 2.4m telescope to enhance light collecting and imaging performance. The main instrument is a wide-field multi-filter imager with infrared grism spectroscopy. It also features a small-field low-resolution integral field spectrograph. A coronagraph instrument was part of the study and has a primary science focus of direct imaging of gas-giant exoplanets and debris disks.

The WFIRST-AFTA Science Definition Team solicited community input for potential WFIRST-AFTA coronagraphic science investigations related to NASA's Cosmic Origins (COR) theme or Physics of the Cosmos (PCOS) theme. Such science investigations could further enhance the science case for the AFTA-study design that includes the coronagraph. While not a primary driver for coronagraph design, science investigations other than exoplanet and debris disk studies might provide helpful insight for future design choices.

SAG #6 was formed to analyze the submissions received in response to this call, and to document this analysis in a report to the Astrophysics Subcommittee. The SAG also solicited additional scientific input from experts in the community to include in its report.

Report: https://cor.gsfc.nasa.gov/sags/COPAG_SAG6_final_report_Jan2015.pdf

SAG #7: Cosmic Origins Science Enabled by Operations Overlap of the Hubble Space Telescope and the James Webb Space Telescope

The James Webb Space Telescope (JWST) was (originally) scheduled for launch in October 2018, with science operations to commence in mid 2019. The Hubble Space Telescope is presently expected to continue operations that will enable at least one year of science observation overlap with JWST. Both observatories offer exquisite imaging, exceptional pointing stability, and a broad array of instrumentation that can be used to study astrophysical objects ranging from planets in the Solar System to distant galaxies. Much of the science conducted with JWST will build off of existing Hubble data and science results. However, it is expected that the astronomical community will have compelling ideas for Cosmic Origins investigations requiring observations with both observatories in the timeframe in which their operations overlap. These observations need not be simultaneous, but they may require concurrent or follow-up observations from one or both observatories to maximize their scientific potential.

SAG #7 was formed to engage the astronomical community in outlining the scientific case for having HST and JWST operations overlap:

- Are there precursor observations that HST should do prior to JWST launch that might not otherwise be done through the regular time allocation process?
- Are there compelling science cases for simultaneous HST–JWST observations?
- Are there compelling science cases for HST follow-up of JWST observations or discoveries?
- Are there expected discoveries by other facilities in the 2020 timeframe (such as Euclid or LSST) that would require follow-up by both HST and JWST?

The SAG analyzed the input it received from the community, identified compelling Cosmic Origins science requiring simultaneous operation of HST and JWST, and determined if there were science drivers that may be of benefit in planning early operations of JWST or extended operations of HST.

Report: https://cor.gsfc.nasa.gov/sags/COPAG_SAG7_FinalReport.pdf

SAG #8: Cosmic Origins Science Enabled by the WFIRST-AFTA Data Archive

Achieving the full science potential of WFIRST-AFTA (see above) will require input from the astronomical community on how it intends to use the vast WFIRST-AFTA data archive for Cosmic Origins science. The infrared surveys and coronagraphic investigations will provide abundant opportunities for archival research. The high latitude wide-field infrared survey alone is expected

to observe more than 500 million galaxies over a 2000 square degree area at a resolution of about 0.11 arc seconds in four broad near-infrared passbands. An active Guest Observer program will further populate the archive with a multitude of datasets. A cross-section of archival Cosmic Origins science investigations would be valuable input in the formative stages of the mission for discussions of high-level science products, catalogs, archive interface design, calibration requirements, data accessibility and distribution, computing resources, and archive operations.

SAG #8 was formed to analyze how the archive is to be used and scope the data requirements necessary to conduct science investigations related to the Cosmic Origins theme. The SAG solicited input from the community to identify the types of investigations that would be conducted, and the kinds of data products that would be valued and needed. The SAG also considered what other assets or efforts may be needed to maximize the science return from the WFIRST archive (e.g., coordination of WFIRST-AFTA data with LSST, Euclid, or JWST; GO funding for ground-based observations or theoretical studies).

Report: https://cor.gsfc.nasa.gov/sags/SAG8_Final_Report.pdf

SAG #9: Science Enabled by Spitzer Observations Prior to JWST Launch

The James Webb Space Telescope (JWST) was (originally) scheduled for launch in October 2018, with science operations commencing in mid 2019. The Spitzer Space Telescope was expected to continue operations through 2015, but was not expected to still be operational at the time that JWST began science observations. Much of the science conducted with JWST will build off of existing Spitzer data and science results. Spitzer entered a new phase of many years of its Warm Mission, which enables imaging with the IRAC two shortest wavelengths, 3.6 and 4.5 micron, at ~1.9" resolution, over a 5' x 5' field of view. These capabilities offered unique science opportunities, and it was expected that the astronomical community would have compelling ideas for Cosmic Origins investigations with JWST, that would require Spitzer precursor observations.

SAG #9 was formed to engage the astronomical community, the Spitzer User's Committee, and JWST Science Working Group in identifying compelling science to be done with JWST, that would be enabled by or that would benefit from large blocks of Spitzer observing time prior to JWST launch. Science areas to be explored included, but were not limited to:

a. extrasolar planets and planetary systems
b. the properties and structure of the Milky Way and its components
c. nearby galaxies
d. galaxy evolution and cosmology.

Within each of these science areas, the unique contributions that the Spitzer capabilities could offer were considered, in light of past results. The SAG also included and analyzed the results of SAG #7 (Science enabled by operations overlap of HST/JWST) to determine whether the science cases identified by SAG #7 would also benefit from new Spitzer observations.

Report: https://cor.gsfc.nasa.gov/sags/SAG9_Report_v5.pdf

Concluding Remarks

We present these reports and their findings to the NAS Astro2020 Decadal Survey Committee in the hope that they will be useful when considering the events of the past decade, but also in terms of informing possible new synergies between observatories currently under construction for flight in the next decade, such as JWST and WFIRST, as well as informing any possible prioritization of new strategic developments as we look into the new decade. We also note several community-based activities derived from our Science Interest Groups. Results of surveys (Scowen et al 2013) and a 2015 workshop on the future of UV-visible astronomy from space (Scowen et al 2017) are available.

References

- "Scientific objectives for UV/visible astrophysics investigations: a summary of responses by the community," 2013, Paul A. Scowen, Mario R. Perez, Susan G. Neff, Dominic J. Benford, *Experimental Astronomy*, November 2013, Springer Netherlands, 0922-6435 (print), 1572-9508 (online).
- "Finding the UV-Visible Path Forward: Proceedings of the Community Workshop to Plan the Future of UV/Visible Space Astrophysics" 2017, Paul A. Scowen et al., PASP, 129, 600.