

# NASA ADVISORY COUNCIL

## ASTROPHYSICS SUBCOMMITTEE

November 19, 2013

Teleconference

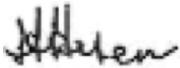
MEETING MINUTES



December 11, 2013

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Brad Peterson, Chair



December 11, 2013

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Hashima Hasan, Executive Secretary

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Tuesday, November 19, 2013

Welcome and Introductions

Dr. Bradley Peterson, Chair of the NASA Advisory Council (NAC) Astrophysics Subcommittee (APS), opened the meeting by welcoming the participants and calling roll.

Astrophysics Division Update

Dr. Paul Hertz, Director of NASA's Astrophysics Division (APD) explained that the United States invests in astrophysics because we want to understand how our universe began and evolved; how galaxies, stars, and planets came to be; and if we are alone in the universe. These questions flow through the Decadal Survey (DS) and the various NASA strategic plans to become goals and objectives for APD to realize. These are compelling questions that resonate with the public and the science community.

The budget for astrophysics, including the James Webb Space Telescope (JWST), supports a good program. APD operates a number of large and small missions, along with multiple great observatories. The Science Mission Directorate (SMD) is building JWST, which is on schedule and on cost. APD also contributes to international missions, has begun two new Explorer projects, supports a range of individual investigators, and is preparing for the mission to follow JWST.

However, the budgetary future remains uncertain, requiring difficult choices. APD is operating under a Congressional Resolution (CR) and does not know whether the final appropriation will be closer to the Fiscal Year (FY) 2013 budget or the President's FY14 budget request. There may be a need for reductions and content cuts, necessitating identification of high and low priorities. Budget reductions are likely to reflect such priorities rather than be spread evenly across the Division.

Although APD tries to follow DS priorities, it is not possible to implement the DS exactly as written due to budget differences. While the Division wants to make progress in smaller areas, such as suborbital flights and Explorers, the highest priority is to prepare to start a mission when funds are available following the launch of JWST. To that end, the Wide Field Infrared Space Telescope (WFIRST) is of great importance. APD is studying a concept for WFIRST using the 2.4-meter telescope assets made available to NASA by the National Reconnaissance Organization (NRO). Specifically, a team is examining how to best use one of the mirrors and build a mission around it. A science definition team (SDT) has identified the needed technology investments. APD is also studying several probes in the event that WFIRST does not follow immediately after JWST. These include an internal and an external occulter, as well as an x-ray probe.

APD has asked the National Research Council (NRC) to compare the SDT report to the DS and determine if the report's WFIRST concept would be responsive. APD will also ask the NRC in early 2015 to conduct an ad hoc comparison of mission concepts against the DS recommendations. In addition, there will be a mid-DS review in 2015/16.

Regarding NASA participation in the European Space Agency's (ESA) upcoming L2 and L3 missions, NASA has told ESA of NASA's interest in partnering on missions that are responsive to the DS. ESA has been receptive to this idea.

Dr. Joel Bregman observed that the big projects follow the DS, while the smaller things, like the small Explorers (SMEXes) are chosen by committees that can ignore the DS priorities. He asked if NASA would ever restrict the selections to the DS recommendations. Dr. Hertz replied that the Explorer competition is referenced in the DS, which also addresses the kinds of science to be done. Dr. Fiona

Harrison added that the DS specified that Explorers are to broaden the science portfolio beyond what is in the DS, and are not to be prescribed. Dr. Gabriela Gonzalez asked if there had been any talk about equal partnerships with ESA. Dr. Hertz replied that ESA has been explicit about not wanting international partners to be responsible for more than 20 percent of an ESA-led mission.

The Astrophysics-Focused Telescope Assets (AFTA) study of the NRO telescope assets did an original costing based on a strawman concept. As that concept matures, APD continues to track the likely costs. At this time, it appears that the cost of a WFIRST mission with the NRO telescope assets but without the optional coronagraph and uncertainty about the launch vehicle is comparable to the cost of a WFIRST mission built from the ground up. This will be studied further. APD is mindful of the DS recommendation that large missions should not cost more than \$2 billion, and a WFIRST mission should be \$1.5-2 billion. All probes are defined as costing less than \$1 billion.

Dr. Chryssa Kouveliotou added that the x-ray community had defined four possible missions. If ESA goes forward with the proposed Athena-plus mission, the science will not cover all of these possibilities. This leaves open the option of at least one U.S.-led x-ray probe. Dr. Hertz explained that the purpose and timing of the probes is to inform what the Division will do after JWST. If NASA is doing an x-ray mission with ESA, APD would not also recommend a NASA-led x-ray mission. However, that does not mean that x-ray missions will not be priorities in the next DS.

Dr. John Nousek said that he understands that ESA likely to want to move ahead swiftly if they announce an x-ray L2 launch. He asked how Dr. Hertz envisioned NASA's decision being made. Dr. Hertz said that when ESA is ready, there will be discussions about where the United States could contribute. At the highest level, he can imagine NASA negotiating to contribute a capability, then having a competition for provision of that capability.

Dr. Hertz next discussed the impact of the October shutdown of the Federal government. The major effect for APD was that the annual Antarctic long duration balloon (LDB) campaign, involving three flights, had to be cancelled due to the lost time. Since there are already three payloads planned for next year, APD will have to determine how to address the situation. There can only be three Antarctic balloon payloads per year. The shutdown also caused the cancellation of nine Stratospheric Observatory for Infrared Astronomy (SOFIA) science flights with U.S. instruments. The commissioning of the First Light Infrared Test Experiment Camera (FLITECAM) was affected as well. There were other impacts, which APD is still assessing.

Dr. Eric Smith, Acting Program Director for the JWST Program Office, added that the impact of the shutdown was being assessed for that mission. Any effects would be felt first in the telescope area (because the telescope is on the critical path). Telescope backplane testing was halted at Marshall Space Flight Center (MSFC), and a revised schedule was developed. However, this will not affect the 2018 launch date. Many activities were able to continue due to pre-funding of contractors. The two biggest impacts were with backplane testing at MSFC and the Integrated Science Instrument Module (ISIM) cryo-testing at Goddard Space Flight Center (GSFC).

Fifteen of the 18 JWST telescope segments are at GSFC, as are all of the science instruments. The backplane has been delivered to Northrup Grumman. There were a few software issues uncovered in the Fine Guidance Sensor (FGS) during the ISIM testing – but those are being worked by the Canadian Space Agency, and the Near Infrared Camera (NIRCam) has started replacing its detectors. JWST spacecraft is completing the critical design review, which was affected by the shutdown. The sunshields and other elements are coming together.

The mission has liened more fiscal 2014 funding reserves than expected at this point. A primary job of project managers this year will be to regulate spending. A number of technical issues remain, including the cryo-cooler and its compressor assembly with manufacturing issues, and a nonexplosive actuator employed to hold the telescope down to the spacecraft during launch, which is not meeting the shock requirements and will be redesigned. Stray light issues have been a problem for the mirrors, and this is being addressed. JWST remains on schedule and on budget, with FY14 as the peak funding year.

Dr. Hertz next discussed the Kepler mission. The analysis of the mission's first 3 years resulted in over 3,500 planet candidates. The smaller planet category grew the most. Kepler is sampling the habitable zone and has found 104 Earth-size and super-Earth size candidates. The Kepler spacecraft is still being held in the point-rest-state, which is stable and conserves thruster fuel. The two-wheel operating mode and science campaign, based on a call to the community for ideas, is called K2. Engineering tests have been done to determine the stability of two-wheel operations, and a report is due soon on results of tests and assessment of the quality of science that can be done, the feasibility of the engineering, and the cost of the science. If continued operations are deemed feasible, Kepler will continue through to the senior review. Otherwise, the mission will move to termination. Dr. Hertz explained that when these wheels fail, they create noise from friction and progress to complete failure rapidly. The remaining wheels give no sign of this, but he cannot predict how long they will last.

SOFIA is flying science flights and is in Cycle One of the Guest Observer program. The full operational capability has been delayed to spring of 2014, and the vehicle will undergo heavy maintenance in Germany during the summer and fall 2014. Cycle Two science will be done both before and after the heavy maintenance period. SOFIA is not close to going to senior review. When the mission enters formal operations, the clock starts on its 20-year lifetime and flight requirements to meet full flight hour requirements within 4 years.

Regarding the NRO telescope assets WFIRST, in May 2013 the NASA Administrator gave APD permission to continue studying them and to preserve the option to follow JWST. The Administrator also made APD responsible for these assets for the Agency. Any decision to use them will be made no earlier than the FY17 President's budget request. The DS had WFIRST beginning in 2011, but it will start no earlier than 2017. APD is trying to implement other DS recommendations, like increasing the Explorer budget. Only large missions are being delayed until the launch of JWST.

Dr. Hertz drew attention to the Research and Analysis (R&A) program selections. In core elements, such as the Astrophysics Research and Analysis Program (APRA), Astrophysics Data Analysis Program (ADAP), Origins of Solar Systems (OSS), the selection rates have fallen to around 12 percent. This has been driven by sequestration and the increased number of proposals, both of which lowered the selection rate. If APD receives a lower budget, there will be even more pressure here. Dr. Hertz would like to discuss this at the next APS meeting, because low selection rates mean a lot of effort goes into writing and reviewing proposals that are not funded. The selection rates have to be more robust in order to make the effort worthwhile. The Division had to rephase R&A grants due to sequestration, and a further reduction will cause a cascading effect.

A graphic of the budget with and without JWST showed that if the APD budget is reduced further, the Division will have to adjust its plans. JWST is the highest priority of the Science Mission Directorate (SMD). In FY13, APD took the following steps to address reduced funding due to sequestration:

- Reduced carry-over for operating missions, to include rephasing of guest observer funds;
- Rephased unneeded FY13 reserves for developing missions;
- Rephased R&A funding until FY14 for some principal investigators (PIs) and reduced selections;
- Slowed development of current and future Explorers; and

- Postponed needed upgrades in infrastructure programs.

The President's FY14 funding request for APD is \$642 million.. For JWST, the funding request comes to \$658 million. APD is funding projects only as needed to stay on track. If the CR is annualized, APD would be \$35 million down from the planning budget. The House and Senate are proposing different numbers altogether. Dr. Hertz provided some programmatic budget details, noting that APS can recommend to NASA prioritization for allocating budget reductions under a sequestration.

After showing a graphic of the status of completed and pending launches, Dr. Hertz said that APD expects to issue a SMEX announcement of opportunity (AO) in 2014, with the expectation of a launch by the end of the decade.

#### PhysPAG Update

Dr. John Nousek reviewed the charter for the Physics of the Cosmos Program Analysis Group (PhysPAG) and listed the current members of the Executive Committee. Nominations for EC membership for the term January 2014 – December 2016 are being reviewed by HQ and the PCOS Program Office, with targeted selection by mid December. Dr. Nousek then described the program objectives and drivers of APD's Physics of the Cosmos (PCOS) program. In the DS, two of the top four large missions are in the PCOS area.

At the upcoming American Astronomical Society (AAS) meeting in January 2014 in Washington DC, the PhysPAG will hold a meeting. Dr. Hertz said that he hoped to speak with all three Program Analysis Groups (PAGs), though logistics were still being determined.

The X-ray Science Interest Group (XRSIG) has taken the initiative to provide analysis for possible NASA contributions to the L2 mission, to be selected in 2014 by ESA. This analysis was initiated by the X-ray community through the XRSIG; Dr. Nousek reassured the APS that he will keep them informed on the initiative. Dr. Hertz concurred.

#### Astrophysics Roadmap Presentation and Committee Discussion

Dr. Kouveliotou explained that the Roadmap, entitled "Enduring Quests, Daring Visions," is not a mini-DS, but rather serves as a long-range vision document. Once APS has approved and accepted the final draft, the team will disband. Delivery of the final report is planned for late December, 2013.

The Roadmap addresses the same three core questions Dr. Hertz spoke of earlier, though in reverse order:

- Are we alone?
- How did we get here?
- How does the universe work?

To address the question "Are we alone?", the Roadmap discusses the following topics:

- *The exoplanet zoo: Complete the census of exoplanets.* Much has been done in this area and the work will continue with WFIRST and other missions.
- *What are exoplanets like? Comparative planetology.* Scientists need to know the sizes, masses, and spectra of planets.
- *The search for life: Pale blue dots.* This will involve identifying and characterizing habitable planets.

Dr. Kouveliotou described challenges and likely missions in each of these areas. They are further divided into three eras: near-term, formative, and visionary.

Under the question “How did we get here?”, the Roadmap emphasizes the following areas:

- *Stellar lifecycles: Evolution of the elements.* This area will chart stellar nurseries, characterize supernovae, and establish the stellar initial mass function over a range of scales and environments.
- *Archaeology of the Milky Way and its neighbors: Study the fossil records.* This effort will characterize the elements and structure of our galaxy.
- *The history of galaxies: Monsters in the middle.* For this topic, scientists will study galaxy growth and the behavior and characteristics of black holes.
- *The history of galaxies: Manufacturing and assembly.* Scientists will characterize the physical nature of the first galaxies and examine the behavior of the gasses that comprise them.

The final question, “How does the universe work?”, will consider these general topics:

- *The origin and fate of the Universe: The Big Bang.* Studies here will focus on cosmic evolution and where the trajectory is taking us.
- *Extremes of nature: Black holes.* The goal is to understand the accretion-driven engines.
- *Extremes of nature: Neutron stars.* Investigators will determine the composition and interactions of particles at the neutron star cores.
- *Listening to the Cosmos: The Gravitational Wave window.* For this topic, investigators will use gravitational wave data to track the expansion of the universe.

Finally, Dr. Kouveliotou said that public engagement in connecting through astronomy is the highest priority. The Roadmap team devised four key elements of this important function:

- Engage the entire continuum of astronomy learners;
- Recognize that the cornerstone of communicating astronomy is unique data;
- Move audiences from online to in-person involvement; and,
- Ensure diversity and inclusion through science, technology, engineering, and mathematics (STEM) education success.

To realize the vision, the Roadmap team suggested notional missions and technologies envisioned as necessary to address the enduring quests over the next 30 years. The team came up with five surveyor missions for the formative era and four mappers for the visionary era. These will include a number of probe-scale missions that provide a range of measurements.

The formative era surveyors include a gravitational wave surveyor, cosmic microwave background (CMB) polarization surveyor, far-infrared (FIR) surveyor, large UV/optical infrared (LUVOIR) surveyor, and x-ray surveyor. The visionary era mappers are all interferometers, and include a gravitational wave mapper, a cosmic dawn mapper, an exo-earth mapper, and a black hole mapper.

The challenges inherent in visionary science lead to a need for cross-cutting and game-changing technologies, such as bigger and better telescopes, new ways to assemble and test them, improved mirrors, on-orbit fabrication, and the use of 3-D printing.

The Roadmap team would like to see at least some of the following “daring visions” become reality:

- Sense the ripples in gravity out to the edge of the universe;
- Chart the warped space of a black hole and reveal how black holes power the greatest outflows of energy in the cosmos;

- Tell the complete the story of galaxies – from quantum fluctuations through first light to the present day;
- Reconstruct the complete star formation, structural, and chemical history of the Milky Way and its neighbors;
- Map the surface of an Earth-like planet; and,
- Find evidence of life beyond the solar system

#### *Discussion*

Dr. Karl Stapelfeldt praised the report. He noted that the audience will likely be non-experts from within the government, such as Office of Management and Budget (OMB) staffers. He asked about the plan to have additional reviews by non-astronomers. Dr. Kouveliotou replied that an earlier draft was given to scientists who had served at the OMB and other government positions. The reviewers indicated that there is a different level of discussion by segment – some are easier to understand and others are more complex. However, they were also told not to forego the science. The most important part of the document for OMB staff and other non-scientists is the executive summary.

Dr. James Bock expressed concern that the report did not mention Explorers. While the Roadmap is to be visionary, much of the new science comes from Explorers. Dr. Kouveliotou explained that the team was instructed to consider the probe and bigger size notional missions. Smaller competed missions such as the explorers were not in the scope of the task.

Regarding APS comments and document approval, there were Subcommittee members who were ready to approve it with some minor modifications, and others who wanted to wait until the next version. Dr. Peterson noted that the community has had opportunities to contribute. The December release is final. Dr. Kouveliotou further explained that, given the small number of pages the Roadmap team had to work with, not all topics were covered as comprehensively as some would like. Additional APS comments would be considered and, if appropriate, incorporated.

Dr. Terry Oswalt moved to approve the report, and Dr. Edna DeVore seconded. Dr. Peterson conducted the vote by roll call. Dr. Bock said that he was voting not to approve the report due to the need for better balance of costs. Dr. Peterson explained that the Roadmap team had been told not to consider costs, and that was noted in their charter. Dr. Bregman abstained. Drs. Julianne Dalcanton, DeVore, and Giovanni Fazio voted to approve. Dr. Scott Gaudi abstained, as he was on the Roadmap team. Drs. Gonzalez and Harrison voted to approve. Dr. Kouveliotou abstained, as she was on the team. Dr. Gary Melnick abstained. Drs. Oswalt, Sembach, and Stapelfeldt approved.

The motion passed and the report was accepted. The Roadmap would consider the APS comments. It was later clarified that the votes of Drs. Peterson, Gaudi, and Kouveliotou were procedural abstentions. Aside from them, there were eight votes in favor of accepting the report, one against, and two non-procedural abstentions.

#### Explorer Program Update

Dr. Wilton Sanders explained that current APD Explorer missions include Swift, Suzaku, and NuSTAR, all of which will be subject to the 2014 senior review. ASTRO-H is being developed in conjunction with the Japan Aerospace Exploration Agency (JAXA), and the Transiting Exoplanet Survey Satellite (TESS) and the Neutron Star Interior Composition Explorer (NICER) are in formulation. In late summer/early fall of 2014, APD plans to issue an AO for a SMEX and a Mission of Opportunity (MO) for launch dates in 2020. Another AO is planned for an Explorer and a MO no earlier than 2016, for launch around 2022.

A Community Announcement of the upcoming SMEX AO was recently released, with a draft AO release planned for spring of 2014 and the final AO release in late summer/early fall of 2014. Proposals will be due 90 days after the final AO is issued. The PI cost cap will be \$125 million for the SMEX, not counting the costs of the launch vehicle or transportation to the International Space Station (ISS). Dr. Sanders anticipated three categories of MOs: Partner MOs, New Missions using Existing Spacecraft, or Small Complete Missions. The PI cost cap for suborbital MOs is \$35 million, while other MOs will have a \$65 million PI cost cap. Step 1 will fund two or three SMEXes at \$1 million each and one or two MOs for \$250,000 for concept studies. Step 2 will result in a down-select for one SMEX and one MO. Although the last MO solicitation did not have two steps, the two-step process results in a better product with SMEXes, so it is being applied to MOs as well.

There was discussion that, despite adjustments, the cost cap might not be keeping up with inflation and real cost changes. Dr. Sanders explained that an increased cost cap would be likely to affect the AO cadence, but he would consider APS recommendations. Dr. Melnick noted that proposals always push up against the cost cap, no matter what it is. He suggested that APS devote a teleconference to the issue of increment and cadence. Dr. Harrison thought that APS would be able to make a better decision on this if the members had data and time to think about it. Dr. Melnick questioned whether a SMEX was really appropriate at this time, adding that the cost caps should increase significantly. Dr. Sanders said that any re-evaluation of the costs and cadence should occur before the AO.

Dr. Harrison recommended that APS consider this situation. She would also like to see a MIDEX opportunity. Dr. Sanders explained that the current Explorer (EX) is essentially a MIDEX and that the DS advised a cadence for SMEXes and MIDEXes. Dr. Harrison said that this was even more reason to reconsider costs. Data on the program history and science output would be essential, along with actual cost data on the MIDEXes. Dr. Peterson noted that his concern was that it is becoming difficult to do high-impact astronomy missions at the SMEX level. He would prefer fewer, more capable missions.

Dr. Sembach asked if the \$125 million SMEX cost cap also applies to SMEXes on the ISS. Dr. Sanders said that the cost cap would be for the payload. Dr. Sembach added that he had heard from community members who were unhappy with the evaluation findings of debriefings from prior reviews, specifically comments indicating that the science was too broad. He asked how cost played into that, especially regarding missions proposing multiple investigations for the same cost. Dr. Sanders explained that sometimes the science goals were unfocused or scattered, and the proposers did not convince the reviewers that the proposed projects would do anything particularly well. It is not a matter of Explorers being required to have only one activity.

Dr. Peterson advised an offline discussion looking at Explorer cost caps, to come back to the Subcommittee. The members agreed, and this was taken as an action item.

#### E/PO Status Update

Dr. Jeff Hayes discussed the current state of affairs regarding SMD's education and public outreach (E/PO) function. Nothing was settled at the time of the teleconference. The Offices of Communications and Education at NASA Headquarters control the function, with input from and activities by the four mission directorates and the four NASA field centers. Under the CR, NASA will continue doing E/PO. However, with the funds lost under sequestration and new money hard to find, this remains complicated. As of November 8, 2013, authority to approve or deny SMD E/PO waivers was delegated back to SMD for the duration of the CR.

Dr. Hayes reviewed how SMD conducts E/PO, noting that the Directorate is very effective in this function. Evaluation plans examine a number of criteria, such as whether the E/PO programs are telling people something they can understand and retain. SMD wants to be able to show NASA and its stakeholders – especially Congress and the Office of Science and Technology Policy (OSTP) – that its education activities make a difference. SMD's E/PO efforts are seen as a model by the rest of NASA.

Dr. Peterson asked for more information about program assessment, particularly whether the E/PO programs are meeting their goals. It was explained that each mission has an evaluation plan, and the methodology is based on the scope of the mission and tailored to the project. The measurements gauge various impacts, such as reach and learning gains by teachers and students. Dr. Denise Smith, Astrophysics Science Education and Public Outreach Forum (SEPOF) Lead, offered to share with APS a recent paper on this topic.

Dr. Sembach expressed concern about transparency in E/PO decision-making and asked about the mechanism by which the community might gain insight into this area. Dr. Hertz replied that Dr. Sembach had asked two questions: How can the community find out what is going on, and how can the community participate? The E/PO consolidation situation, the current process, and how to manage it is not an APD or even SMD decision. Rather, it is addressed at the Agency level. The meetings of internal NASA management groups are not public. The Office of Education will have a leadership role regardless of what happens, however. The Office has an advisory committee under the Federal Advisory Committee Act (FACA) structure, and the community can provide input there. Meanwhile the project personnel have not been told what is going on because no decisions have been made that APD can transmit. Dr. Sembach observed that there are many dedicated E/PO people who want to help NASA succeed in making science available to the public, and it would be good to give them some reassurance that their input would be helpful. Dr. Hertz said that APD values the Division's E/PO partners, and has no doubt in the quality of their work. Although it looks like NASA will continue conducting E/PO at least for the duration of the CR, the guidelines after that are unknown. APD will communicate the decision once it has been reached.

#### CoPAG Update

Dr. Sembach began the update of the Cosmic Origins Program Analysis Group (CoPAG) activities by listing the members of the executive committee and noting that the committee was seeking new members. CoPAG currently has five science analysis groups (SAGs).

SAG 1 addresses the science objectives of a 4-8 meter UV/optical mission. CoPAG asked that this SAG be formally closed, as it has been superseded by other efforts. SAG 2, which addresses technologies for a 4 meter-class monolithic telescope UV/optical mission with internal coronagraph, has also been superseded by other efforts, and CoPAG sought to close it as well.

SAG 3 was to have dealt with technologies for an 8 meter-class segmented telescope UV/optical mission with an external occulter, but it never truly got started and was also superseded by a number of other efforts. CoPAG was requesting permission to close it, too. SAG 4 completed its work on technologies for a future far-infrared (IR) mission. CoPAG asked to have this SAG formally closed upon acceptance of the report by APS. However, SAG 4 wanted APS comments first. SAG 5 focuses on the science objectives and technical requirements for a series of cosmic origins probes. The work was on hiatus, but the SAG expected to issue a report to APS in early 2014.

In summary, CoPAG wanted to close SAGs 1-3, and close SAGs 4 and 5 upon acceptance of their reports.

CoPAG also hoped to start several new initiatives. SAG 6 would be devoted to cosmic origins science enabled by the WFIRST-AFTA coronagraph. CoPAG did not receive as many submissions as it expected, and will seek more information if the mission does go forward.

SAG 7 would address cosmic origins science enabled by overlap between the Hubble and JWST. CoPAG has wanted to do this for a while, in order to bring the two missions more into the cosmic origins area and engage the community in outlining the science case. This SAG would identify any compelling science that requires both observatories operating simultaneously.

SAG 8 would examine the possibilities for cosmic origins science enabled by the WFIRST-AFTA data archive. Because of the many science investigations that could be done with WFIRST science, CoPAG wants its community to be able to provide input into the archive structure.

Finally, CoPAG wanted to authorize SIG 1, on far-IR cosmic origins science and technology development. This group would address long-term objectives, probably through a workshop and quarterly or semi-annual reports. This would be a longer-term effort.

Dr. Sembach asked that APS approve the closure requests and that the requests for the new SAGs and the SIG be approved.

Dr. Bregman thought some of the new SAG issues would be handled in calls for proposals. There is usually a strong science case for a project, for example, and it is years before the project is built. Dr. Sembach explained that these are not suggestions for key projects or efforts to supersede JWST science objectives. The goal is to understand any synergies that could be exploited if they are identified early enough. In addition, the community wants to be involved in defining the archives, which will help maximize the science returns. Dr. Stapelfeldt suggested that the proposed SAG 6 think more broadly and provide more input to the exoplanet SAGs, leaving more time for general astrophysics. Dr. Sembach agreed to talk with him about that.

Dr. Peterson asked that the closures of SAGs 1, 2, and 3 be voted on as a single motion. All APS members present voted their approval, except for procedural abstentions by Dr. Sembach, who is the CoPAG chair, and Dr. Dalcanton, who is a CoPAG member. The motion passed.

For SAG 4, it was decided that APS would review the report and vote at the next meeting. This was agreed upon by acclamation. The formation of the three new SAGs and the SIG were also voted on by acclamation, and passed with no opposition.

#### ExoPAG Update

Dr. Gaudi provided an update on the Exoplanet Exploration Program Analysis Group (ExoPAG). There are three active SAGs. SAG4 addresses the planetary measurements needed for exoplanet characterization and had recently completed a draft report. The final report was to be delivered at the next ExoPAG meeting. SAG8 deals with the requirements and limits of future precision radial velocity measurements. A final report is expected soon. Finally, SAG9 looks at the mission requirements and characteristics for an exoplanet probe to do medium-scale direct imaging.

ExoPAG's eighth meeting occurred in Denver on Oct. 5-6, 2013. It covered a range of topics, and some of the talks are available online. The focus was on updating the progress of the existing SAGs, a high-contrast imager in space, and measurement of near-Earths. There was also discussion of developing a broad, unified, and coherent exoplanet roadmap.

ExoPAG sought approval of two new SAGs. SAG10 would be tentatively entitled “Characterizing the Climate of Transiting Planets with JWST and Beyond,” and would ask what we need to know about exoplanet atmospheres, with a focus on transmission spectroscopy and whether JWST will provide the desired measurements. SAG11 is intended to address what the exoplanet community would need to do to prepare for and maximize the value of the WFIRST micro-lensing survey.

The exoplanet roadmap would include the entire exoplanet community in developing a broad picture of where this science should go in the next 5-10 years. This is not meant to duplicate the larger-scale APD Roadmap. This effort would have a shorter timescale and be more specific. The thinking is that if the exoplanet community can come to some consensus going into the next DS, there will be better chances for their priorities to be highly ranked. There was some consensus to pursue this effort.

Dr. Gaudi asked for APS approval of the two new SAGs and an endorsement of the roadmap activity.

Dr. Bregman was concerned that the new roadmap activity would cover the same territory as the APD Roadmap. Dr. Gaudi said that he did not mean to imply that it would choose missions. Rather, the goal is to identify measurements and capabilities needed for those measurements. Dr. Peterson explained that the APD Roadmap was a visionary document. Dr. Bregman noted that the APD Roadmap and the proposed ExoPAG roadmap would both discuss near-term and longer-term directions. Dr. Gaudi replied that the ExoPAG roadmap would not address the long term. The idea is to determine what is needed to get to a direct imaging flagship mission. It was suggested that the word “roadmap” might be confusing, and Dr. Gaudi agreed that another term might be better. He asked Dr. Bregman to further explain his concerns.

Dr. Bregman said that the DS tries to do this very same activity, and spends a lot of money and time in reaching out to the community. What made him uncomfortable was the possibility that this exercise might be misunderstood as taking the place of the DS solicitation of community input. He also felt that it might select or prioritize missions. Dr. Gaudi explained that, when giving input for the previous DS, the exoplanet community’s responses were very fragmented. The community wants some semblance of a consensus next time. Dr. Bregman replied that the risk is that this effort would be endorsed by APS, resulting in a statement about a plan on how to go forward. That is powerful in both good ways and bad. It might lead to crowding out other science fields, among other things.

Dr. Peterson suggested that this proposed group be designated a SIG. Dr. Gaudi noted that the ExoPAG charter calls on the PAG to gather community input and consensus on issues. This would have a broad scope and possibly be more powerful, but that was the idea. Dr. Sembach said that while Dr. Bregman made an interesting point about the document taking on a life of its own, any actions would have to go through APS, which would not want to endorse a conflicting roadmap. APS might tell the group to start over, or the Subcommittee might find the resulting document to be powerful. He suggested calling it a “capabilities matrix” instead of a roadmap, and asked Dr. Bregman if that would make a difference.

Dr. Bregman answered that a NASA outsider might see an APS-approved document as something that is set. He was further concerned that those outside the process would see this as advocacy. Dr. Sembach stated his belief that the purpose of the PAGs was to bring the communities together to discuss and endorse ideas about what NASA should be doing. Dr. Bregman thought that if this were being done by the other PAGs, it would be seen as more even-handed.

Dr. Harrison was not sure how someone could mistake this as coming from NASA, Dr. Peterson said that it is a way to reach to the community, Dr. Stapelfeldt said that the community is invited to come to the meetings and give input, and Dr. Gaudi said that he was specifically asked to broaden the reach and scope

of ExoPAG. He would be happy to write it up as a SIG to be approved at the next meeting, though he still intended to gauge community interest in the interim.

Dr. Peterson held a vote on the proposed SAGs. They were unanimously approved by acclamation, with no abstentions.

#### Senior Review Planning

Dr. Hayes explained that APD must conduct a comparative senior review every 2 years. Once a mission is through Prime Phase E, NASA will accept a higher operating risk, and the mission is assumed to be less expensive. The priority is maintaining instrument performance and producing good science. The 2014 senior review will cover all operating missions, possibly including Kepler, though Hubble and Chandra will be in another review. Missions in the senior review will be examined and ranked for FY15-16, as well as for FY17-18. In addition to science return, the review panel assesses cost efficiency, current costs, and the scientific tradeoffs. The panel will also provide an overall assessment of the strength and ability of the Mission Operations and Data Analysis (MO&DA) portfolio and provide findings. Proposal content is to include scientific merit; promise of future impact and productivity; impact of past scientific results; broad accessibility, usability, and utility of the data; spacecraft and instrument health and safety; productivity and vitality of the science team; and, level and quality of observatory stewardship.

Dr. Harrison asked for further information about the allocation of resources for extended missions. Dr. Hertz explained that Chandra and Hubble have continuing budgets because they are not at risk and will not be terminated. All other eligible missions are held in the senior review budget wedge. The Hubble and Chandra reviews are not comparative; those committees will assess how well they are performing and whether they could do better or be more efficient. Dr. Bregman noted that the previous senior review, of which he was chair, divided missions into different categories. Although some complicated matrices resulted, it was not sufficient to just evaluate science per dollar.

#### AFTA Coronagraph Update

Dr. Feng Zhao, AFTA Coronagraph Instrument Manager, discussed the technology recommendation process. AFTA is required to produce a compelling and viable mission concept, including a coronagraph, within the budget and schedule guidelines for a potential new mission to start in FY17. The AFTA Coronagraph Working Group (ACWG) is to choose primary and backup coronagraph technologies for which to focus design and technology investments. The ACWG had held two workshops and was about to hold a third.

The recommendation of the Exoplanet Exploration Program Office (ExEPO) and the AFTA Study Office (ASO) will be based on inputs from the SDT, which sets the science requirements. The ACWG will deliver technical figures of merit (FOMs) and technology plans, and aim for a positive, consensus product. The SDT will deliver the science FOMs. The technical Advisory Committee (TAC) will provide an analysis of the technical FOM and technology readiness level (TRL), readiness plans, and risks.

The ExEPO and ASO recommendation to the APD Director will be based on the following:

- Technical and programmatic elements;
- Musts (requirements), Wants (goals), and Risks;
- Description and evaluation distinguished from one another.

The APD Director will make the final decision.

The evaluation will look at go/no-go requirements, such as determining if the technology is ready, etc. Dr. Zhao summarized the current science requirements as baseline (musts), beyond (wants), and threshold (risks). He next presented the mask architecture for the six options under consideration. The more an option can do, the higher its score. A flow chart illustrated the path of the comparative analysis, and Dr. Zhao presented the down-select schedule. He also showed a graphic of the high-level instrument and the six concepts. After NASA makes decision, the project will start technology demonstrations to get to TRL5 by 2016 and TRL6 by 2017.

Dr. Zhao then presented some details of the six concepts:

- Hybrid lyot;
- Shaped pupil;
- Vector vortex;
- Phase-induced amplitude apodization-complex mask coronagraph (PIAA-CMC);
- Visible Nulling Coronagraph – Phase Occulted (VNC-PO); and,
- VNC DaVinci.

Dr. Zhao explained that for the telescope, sensitivity is a criterion. Dr. Stapelfeldt asked the extent to which the ACWG will be involved after the two options are selected for the first phase. Dr. Zhao explained that there are funds to enable the continuation of the expert advice. Dr. Hertz added that the current instructions are that telescope will be used as is, and the coronagraph is not a Level 1 requirement.

#### Public Comment Period

The meeting was opened to any member of the public who wished to make a statement. There were none.

#### Subcommittee Discussion

Dr. Hertz thanked the five APS members whose terms were to expire in March, 2014: Drs. Gary Bernstein, Edna DeVore, Gabriela Gonzalez, Terry Oswalt, and Paul Ray. He also noted that this was Dr. Joan Centrella's last meeting as executive secretary, and thanked her. From this point on, Dr. Hashima Hasan will fill that role.

Dr. Peterson also thanked the departing members and Dr. Centrella.

#### Adjourn

Dr. Peterson adjourned the teleconference at 4:46 p.m.

**Appendix A**  
**Attendees**

Subcommittee members

Bradley Peterson, Ohio State University, *Chair Astrophysics Subcommittee*  
Joan Centrella, NASA, *Executive Secretary*  
James Bock, Jet Propulsion Laboratory  
Joel Bregman, University of Michigan  
Julianne Dalcanton, University of Washington  
Edna DeVore, SETI Institute  
Giovanni Fazio, Harvard Smithsonian Center for Astrophysics  
B. Scott Gaudi, Ohio State University  
Gabriela Gonzalez, Louisiana State University (via WebEx)  
Fiona Harrison, CalTech  
Chryssa Kouveliotou, Marshall Space Flight Center  
Gary Melnick, Harvard University  
John Nousek, Pennsylvania State University  
Terry Oswalt, Florida Institute of Technology  
Paul Ray, Naval Research Laboratory  
Karl Stapelfeldt, Goddard Space Flight Center

NASA attendees

Paul Hertz, NASA HQ, *Director, Astrophysics Division*  
Jeff Hayes, NASA HQ  
Wilton Sanders, NASA HQ  
Eric Smith, NASA HQ

Webex\*

Hashima Hasan, NASA HQ  
Feng Zhao, NASA

\*Due to technical difficulties, the WebEx list of participants was unavailable.

**Appendix B**  
**NAC Astrophysics Subcommittee Members**

**Bradley Peterson**, Chair  
Department of Astronomy  
Ohio State University

**Joan Centrella**, Executive Secretary  
Astrophysics Division  
Science Mission Directorate  
NASA Headquarters

Gary M. Bernstein  
Professor of Physics and Astronomy  
University of Pennsylvania

James J. Bock  
Jet Propulsion Laboratory

Joel Bregman  
Department of Astronomy  
University of Michigan

Julianne Dalcanton  
Professor of Astronomy  
University of Washington

Edna DeVore  
Director of Education and Outreach; Deputy CEO  
SETI Institute

Giovanni Fazio  
Harvard Smithsonian Center for Astrophysics

B. Scott Gaudi  
Department of Astronomy  
Ohio State University

Gabriela Gonzalez  
Professor, Physics and Astronomy  
Louisiana State University

Fiona Harrison  
Professor, Physics and Astronomy  
CalTech

Chryssa Kouveliotou  
Marshall Space Flight Center

Gary Melnick  
Senior Astronomer  
Harvard Smithsonian Center for Astrophysics

John A. Nousek  
Professor of Astronomy & Astrophysics  
Pennsylvania State University

Terry Oswalt  
Chair, Department of Physical Sciences  
Embry-Riddle Aeronautical University

Paul S. Ray  
Naval Research Laboratory

Kenneth Sembach  
Space Telescope Science Institute

Karl Stapelfeldt  
Goddard Space Flight Center

**Appendix C**  
**Presentations**

1. *Astrophysics Report to the NAC Astrophysics Subcommittee*, Paul Hertz
2. *Physics of the Cosmos Program Analysis Group: Status Report*, John Nousek
3. *Enduring Quests – Daring Visions: Astrophysics Roadmap*, Chryssa Kouveliotou
4. *The Explorer Program: Presentation to the Astrophysics Subcommittee*, Wilton Sanders
5. *E/PO Status Update*, Jeff Hayes
6. *Cosmic Origins Program Analysis Group*, Kenneth Sembach
7. *ExoPAG Report*, Scott Gaudi
8. *2014 Astrophysics Senior Review*, Jeff Hayes
9. *AFTA Coronagraph Technology Recommendation Process*, Feng Zhao

**Appendix D**  
**Agenda**

**Astrophysics Subcommittee teleconference**  
**November 19, 2013**

**AGENDA**

Tuesday, November 19

- 11:00 – 11:10 am Welcome and Introductions – Brad Peterson (*APS Chair*)
- 11:10 am – 12:15 pm Astrophysics Division Update – Paul Hertz (*Astrophysics Division Director, NASA HQ*)
- 12:15 – 12:30 pm PhysPAG Update – John Nousek (*APS Member, PhysPAG Chair*)
- 12:30 – 1:15 pm Astrophysics Roadmap Presentation and Committee Discussion – Chryssa Kouveliotou (*Roadmap Chair; APS Member*) and Brad Peterson (*APS Chair*)
- 1:15 – 1:45 pm Explorer Program Update – Wilt Sanders (*Astrophysics Division, NASA HQ*)
- 1:45 – 2:15 pm Break**
- 2:15 – 2:30 pm EPO Status Update – Jeff Hayes (*Astrophysics Division, NASA HQ*)
- 2:30 – 2:50 pm CoPAG Update – Ken Sembach (*APS Member, CoPAG Chair*)
- 2:50 – 3:10 pm ExoPAG Update – Scott Gaudi (*APS Member, ExoPAG Chair*)
- 3:10 – 3:40 pm Senior Review Planning – Jeff Hayes (*Astrophysics Division, NASA HQ*)
- 3:40 – 4:10 pm AFTA Coronagraph Update – Feng Zhao (*JPL*)
- 4:10 – 4:10 pm Public Comment Period – Brad Peterson (*APS Chair*)
- 4:10 – 5:00 pm Committee Discussion – Brad Peterson (*APS Chair*)
- 5:00 pm Adjourn