NASA ADVISORY COUNCIL

ASTROPHYSICS SUBCOMMITTEE

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NASA Headquarters
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MEETING MINUTES

Alan Boss, Chair

Rita Sambruna, Executive Secretary

July 13, 2011

Welcome and Conflict of Interest Review

Dr. Alan Boss, chair of the Astrophysics Subcommittee (APS), convened the meeting by welcoming those present, including the new APS members: Dr. Gary Bernstein, Dr. Edna DeVore, and Dr. Terry Oswalt. New member Dr. Paul Ray participated by phone, and Dr. Gabriela Gonzalez attended on Webex. Dr. Boss then asked the APS members to briefly introduce themselves and state any conflict of interest with the agenda. Dr. Boss reminded the Subcommittee members that they are subject to Federal Advisory Committee Act (FACA) rules. This meeting included a public comment period. Otherwise, only APS members were to participate in the discussion. Dr. Boss then asked for a roll of those attendees, both in the meeting room and on the conference call, who were not members of the Subcommittee.

Ethics Training

Dr. Rita Sambruna, executive secretary of APS, reviewed the FACA rules with the Subcommittee members. She reminded them that any communication between the members that deals with APS subject matter constitutes a meeting. This includes e-mail exchanges. All meetings must include her and must be documented with minutes.

Mr. Adam Greenstone, an attorney with NASA and the Ethics Team Lead, gave a presentation on ethics under FACA. He described how NASA's advisory committees operate in filling their mission of providing advice and informing NASA of external concerns. An internal NASA directive, NPD 1150.1, provides further detail.

Mr. Greenstone explained that the APS members are considered Special Government Employees (SGEs). Mr. Greenstone reviewed SGE ethics rules, with emphasis on financial conflict of interest and representation. Mr. Greenstone said that the Ethics Team is available to advise on more specific cases.

Regarding financial disclosure, Mr. Greenstone said that if a member sees a potential conflict of interest, it is important to stop working on the matter immediately. The member should contact Dr. Sambruna and seek legal advice through NASA.

The related discussion with APS led to the topic of communications with Congress. Mr. Greenstone reiterated the invitation for members to contact the NASA Ethics Team. The members must take care because of their responsibilities as APS members. If communicating to Congress about a NASA-related issue, the members should not identify themselves as being on APS.

Mr. Greenstone also reviewed the post-employment restrictions for SGEs. Post-employment restrictions are another area of concern for SGEs. Mr. Greenstone then reviewed the Federal gift rules and impartiality, and ended his presentation by identifying NASA's ethic officials.

APD Programmatic Update

Dr. Jon Morse, Director of the Astrophysics Division (APD), gave an update of Division activities. He discussed recent press releases and science highlights; an update on missions; research and analysis (R&A) and archives; and responses to the Decadal Survey (DS).

Science highlights

A Chandra press conference on super-massive black holes in the early universe was followed by a live web chat. Fermi continues to produce observations of objects such as radio pulsars in a high-mass X-ray binary system. Dr. Morse showed a long list of Division press releases, which sometimes come out twice a day.

Mission events

The next mission launch is the Nuclear Spectroscopic Telescope Array (NuSTAR) in February 2012. The Laser Interferometer Space Antenna (LISA) Pathfinder (LPF) ST-7 will likely launch in mid-2013, the Astro-H telescope is scheduled for a February 2014 launch, and the Gravity and Extreme Magnetism Small Explorer (GEMS) is scheduled to launch in July 2014. The sub-orbital rocket program is still addressing technical issues with rocket motors, but making progress. Balloon campaigns have been successful and upcoming campaigns have been recertified. The announcements of opportunity (AO) for missions for calendar year 2011 include the Stratospheric Observatory for Infrared Astronomy (SOFIA) and, possibly, the Standalone Missions of Opportunity Notice (SALMON). Future AOs will depend on resources.

The Missions in Formulation and Implementation review showed that ST-7, GEMS, SOFIA, and the balloon programs are strong, while NuSTAR and Astro-H had some issues that are likely to be resolved within the planned margins. With Astro-H, there are concerns about the Japanese and their ability to make progress in light of that country's natural disasters earlier in the year. GEMS went through a re-plan to tighten its scope. The Wide-Field Infrared Explorer (WISE) has been decommissioned but is providing products for the science community.

Dr. Morse updated APS on the activities of specific missions, including SOFIA, NuSTAR, Astro-H, GEMS, and the Hubble Space Telescope (HST). In order to lower costs, staffing for Hubble will go to a single shift 5 days a week instead of the previous 24/7 coverage, but someone will always be on call and NASA will preserve the science by automating the process. Hubble collected 1 million exposures as of July 4. Finally, the Physics of the Cosmos (PCOS) program went through the Program Acceptance Review (PAR) in May, and a Program Implementation Review (PIR) is pending.

R&A and archives

The agenda included presentations by Drs. Linda Sparke and J. S. Gallagher, who addressed the recent Senior Review of the Astrophysics Research Program. In addition, Dr. Morse explained that a Senior Review of the Astrophysics Data Archives is conducted every 3 years. The 2011 review rated all the archives as Excellent or Very Good, except for the NASA Star and Exoplanet Database (NStED), which was rated Fair. The review panel did not see evidence that NStED is having a significant impact on the scientific productivity of the field, and so recommended to discontinue it, while preserving the data. One

general finding was that NASA should better define the roles and responsibilities between the data archives and the Virtual Astronomical Observatory. The panel was concerned about long-term planning for the archives, and about improving access for automatic data downloads while maintaining security.

The Wide-Field Infrared Survey Telescope (WFIRST) science definition team was also scheduled to speak at the meeting, and an update was planned for the European Space Agency (ESA) L1 mission candidates, of which there will be only one or two, not three as has been rumored. These decisions will affect other APD missions.

APD will send out a NASA Research Announcement (NRA) for medium-class x-ray and Gravity Wave (GW) mission concepts from U.S. teams, distinct from International X-ray Observatory (IXO)/Athena and LISA/NGO. They will be looking for projects under $1 billion. The Fall 2011 SALMON AO will include calls for U.S. science team participation on international mission definition studies. Finally, in Spring of 2012, APD will convene through the National Research Council (NRC) a review panel to re-evaluate the New Worlds New Horizons (NWNH) future strategic missions in light of the President's FY13 budget request and international developments. The Explorer schedule includes 22 full missions, 15 of which are for astrophysics. The Step 1 selections will occur in September, with down-selection planned for February 2013.

Responses to the Decadal Survey (DS)

The APD organizational structure is well aligned with the NWNH scientific thrusts. The small-scale projects are to increase modestly in budget in 2012, and by 25 percent in 2013. Discussions continue with potential collaborators on a wide range of projects. Medium-scale projects include segmented exoplanet technology development, cosmic inflation probe concepts, and a direct detection exoplanet mission. APD is constrained in implementing the next large mission but can support concept planning and technology development.

Discussion

In response to a question, Dr. Morse explained that his team would ask NRC what they need to do to prepare for the next DS. The mid-decade review is a near-term step to begin studies on how NASA looks at participating in international missions, coordinating technology investments, and mission concepts that are alternatives to LISA and IXO. The mission concept studies will be presented to NRC in May. The missions will require a path to implementation, which will happen in the next decade. The concepts must be distinct. There will also be discussion of the role of cost in future missions. Some want to dream big dreams without cost constraints. Others believe NASA should start with a cost cap, as ESA does, to avoid tying up resources in one big project for two decades.

When it was suggested that APD might want to reconsider the DS model for medium-sized missions, Dr. Morse said that it seems prudent to add concepts to that mission class. There is a lack of projects in the middle, and he wants to see if it is possible to significantly advance the field at more modest costs. He also explained that in specifying concepts that are distinct from IXO and LISA, he would prefer complementary science, not duplicative science. Athena and NGO have overlapping science goals, and the question is whether there are other unfulfilled science goals that can be implemented.

Regarding the lack of exoplanet missions, Dr. Morse said that he is thinking about missions that could be executed for less than $1 billion. His interest is in the strategic goals and how to achieve them. He wants

people to think about how to show that what is put in a mission has technology that is ready, with a believable budget.

Dr. Boss asked whether there is a new charge to the Committee on Astronomy and Astrophysics (CAA). Dr. Morse said that the intent is to convene this committee through the Space Studies Board (SSB). It is not clear what the National Science Foundation (NSF) and the Department of Energy (DOE) want to do in terms of sponsoring CAA. Dr. Boss noted that the DS assumed a certain budget, and wondered if it would help for CAA to set up decision rules. Dr. Morse explained that that is a goal of the meeting with NRC: portfolio-class recommendations and clarifications. The NRC may need to convene an ad hoc group.

Dr. Morse elaborated on the budget process for the benefit of the new APS members, explaining where APD is in the process for FY11, FY12, and FY13. SMD wants to pool labor and expenses for civil service in a separate budget category, though Congress may not approve this. The new budgets also break out the James Webb Space Telescope (JWST) as a separate line item. Even adding JWST funds back in, APD has $76 million less for FY12 than originally expected. The APD budget has dropped since FY08. If JWST were added back in, the FY12 budget would be only half of the FY08 budget. Nonetheless, there is strong support for science. The issue is one of priorities.

The DS can be read to prioritize the science in missions. Currently, APD incorporates the DS science objectives into the NASA strategic plan, and the calls reflect that. When concern was expressed about the medium-sized missions, Dr. Morse said that one of the goals of the concept studies is to generate more ideas for LISA and IXO now that ESA has terminated its participation. APD is seeking community input.

2011 Review of Astrophysics Programs in Research, Analysis, and Enabling Technology

Dr. Jay Gallagher of the University of Wisconsin, and Chair of the Astrophysics Research Program Review Panel, presented highlights and findings from the review. The Panel was convened in response to the Fisk Report and the 2010 DS. This was a fast-track review to address questions developed by APD and to explore certain issues. The primary objective was to provide comments to help strengthen APD programs. All 14 panelists had a connection to NASA, resulting in a broad view of what NASA does with missions and science. The panel's perspective was that R&A and enabling technology play a critical role in the relationship between NASA and the scientific community. The Panel received background presentations from Great Observatory (GO) guest-observer programs and from NASA HQ staff, and solicited community input. The panel discussed broad issues as a whole, while smaller groups with expertise and views wrote white papers on special topics. This was not a FACA panel.

Regarding NASA research awards, the Panel explored the value of a formal process involving metrics to support programmatic decisions. In reaction to the Fisk Report recommendation on considering research of high risk, but potentially high reward, the Panel cautioned against excessive risk avoidance, as some failures are inevitable. The Panel also identified a need to train a skilled and highly motivated workforce for the long term. Panelists felt that public awareness of astronomy is high, but that this comes primarily from the Great Observatories, and suggested that NASA should present a broader view. As NASA moves away from the era of Great Observatories, there should be a stronger link between the Astrophysics Research Programs and the scientific community, with better communications, possibly in the form of user committees. While the Panel was split as to whether regular external reviews of the Research Program should be conducted by a standing group or by a periodically convened ad hoc group, there was strong agreement that continuity across reviews is important regardless of the approach.

In looking at the Astrophysics Research and Enabling Technology Program (APRET, formerly APRA), the Panel noted that the science is changing, which affects the balance between flight opportunities and technology. Currently, the panel felt that the balance is appropriate. The appropriate size for research awards is a complex issue, with the perception that a gap must be bridged between Technology Readiness Levels (TRLs) 4 through 6. Technology investments also constitute a workforce issue, and encompass the need for workforce training and student engagement. To that end, the panel particularly liked the planned Astrophysics Technology Fellows. The value of laboratory astrophysics is recognized, but more information is needed to judge appropriate support levels.

The Astrophysics Theory Program (ATP) constitutes part of the division's long range planning. The Panel suggested that APD should consider funding projects of larger scale than the typical single-investigator award, similar to the large observing programs of the Great Observatories. Metrics are needed to assess whether current funding levels are appropriate. The Astrophysics Data Analysis Program (ADAP) complements GO programs rather than duplicating them, and serves as a scientific "shock absorber" to ensure vitality if gaps exist between missions that are large enough to have substantial Guest Observer programs. Many of the ADAP-funded projects involve data from multiple missions.

Dr. Morse noted that there is enormous scrutiny from OMB and Congress regarding duplication, so it is important to show that ADAP does not simply duplicate the functions of the Great Observatory archival research awards. As mentioned by a Subcommittee member, the Panel is concerned about the fact that research funded through the GO programs often has applicability in a wider range of areas, which are then threatened when the funding ends. There is a need for more young researchers, and the ADAP program broadens their access.

Dr. Gallagher next presented the Panel's thoughts on the Origins of Solar Systems (OSS) program. The panel felt that this should continue as an interdisciplinary program, as exoplanets are an important emerging research issue in which NASA must be involved. International ground-based observations, such as those funded through OSS, are necessary. This area could benefit from the development of specific outcome-based metrics. NASA could also do more to encourage the involvement of exoplanet investigators in other solicitations in the Astrophysics Research Program, specifically the Astrophysics Theory Program.

The Panel considered the metrics discussed in the Fisk Report to be part of the process of setting the criteria for reaching program goals. Although this will require significant resources, the Panel suggested that more formalized metrics be phased in, with assessments of effectiveness along the way. Not all metrics are quantitative, but they can be codified. It would be helpful to build on the experience of the GO guest-observer programs, and to use metrics and criteria to better explain and defend critical program choices to the community, funders, and other stakeholders.

Discussion

Dr. Gallagher clarified that facilitating cross-wavelength science through the Astrophysics Research Program was of value, as part of a much wider range of considerations. Further discussion addressed whether science missions generally precede or follow the relevant theoretical work. Dr. Gallagher noted that there are examples of both, which the panel discussed. The key is how to properly size the Astrophysics Theory Program, which is not an easy issue. The panel saw both advantages and disadvantages to separate funding for all exoplanet research. The current arrangement of planetary and astrophysics scientists working together in OSS seems to have the most value at this time. [I have no idea where this sentence attributed to me came from. Maybe someone else made this point?] Others expressed

concern about review panels rejecting projects that are outside the mainstream of what they are considering. The review panels must have the necessary expertise in order to prevent this. If more exoplanet proposals came in, there might be more need for separate panels for them. Dr. Gallagher suggested being more explicit in opening up the ATP and ADAP calls to exoplanet research. Dr. Morse added that he sees benefits to keeping OSS as an interdisciplinary program, as opposed to creating more stovepipes. The exoplanet community currently sends proposals to both APD and the Planetary Science Division (PSD), as well as to the NSF.

Research, Analysis, and Enabling Technology Programs Update

Dr. Linda Sparke, Research Program Manager for APD, began the update by reviewing the data on Research Opportunities in Space and Earth Sciences (ROSES) competitions. The number of proposals has increased up to 55 percent in some programs. Modifications to ROSES-11 now allow data mining proposals in ADAP, and remove the explicit budget cap for the Fermi Guest Investigator program, among other changes. Dr. Sparke noted that APD will not participate in funding conferences for the immediate future. Spending for FY11 will be similar to that of FY10. The FY12 request includes substantial increases, with plans for more balloon flights, including those with super-pressure balloons that remain at high altitude during the night for observations.

High risk/high reward projects are funded through APRET as low-TRL development, and as NASA Advanced Innovative Concepts (NIAC) by the Office of the Chief Technologist (OCT). The SAT program covers mid-TRL development, there is an effort by the Astrophysics Theory Program (ATP) to examine large theory project opportunities, and both ADAP and ATP will call out opportunities for exoplanet research explicitly. Regarding workforce development, fellowships are moving forward. An APD communications plan is being developed to push out more updates. The Program Analysis Groups (PAGs) are part of the communications effort.

The review of the Astrophysics Research Programs indicated that these programs are worth defending, but APD must show that they are well managed and effective. It will be necessary to track metrics without placing an undue burden on investigators and staff. The Fisk Report called for metrics that would lead to great staff increases, for example, and there are no funds for that. APD will seek to set up an equivalent of observatory user committees for the Research Program, and develop other mechanisms to obtain programmatic advice.

Discussion

Regarding the use of citations to gather metrics, Dr. Sparke said that it is possible to generate citation counts automatically, but publications matter a lot in some fields and less in others. They are less important in technology development, for example. She was surprised that the GO programs did not make use of annual reports from Principal Investigators (PIs). But it was noted that papers are often still in preparation when the PI submits a final report, so that the reports represent an incomplete picture of what has resulted from the award.

Dr. Chris Martin asked about how to deal with the overlap between APRET and SAT, and prioritization in the TRL gap at Levels 4-6. Dr. Sparke replied that there is no rigid filter at this point. Although, as Dr. Martin noted, there could be a huge strategic advantage in certain technology for exoplanet detection, it does not fall within any R&A budget lines at this time, and the path forward is not clear. On reports from award PIs, NSF has a web-based process for this. NASA is participating in a program led by NSF to develop a new system to gather project reports; thus NASA will not get funding to develop its own system. Dr. Sparke also explained that the Research Program Review panel did not fall under the purview

of the senior review process because it was did not discuss specific awards, dealt only with public data, and could be done quickly without setting up a new committee.

WFIRST Science Definition Team and Project Interim Report

Dr. James Green (Univ Colorado), co-chair of the WFIRST Science Definition Team (SDT), provided details of the SDT interim report submitted on June 29, 2011 to NASA. The Decadal ranked WFIRST as the top priority among large space missions, with three goals:

- Complete the statistical census of galactic planetary systems using microlensing;
- Determine the nature of the dark energy that is driving the accelerating expansion of the universe;
- Survey the Near Infrared (NIR) sky for the scientific community.

The combined missions make WFIRST powerful. It will deliver the most scientific return for the science available today and it is within current capabilities. The lowest TRL is 6 or 7. For the ad-interim June 2011 report, the SDT was chartered to provide science requirements, investigation approaches, key mission parameters, and other studies needed to go forward for a stand-alone, US-only mission (option A of the NRC December report)..

Dr. Green reviewed the SDT's findings to date. It was determined that it is necessary to include all of the science capabilities recommended by the Decadal, as multiple techniques are required for the study of dark energy. Dr. Green noted that there will be a guest investigator program, and discussed some of the specific approaches, such as the exoplanet micro-lensing technique, which is complementary to Kepler. He explained that the exoplanet survey is expected to detect at least 30 free-floating planets approximately of Earth's mass during a 500-day survey. It is also expected to detect at least 125 Earth-sized planets in 2 years, and at least 25 habitable-zone planets of half to 10 times the mass of Earth.

The three most promising dark energy techniques are Baryon Acoustic Oscillation (BAO), Weak Lensing (WL), and Type Ia Supernovae (SNe). In addition, a fourth technique (Redshift Space Distortions, RSD) was considered and added to the list of desirable techniques; note that data for the RSD method are provided pro-bono from the IR survey. Each provides a different type of observation and unique information. WFIRST will have so many targets that it will be limited by the systematics, so that larger fields of view will not provide a significant improvement. Optimization is waiting for a better understanding of the informatics. Similarly, a systematic error limits the utility of getting more supernovae data. In the comparison with Euclid, there is debate about the systematic errors and concern about realistic comparisons of data. There are contentious issues related to sensitivity as well.

Dr. Green showed a Venn diagram comparing the optimistic estimates of WFIRST metrics with the optimistic estimates of Euclid metrics, based on 1 year of WL, 1 year of BAO, and 6 months of SNe. Under this scenario, Euclid is projected to have more BAO observations, but fewer WL observations and none using SNe. For the NIR survey, the overarching goal is to perform the survey itself, with more specific goals including identification of at least 100 quasars at redshift $z>7$, broadband NIR spectral energy contributions of at least 1 billion galaxies at $z>1$ to extend studies of galaxy formation and

evolution, and mapping of the structure of the Galaxy using red giant clump stars as tracers. WFIRST will incorporation a year of Guest Investigator (GI) studies, with many potential programs. Some of these studies may expand on existing information to make it deeper or broader.

Dr. Green compared the requirement of the EOS Decadal panel with those established for the interim report by the SDT, noting that the latter are more realistic. WFIRST will survey a smaller sky fraction than indicated by the EOS, but will use two color instead of one, for example. The original EOS goal was 2 billion galaxy shapes, and WFIRST will probably get 300 million. A bigger mirror or longer mission would be required for WFIRST to achieve the EOS goal.

The second SDT finding was that, if Euclid is selected, WFIRST should stay with its fundamental design, as there are some significant differences, especially in observational capabilities. WFIRST has significant advantages in BAO and WL. However, the observation program might change in light of Euclid's selection and/or results.

The third SDT finding was that if there is a joint mission or program, all the scientific approaches and broad objectives of WFIRST must be included.

Discussion

In answer to a question about time allocation, Dr. Green explained that microlensing time is driven by complex calculations based on time spent looking at a certain field. There is a minimum, but there are also constraints. Microlensing experts developed the time allocation as a best-case scenario. They would prefer a longer mission for a longer range between the first and last views, rather than a longer stare. The prime mission time is just over 5 years.

Dr. Bernstein said that the reports identify the need for a group to work through issues and numbers. The concern is about the science that the mission is going to do, and there must be a careful accounting of observing time. Dr. Arjun Dey added that preserving GI time will be important in garnering community support for a big mission. When telescope time is allotted, there may be different or shifted priorities by the proposers.

In response to a suggestion regarding target selection for a NIR study, Dr. Green said that, while still too early, studies will be done in the future as well as requiring the community input via dedicated meetings. In a discussion of the lens, he noted that the central spike in the 1.5-meter lens would be taller, but the central energy in the 1.3-meter mirror is better, and the 1.3-meter seems to be optimal given the circumstances. It greatly reduces observing time for WL, though the cost issues are still in contention.

The purpose of the microlensing survey is not to find other Earths. It is optimized for sensitivity across the range. The concept of the 25 habitable zone planets is not a requirement, it is a prediction of performance and a baseline that precedes the requirements phase. Some future study areas will change once more is known about Euclid. Regarding system engineering checks and feasibility, the telemetry

limit still exists, and the team is looking at the thermal and structural stability that have been achieved by expensive spacecraft. It might not be financially feasible without more work in that area.

JWST Program Status and Replan

Mr. Rick Howard, the JWST Program Director, explained that NASA has made significant changes in the management of JWST, with all senior management replaced at both NASA headquarters and Goddard Space Flight Center (Goddard). The replan is proceeding well, achieving cost and schedule milestones, with a projected launch date of October 2018. Communications have improved at all levels, and there has been an independent non-advocate assessment of alternatives against the replan baseline. None of the alternatives provided equivalent Level 1 science at a lower cost.

An Independent Comprehensive Review Panel (ICRP) report released in November showed that there were no technical issues and that the funds so far have been invested wisely. NASA agreed with the recommendations and elevated program visibility. JWST is now a division within the Science Mission Directorate (SMD) and Mr. Howard reports to the NASA Associate Administrator.

JWST is using the ICRP cost and schedule estimate as one of the inputs in developing new baseline. There were 22 ICRP recommendations, and the responses for almost all have been completed. The Program followed the ICRP recommendations in developing a new baseline for JWST. The high probability threats are now included in the baseline. The Test Assessment Team (TAT) report recommendations have been incorporated into new baseline as well.

The SMD budget going back to 2004 indicates a loss of flexibility, with the budget decreasing $10 billion over a 5-year period. There is a lack of stability to support existing programs and plan for the future. What is most important is that the Agency authority to reprogram funds without prior approval of Congress and OMB is capped at $500,000. This restriction limits the Agency's ability to react to situations. There had been a push for a 2015 JWST launch, but the budget profile makes that impossible.

There have been milestones reached with the hardware, which Mr. Howard reviewed. Eighteen telescope mirrors have been assembled, and 13 of these have been fully coated. The one-third-scale sunshield has been tested, completed, and analyzed. The spacecraft design continues to mature. Many subsystem components are far along in the design phase, and the instruments are all in various stages of Integration and Testing (I&T).

To date, 75 percent by mass of the flight hardware is ready to be fabricated, in fabrication or in testing, and some has been delivered. The optical telescope team is making progress on hardware developments, and the integrated science instrument module team is also making good progress. Sunshield engineering model work continues, as do project I&T activities. The FY11 milestones have been completed, some ahead of time.

The replan developed by the Project assumed a constrained budget for FY11 and FY12, with an unconstrained budget for FY13 onward. The replan supports an October 2018 launch date, and the project estimates for cost and schedule are within 1 percent of cost and 6 percent of schedule of the Joint cost and schedule Confidence Limit (JCL). Funding for the replan must fit the overall Agency top line budget. NASA has been in regular communication with its international partners about the replan.

A detailed schedule indicates that there are still periods with low levels of activity. The biggest concern is the loss of government and key contract personnel onto other projects during these slow periods. There are also concerns about budget uncertainty, long-term storage issues, and the focus of the team to keep the momentum going. The primary issue is the potential for key people to leave for other projects, however.

Discussion

In response to a question about Standing Review Board (SRB) involvement, Mr. Howard said that the recommended adjustments were implemented. The replan has been sent back to the SRB and they are still involved. Mr. Howard explained the slide about the joint cost and schedule confidence level. The 80 percent confidence level is within 1 percent of cost and 6 percent of schedule. The challenges of the sunshield are all addressed to the extent possible without completely testing the entire product. The team has tested models and conducted a range of mock-ups.

In regard to the House appropriations bill that included no funds for JWST, Mr. Howard explained that this is one step in the long process to a final FY12 budget. The final answer will not come for months. NASA continues to have discussions with Congressional staffers, but he is not at liberty to provide details. There will be tough choices, and NASA is prepared for the dialogue. If there are no funds, there are "an infinite number of solutions." The President's budget for FY12 and out will put the launch beyond 2020, which is not viable. But there are other options. The replan is best for launching JWST at the earliest possible date. Pushing it out will cost more. In answer to questions about the budget, Mr. Howard said he could not provide the percentage of the total budget on a 2018 launch that has already been spent and the replan costs would be part of the Agency's FY13 President's Budget Request. Through FY11, $3.5 billion has been spent. Dr. Steven Ritz said that these are the questions Subcommittee members are asked. Mr. Howard said that the numbers could be estimated by looking at the ICRP report and previous expenditures.

In terms of bringing in more work and possibly costing important personnel to other tasks to avoid attrition, the core team has been identified and will be present during the slow periods. Other personnel will work on other activities, but for the core, it is important to avoid the risk of dealing with a learning curve. So they will be kept on the project at all times. He cannot discuss the potential cut in appropriations. There has been no assessment of a reduction in scope.

Status of ESA's Next Gravitational-Wave Observatory

Dr. Robin "Tuck" Stebbins gave an update on ESA's New Gravitational-Wave Observatory (NGO) concept study. The core design team, science team, and science performance task force have been holding meetings, the Concurrent Design Facility Study (CDF) has just been completed and the Astrium industrial

study was starting. NASA has provided engineering support on orbits, trajectories, and systems engineering.

Dr. Stebbins outlined the basic parameters of the current concept, and noted the concept uses the LISA payload. The baseline observing period is 2 years, extendable to 5 years. The interferometer now has only a 4 laser links (2 arms). The NGO concept uses 2 Soyuz launches from Kourou. Member states will supply most of the payload. Dr. Stebbins showed several slides illustrating what the spacecraft will look like.

Dr. Stebbins compared the science performance of NGO and LISA. The projected performance of LISA-like detectors has been increasing for several years as additional physics has been included in waveforms. The accuracy with which LISA-like detectors can extract astrophysical parameters of sources is extraordinary by astrophysics standards. The most challenging parameter for NGO is luminosity distance, where the uncertainty is 100 percent at $z>5$; it is 20 percent for LISA. NGO will observe tens of extreme mass ratio "in-spiral sources" (small compact objects spiraling into large massive black holes). This gives a rough idea of the performance the team thinks the NGO concept can achieve.

Upcoming activities include the industrial study from August through October, calculations by the science performance task force, and a science team meeting in September in Paris. The NGO can do extraordinary astrophysics, not as good as LISA but much cheaper. NGO is derived from the LISA design, especially the payload and is comparable with the LISA Pathfinder technology demonstration flight. It makes the 850 million Euro cost cap and can be launched in 2022. NGO can also take advantage of all the European technology work that led to LISA.

Discussion

In answer to a question about the funds necessary for the United States to become a viable participant, Dr. Stebbins said that the more responsibility NASA takes, the larger the participant it will be in the science. At this point, there has been no specific NASA content identified by ESA headquarters. The range might be $50-150M. Dr. Morse agreed, adding that NASA has negotiated participation with ESA. NASA has determined that the Agency is unable to commit by February 2012, which is why any potential contribution lacks specificity.

Athena: The Advanced Telescope for High Energy Astrophysics

Dr. Nicholas White discussed the Athena project. The assumptions were that ESA would lead the project, with low-level contributions from JAXA and NASA. The project is targeting a 2022 launch opportunity. In reformulating the program, the challenge was to retain the key science goals while limiting the cost. The solution was lower mass, reduced complexity, and two instruments instead of six. The tradeoff study identified which instruments should be retained. Task teams were set up to investigate science potential and the impact of tradeoffs. Presentations were made in late April, and the science team met in mid-June.

The Athena implementation now has two telescopes and plans for a 5-year mission. Dr. White showed illustrations of two instruments, the Wild Field Imager (WFI) and the Microcalorimeter (XMS). ESA

would like NASA to supply the focal plane array. The science objectives are similar to IXO objectives. Athena will look at black holes, the physics of feedback, the cosmic evolution of galaxies, and the large-scale structure of universe, along with the astrophysics of hot cosmic plasmas. Compared to Chandra, Athena can do more, and do it faster. Regarding possible NASA contributions, ESA is keen on the calorimeter XMS, specifically a Transition Edge Spectrometer (TES) array and readout electronics, as well as a three-stage Adiabatic Demagnetization Refrigerator (ADR). The WFI electronics and software is another possible contribution. The current thinking is that NASA would participate in a mission of opportunity call.

Discussion

Dr. Morse noted that ESA will down-select the M-class missions in the Fall. After being asked if it might be possible to give up one of the Explorer launches to participate in this mission, Dr. Morse said that, in the absence of other funds, APD's only mechanism is through the Explorer mission of opportunity. The current cost cap of $55 million on a mission of opportunity is low. There might be possibilities following the Earth Sciences Division (ESD) Earth Venture Class approach where there is a higher cost cap. Still, the timeframe is a problem. APD cannot make a decision until after this budget cycle. The Explorer call is supposed to be wide open, and there has not yet been a team identified for this. APD wants a peer review process for the science contribution. The APS concern was about losing Explorer in order to be a small piece of something else. Dr. Morse assured the Subcommittee that they would discuss that issue if it became a possibility. In answer to a question about other collaborations, Dr. White said that JAXA support is anticipated to be at the $80-100 million level.

Rossi X-Ray Timing Explorer (RXTE) Accomplishments

Dr. Tod Strohmayer gave a presentation about the RXTE program. Only Hubble has been operating longer, as RXTE was launched in December 1995 and is currently in its fifteenth observation cycle. RXTE's unique strengths include a very large collecting area, high time resolution, broad bandpass, high telemetry capability, and flexible observing capability.

RXTE has unique observing capabilities, especially in the areas of broad energy band, high throughput timing, and observing agility. It costs only $1 million per year, yet is very productive, with over 2,200 refereed papers. The data are in high demand, and there are still many requests to do observations. RXTE supports many multi-wavelength and multi-mission science programs. There will be a conference in the spring to discuss RXTE's many discoveries. Among the highlights are that RXTE opened the submillisecond x-ray window, for example. The program also found progenitors of recycled ms radio pulsars, supported a great deal of work on magnetars, was behind discovery of the unification of black holes (BHs) across the mass scale, as well as BH jets and spin constraints. RXTE also found new thermonuclear phenomenon. This has resulted in a steady publication rate. Over 400 unique PIs have participated in the program, including many young ones.

There is funding through the end of 2011, but no funding into calendar year 2012, which would mean mission closeout in January 2012. There have been performance degradations. The Proportional Counter Array (PCA) instrument is stable, but some detectors show breakdowns. The spacecraft is performing

well, despite occasional ground system problems. There is now one science planner involved, and the program is still very responsive.

Current science goals address accreting neutron stars, rotation-powered pulsars, magnetars, black hole binaries, blazar jets, and Seyfert Active Galaxy Nuclei (AGN). Dr. explained some of RXTE's specific accomplishments in more detail. Impacts to science include synergies with other missions and observatories, such as Fermi, Chandra, and others. RXTE can often coordinate with ground-based telescopes that operate at night to do simultaneous observations. RXTE can also coordinate with new radio facilities. The Suzaku and Swift programs can reproduce some of RXTE's capabilities, but not all. RXTE looks at more sky than Suzaku and observes more targets and has better communications with the ground. Compared to Swift, RXTE has better millisecond capability, and much better hard x-ray sensitivity.

Possible candidates to replace some of these capabilities include India's ASTROSAT, the Large Observatory for X-ray Timing (LOFT), the Advanced X-ray Timing Array (AXTAR), Athena, and the Neutron Star Interior Composition Explorer (NICER). None of these will be ready for the 2012-13 timeframe, however. The Scientific recommendation is to operate RXTE through ASTROSAT verification and checkout, if funding is available.

Discussion

In discussion, Dr. Strohmayer explained that of the 2,200 papers, many encompassed joint observations between observatories, but he did not have an exact number. RXTE is oversubscribed by a factor of two. A significant U.S. community of 100-200 investigators use RXTE data, as well as a significant European user group. There were 13 new PIs in a recent cycle. Having new people come in shows there are many PhD students wanting to submit now that the proposal process has been simplified. The program requires about $1 million per year to continue. Sky coverage is more constrained compared with ASTROSAT. There was an investigation of the possibility of maintaining the program through university or consortia support, but it was not promising and NASA chose not to pursue this avenue.

E<u>SA's International Gamma-Ray Astrophysics Laboratory (INTEGRAL) Mission</u>

Dr. Gerry Skinner explained that this project was originally planned as a 50/50 ESA/NASA mission but became a European mission with U.S. and Russian participation. In the end the US had only a very minor hardware involvement but provided some software and other support. Launched in 2002, it is a Gamma-ray astronomy mission with two main instruments, an SPI spectrometer and the IBIS imager. It has been very successful and is the only operating or planned mission providing imaging and spectrometry in the MeV energy band.

Mission highlights include detection of polarization in hard x-rays from the Crab Nebula; discovery of supergiant fast x-ray transients and their recognition as a new class of high mass x-ray binaries; gamma-ray line astronomy; a key role in detecting highly obscured sources; and discovery of hard power-law spectral components in the quiescent emission of many AXPs and Soft Gamma Repeaters (SGRs). Dr.

Skinner described the gamma ray polarization of the Crab Nebula and discussed the gamma ray line spectroscopy, and the bulges and asymmetries that were unexpected in light of other information.

The U.S. role has been much reduced, with most support ending in 2008 and much of what remained ending in 2010. NASA still supports the U.S. data archive mirror through the High Energy Astrophysics Science Archive Research Center (HEASARC). NASA has offered continued use of the Goldstone ground station, but ESA does not need it now. Most important is that NASA dropped the already reduced support for U.S. PIs and co-PIs who have successful guest observer proposals in 2010. As an indication of the level of involvement in observations, in AO17 there were 137 winning US-led proposals, and 246 publications with U.S. authors. Funding support had been provided for typically 35 proposals per year. The impact of termination of NASA support is that there is now no guest investigator funding or user support from a GOF. In addition a negative message has been sent to ESA about future mission extensions, and there are potential problems if further SPI detectors should fail and a modified response matrix is needed.

Historically, because of phasing and the relatively low level of support needed, ADAP has proved maladapted to supporting Integral observers but is now the only route available. A few Integral-related ADAP proposals were submitted at the last round but results were not available at the time of the meeting.

Galaxy Evolution Explorer (GALEX): Scientific Accomplishments and Impact of Mission Termination

Dr. David Schiminovich explained that GALEX has been successful and is doing well now in an extended mission. A senior review recommended closeout in 2013 but GALEX will terminate in September 2011. Launched in 2003, the primary mission science objective of GALEX is to map the global history of star formation to determine the star formation rate of the universe, and determine when and where today's stars and elements originate. GALEX has surveyed 80 percent of the sky, and had a guest observer program.

Key accomplishments include surveying the Ultra-Violet (UV) sky, producing a new understanding of using UV, discovering the star-forming main sequence, and more. When GALEX observes any part of the sky, it reaches flux limits 10,000 times deeper than any previous UV all-sky source. GALEX discovered star formation at low density and in extreme local environments. The top-cited science team publications from GALEX have increasing impact and utility, and this continues. Five percent of all American Astronomical Society (AAS) science abstracts mention GALEX.

The GALEX extended mission objectives continued some surveys of primary mission. These include extending star-formation history to the low stellar mass/low density universe; exploring the connection between star-formation history and other physical properties, and determining the fundamental drivers; exploring the UV universe into dynamic and low-surface-brightness regimes; and extending the reach of primary mission surveys. The community indicates a strong interest in the GALEX legacy survey, the

Magellanic Cloud, and the Galactic plane survey. The key extended mission involves providing initial mass, Near-UV (NUV) science data; and initial mass, extending the measurements with gas formation.

In 2010, the GALEX team made a senior review proposal to continue implementation of the GALEX legacy survey, incorporating proposals to save costs. One issue the team encountered was how to balance the need to have experienced analysts against the cost savings of a streamlined operations staff. The senior review recommendation was to close down GALEX in 2013 and complete as much as possible during that time, while lowering the budget. However, NASA instructed the project to terminate at the end of FY11. GALEX was prepared to shut down eventually, but this timing was not expected. The team has explored end-of-mission scenarios, while reducing staff and evaluating tradeoffs. The President's FY12 budget does not include sufficient funds to properly close out the mission data.

New GALEX observations add significant scientific value to existing survey data. There is a skeleton plan that would allow the team to complete the Galactic plane survey and look further at the Magellanic cloud. Regardless, there should be more funds for the closeout, with additional funds possibly going toward a recoverable closeout.

Suzaku Science Highlights and Consequences of Mission Termination

Dr. Rob Petre, U.S. Suzaku Project Scientist, presented science highlights from and mission termination implications for the Suzaku mission. Japan launched Suzaku 6 years ago with a major U.S. implementation contribution. The terms of the partnership are such that U.S. scientists gain access to half of the data right away, and the rest after a year. The spacecraft performance is nominal and aging as expected.

Dr. Petre briefly reviewed the unique science enabled by Suzaku. Major themes the program addresses include the nature of space and time near black holes, the nature of dark energy, the workings of cosmic accelerators, and the cycles of matter in the Universe.

Suzaku is the best observatory for measuring the spin of supermassive black holes via studies of the broad iron line because it is the only observatory that covers the wide spectral band needed to understand the contribution of the all the components affecting the X-ray spectrum. Even in the sources with relatively uncomplicated spectra, like Fairall 9, the broad iron line is weak, and careful modeling must by done to produce an estimate of the black hole spin. However, using Suzaku it is possible to infer the black hole spin even in more complicated sources, such as the Seyfert 1.5 Nucleus in NGC 3783.

Suzaku's broadband capability also reveals important physical effects in Galactic black holes. In Cygnus X-1, a set of simultaneous X-ray and radio measurements shows that the radio flux, which arises from a jet, is independent of the inferred accretion disk inner radius. This measurement is inconsistent with the idea that the jet is fed by the accretion disk and thus the radio flux should be correlated with the disk inner radius.

Suzaku is doing several sets of observations of the outskirts of galaxy clusters; it provides the clearest view of the previously unexplored outskirts of galaxy clusters. It is also the only observatory that can detect X-ray flux to the cluster virial radius, and thus resolve the question of how common or rare is clumping in the intracluster gas as it accretes into the cluster's gravitational well.

Dr. Petre reviewed a number of other important findings from Suzaku. He showed a list of possible future key projects, which shows there could be many more years of high quality, unique science. JAXA has no plans to shut off Suzaku. However, it is impractical for JAXA to assume the full role, and JAXA has asked NASA to continue to participate. The two countries' data center roles were optimized to make the best use of their strengths. The U.S. withdrawal would cause a serious negative impact, as the work is very intertwined. NASA has handed off to JAXA those activities easily transferred, closed out others such as analysis software development, and reduced the calibration work.

Discussion

All data are made public eventually. Key project data are released immediately, and the rest are released within a year. When asked about the original plan, Dr. Petre explained that this was predicated on a project that never happened. NASA never renegotiated how this would proceed. It would be hard for JAXA to continue support if NASA dropped out. The most significant risk is associated with the processing pipeline, which was developed and is maintained by NASA. JAXA does not have the capacity to maintain the pipeline. They want U.S. involvement.

Summary Day 1

Dr. Boss asked the Subcommittee members what they would like to highlight in a letter report to Dr. Morse. He proposed the idea of the wonderful science that could be done for a minimal amount of funding. Dr. Oswalt said that there is an overarching feeling that in a time of austere budgets and not many new missions, it behooves NASA to extract the utility of the missions it does have, especially the low-cost ones. That should be a theme. Dr. James Kasting said that he was impressed by GALEX in particular, and the need to archive data. Dr. Ritz noted that APS wanted a good idea of the science being lost, which they saw that afternoon. He suggested they address this in the letter, but noted that Dr. Morse will ask where the funds should come from, and APS will need to know that. Dr. Dey pointed out that the senior review is charged with ranking missions. He observed that it was not clear where the funds exist, and that they had spent 2.5 hours talking about a $5 million fraction of the total portfolio. Dr. Sambruna explained that the presentations were in response to a specific APS request.

Dr. Hughes said that the funds would come from Hubble and Fermi, and APS did not have the full picture. It is unfortunate that the budget situation is not better, but he thought APS was not in position to make recommendations. Dr. Mary Elizabeth Kaiser noted that some of this is new science that did not go into the senior review. Dr. Ritz added that the situation is not normal. The fact that there are not launch opportunities and new missions coming along makes this science more valuable. There was uncertainty as

to whether the senior review understood the implications of their recommendations in context of the current budget climate. Dr. Hughes said that APD still has a "fabulously powerful" suite of main observatories, and it is important not to put them at risk.

It was suggested that Dr. Boss point out in the letter that some things have changed since the senior review. However, the implications to the overall budget should be considered. In two cases, NASA is shutting down satellites that will never go live again, and in the other two, NASA is shutting down U.S. participation. Yet even in that context, it is important to ensure that the data are archived well.

Dr. Boss turned the discussion to WFIRST. It is not yet clear what will happen if Euclid goes forward, and it is not yet possible to know about funding. APS should push for a major mission. ESA has already replanned because of NASA's preferences. Meanwhile, NASA is developing credibility issues because of pulling out of other projects.

Dr. Boss then suggested they address the information presented by Drs. Gallagher and Sparke. There was some concern that Explorer is seen as a bank. It was suggested that the letter support Dr. Morse on that program, and mention preserving the Explorer program whether or not NASA engages in the other missions under consideration. It was also noted that this is a very difficult time and situation. Some APS members found the mission concept study call confusing. It was suggested that that discussion was about keeping options open. Some members want to encourage more inputs into the next DS. The recent DS did not have a huge menu across the range of missions. APD needs more affordable mission options.

In discussing the expenditures to date on JWST, it seemed that half had been spent out of a projected $6.5 billion for a 2015 launch. It was also suggested that Subcommittee members ask Dr. Ed Weiler, Associate Administrator for SMD, if there is a baseline budget for APD that he will not go below, and whether he sees the APD budget shrinking or growing. An overarching issue is how NASA proceeds into the next DS. Dr. Dey expressed concern about how NASA plans missions for costs. Dr. Boss asked him to start a paragraph on that for the letter. There was also concern about the rising costs of missions. To do a big mission, there must be funds toward technology development at the beginning.

Dr. Boss adjourned the meeting for the day at 6:35 p.m.

July 14, 2011

Dr. Boss opened the meeting by reviewing the agenda and asking phone attendees to identify themselves. He explained that Dr. Chris Martin would be making an unscheduled presentation about the Cosmic Origins Program Analysis Group (COPAG) activities.

Joint ExoPAG/COPAG Meetings and Activities

Dr. Kasting discussed the recent activities of the Exoplanet Exploration Program Analysis Group (ExoPAG). Since February, there had been a joint meeting with COPAG in April, with 20 attendees, and the fourth ExoPAG meeting in June with about 60 individuals present.

At the joint meeting, much of the discussion centered on large space telescopes, which the two groups would like NASA to emphasize when there is appropriate funding. The resulting recommendation was that both groups should pursue the study of two different types of representative missions. One would be a 4-meter aperture monolithic telescope with an internal coronagraph. The other would be an 8-meter aperture segmented telescope that relies on an external occulter to achieve the high contrast needed to find an exoEarth. The details remain to be worked through. Most important is that investigators need to know factors such as η_{Earth} from Kepler, exozodi brightnesses, and the desires of the COPAG science community.

At the ExoPAG4 meeting, there was discussion of the proposed Imaging Performance Study (IPS) to be carried out by the Exoplanet Exploration Program office at the Jet Propulsion Laboratory (JPL). (Note: This study has now been postponed until next Spring at the earliest at the request of NASA Headquarters.) ExoPAG hopes to rewrite the science requirements for a direct imaging mission. The thought is that the best way to phrase the requirements is to use a Kepner-Tregoe table in which some requirements are considered as absolute, while others are evaluated on a point-scoring basis.

The New Worlds Technology Development Program (NWTDP) was recommended as the top medium-class priority by the DS. An action item was proposed after Dr. Web Cash argued that the level of technology funding for the NWTDP is insufficient to enable a direct imaging mission to be selected in 2020. He wants ExoPAG to play a role in advising how technology money should be spent. The plan should include demo missions for the various technology concepts (i.e., occulters and coronagraphs).

Therefore, the action item is in the form of a request to APS, that ExoPAG be allowed to set up a new study analysis group (SAG) to examine how the NWTDP could be most effectively implemented. Dr. Cash would be the chair. A report would be presented at the ExoPAG meeting in January 2012, then forwarded to the APS committee if approved by the ExoPAG.

Discussion

In response to a question about the level of technology funding Dr. Cash believes necessary to be ready by 2020, Dr. Kasting explained that Dr. Cash hopes for a great deal of funding for demo missions. He suggested a low-Earth-orbit occulter, though Dr. Kasting himself is unsure that such a demo mission is feasible. Dr. Morse said that APD wants science requirements from the PAG, and technology proposals. APD will then determine if and how to make projects happen.

A member of the public in the room said this would be a good thing to demonstrate in space regardless of who pays for it. It would give the science community a coherent set of themes and recommendations. He was at the ExoPAG meeting and has been getting feedback. The messages from subcommittees are heard more clearly when there is a call for a new flight mission. An APS member asked if the suggestion is to look into technology requirements for prelaunch verification or an on-orbit occulter verification. Dr. Kasting replied that Dr. Cash wants both. He also wants a technology SAG to make recommendations about how technology is funded. Dr. Heap said that all occulters have problems with ground-based

testing. A SAG to look at requirements for prelaunch testing would be a good idea, but APS should be careful in defining the task and make sure to do so in a useful way. In later deliberations, the APS committee recommended against setting up such a technology SAG. In place of this, Dr. Cash will be encouraged to write a white paper on technology funding, with community involvement. Dr. Morse cautioned that this paper should focus on technical aspects of how the NWTDP goals can be met, and not on programmatic issues such as how available funds are allocated.

Discussion revealed that it is not clear the extent to which certain programs are driven by the peer review process or strategic prioritization across the spectrum of possibilities. Nor is it clear who should weigh in on how a program is prioritized. Dr. Morse explained that ROSES, R&A, and other activities are carried out through competitive means. The strategic technology investments come from the three strategic science themes. The budget horizon is mid-decade. The PAGs help set roadmaps in the strategic areas aligned with DS goals. The balance will be set largely by DS rankings and priorities.

In response to a question about the appropriateness of ExoPAG addressing how to broaden the study to lower costs, Dr. Kasting said that the looming question is whether APD wants to conduct small missions and delay big ones. Dr. Morse said that in strategic planning, APD looks at the DS recommendations. To the extent the Division considers the future budget environment, APD will need to consider cost versus impact. Dr. Boss advised asking ExoPAG if they want to do another SAG before APS makes the decision. It is unclear what benefit a SAG would present. One of the main values of the PAGs is the community sense, and there is a sense that the community wants to move this along. Dr. Morse said that the PAG should develop roadmaps. Dr. Kasting agreed to return to the PAG with that statement.

Physics of the Cosmos Program Analysis Group (PhysPAG) Activities Report

Dr. Ritz described recent activities, including an in-person meeting in Anaheim in May. One main goal was to increase community engagement in PCOS science. The agenda included news from HQ, PCOS program office activities and technology road-mapping plans, discussions of gravitational wave and X-ray science in the coming decade in light of recent events, discussions about gamma-ray science opportunities, CMB science opportunities, and IPSAG and TechSAG activities. One action item was to develop a proposal for a new gamma-ray SAG. If this proposal is approved by the PhysPAG, Dr. Ritz will bring it to APS. The next face-to-face PhysPAG meeting will be the before the AAS meeting. PhysPAG will plan a set of talks from the community to improve participation in several areas. There will also be a special summary session at AAS for all three PAGs, which will take place on January 10.

The TechSAG is continuing to gather inputs from the community for the next technology call. HQ needs those inputs this summer. This is a collection exercise, not a critical evaluation, but the goal is to map to PCOS science needs. TechSAG will also note if a technology is potentially important for Explorers. The Inflation Probe SAG (IPSAG) and TechSAG will coordinate on a comprehensive list of technologies.

Regarding the gravitational wave and X-ray discussion, the U.S. community is exploring with the Europeans and NASA the potential modes of participation in the European-led missions. PhysPAG wrote a statement to communicate to APS:

> "*The PhysPAG understands the X-ray and Gravity Wave communities in the US, after decades of investment, have great interest in finding a minor, but significant, hardware role in the emerging European-led missions, and continued deep involvement in this science. The opportunity costs and priorities for such a role should be understood in a timely manner. Regardless of the outcome of the European selection process, the communities see as vital the continued support of technology to enable possible future US-led missions in these science areas, as highlighted in the Astro2010/NWNH Decadal Survey."*

Dr. Boss thought this statement was noncontroversial and asked the Subcommittee members if they wanted to include it in the letter report. They did. In answer to a question, Dr. Ritz said that the PAGs and SAGs do take into account both ground and space capabilities. IPSAG is very aware of this. Dr. Shaul Hanany, participating via phone, said that there is much suborbital work. The PAGs are not funded to do continual studies of balance, but can be aware of these things and voice needs.

PhysPAG agreed that the HQ idea of a PCOS newsletter is very good, and added that community wants to know the realistic landscape of future opportunities: what work could realistically move forward on a path to a possible launch over the next 5-15 years? This would help stimulate their work. TechSAG agreed that on the PCOS technology assessment task, they want the next round iterated and a note out to the community to solicit comments. IPSAG is very active, looking at technology needs in terms of what NASA wants and the mid-decadal review.

COPAG Activities

Dr. Martin identified three new members that COPAG hopes to add to the executive committee. Recruitment has been difficult. COPAG has had regular teleconferences and two meetings, with a workshop planned for the Fall. The PAG provided inputs to the NRC/NASA technology roadmap process as well. Dr. Martin noted the highlights from the joint meeting with ExoPAG and repeated the recommendation for the 4-meter and 8-meter aperture telescopes.

COPAG revised its list of 2011 tasks, to include APS approval of four SAGs:

- SAG1: Science Objectives for a Next Generation UVOIR Flagship Mission (4-8 m)
- SAG2: Determine technology focus areas for a monolithic 4m Aperture UV/Optical/NIR mission with Internal Coronograph for Exoplanet Imaging
- SAG3: Determine technology focus areas for a segmented 8 m Aperture UV/Optical/NIR mission with External Occulter for Exoplanet Imaging
- SAG4: Determine technology focus areas for future Far IR Instruments

There are also questions about the definition of a roadmap. Dr. Morse said that he wants the groups to avoid narrowing down options prior to proof of technology, and while he wants multiple paths, it is important to not spend time on infinitely expensive possibilities. APD is seeking technical analysis of what is feasible for timescales and possible investments, though programs at NASA hone in on the latter.

Discussion

In answer to questions about the four proposed SAGs, Dr. Martin said that SAG 1 is a science SAG, and SAGs 2 and 3 are taking contrasting looks at successors to Hubble. Regarding the new candidates for the executive committee, there was concern about diversity on a number of levels, including institutional, geographical, and gender. Dr. Dey offered to send Dr. Martin a list of potential candidates, though Dr. Martin said that many individuals were contacted and had refused. It was suggested that the three listed candidates be approved while COPAG continues considering candidates who might bring more diversity to the executive committee. APS voted to approve the SAGs and the candidates.

APD Performance Plan Evaluation

Dr. Sambruna introduced Ms. Jennifer Kearns, from NASA Headquarters, who outlined the APS tasks for the Government Performance and Results Act (GPRA). This is a process in which APS evaluates APD performance in certain key areas. The evaluation is color-coded:

- Green: Expectations for the research program fully met in context of resources invested.
- Yellow: Some notable or significant shortfalls, but some worthy scientific advancements achieved.
- Red: Major disappointments or shortfalls in scientific outcomes, uncompensated by other unusually positive results.

Dr. Sambruna had distributed a draft response with examples of press releases to the APS members. She asked for their help in providing images and graphics. Ms. Kearns added that APS was to rate how SMD has performed in actual science results. Due to the nature of the process, the APS is being asked to consider accomplishments over the prior 12 months rather than the fiscal year. The NASA Chief Financial Officer (CFO) had requested that the information arrive in that office by mid-August, and Ms. Kearns will need the APS report before then.

The report given to APS before the meeting was to be the basis of the color ratings. APD would then submit the APS report to SMD, which will take portions of the document to create a report geared to an intelligent layperson audience. Therefore, any science examples are more likely to make the larger report if they can be accessed by non-experts. There will be a minimum of two and a maximum of four examples for each of the three key areas.

Dr. Sambruna had pulled together some examples of accomplishments on the various metrics under consideration, and APS was free to add to those or delete from the list. What goes forward provides a few representative accomplishments and possible disappointments. The color rating is a requirement, while the text provides support.

The “intelligent layperson” they are writing for includes people like OMB and Congressional staff. Dr. Boss said that the APS members could find the pictures to support the accomplishments. He suggested they make a fast pass through the document, vote, and assign the remaining work to individual members.

APD Performance Evaluation: Report Writing

The three performance areas are as follows:

•Goal 1: APG 2.4.1.1: AS-11-1

Demonstrate planned progress in understanding the origin and destiny of the universe, and the nature of black holes, dark energy, dark matter, and gravity. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.

•Goal 2: APG 2.4.2.1: AS-11-3

Demonstrate planned progress in understanding the many phenomena and processes associated with galaxy, stellar, and planetary system formation and evolution from the earliest epoch to today. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.

•Goal 3: APG 2.4.3.1: AS-11-5

Demonstrate planned progress in generating a census of extra-solar planets and measuring their properties. Progress relative to the objectives in NASA's 2010 Science Plan will be evaluated by external expert review.

Dr. Boss suggested grading the three areas first. Dr. Heap, who wrote her comments in a document distributed to the other members, noted that they were considering science results on missions that are being implemented. Dr. Boss added that they were only to consider what had been done in the last year. The three metrics were pulled from performance plan.

Discussion of Goal 1

Dr. Heap suggested putting the example "Mysterious Giant Bubbles in Our Galaxy Hint at Past Explosion in the Galactic Center" under the second goal, but it was decided to keep this example under the first goal. Dr. Sambruna volunteered to find an accompanying graphic. It was suggested they keep the next example, "Youngest Nearby Black Hole Found at X-rays: Constraints on BH Formation," under the first goal as well. However, some felt this might not be a strong example, so it was kept in reserve. Discussion of the third example, "Fermi Catches Earth Thunderstorms Hurling Antimatter into Space," centered on the relative importance of serendipitous findings. APS agreed to keep it, and Dr. Oswalt was designated to find images. Another example, "Evidence for Superfluidity in Neutron Star's Core, Unattainable on Earth" was the result of observations by Chandra taken over 10 years. Several papers have resulted. Dr. Hughes offered to find images.

Dr. Heap also recommended keeping "Swift/Hubble/Chandra: Telescopes Join Forces to Observe Unprecedented Explosion." This example provides an opportunity to highlight to Congress the importance of having different types of telescopes. Dr. DeVore took the lead for this one. In her analysis, Dr. Heap did not think that "Gravity Probe B Confirms Two Einstein Space-Time Theories" warranted inclusion. As funding has been cut off for this project, the Subcommittee concurred after some discussion. "High-Energy 'Superflares' in the Crab Nebula" was recommended for inclusion. People who are not experts talk about the Crab Nebula research, and the findings here confound theorists, which is a key to learning. Drs. Ritz and Hughes took on the task of locating pictures.

Dr. Heap thought the NASA link to "Radio Telescopes Capture Best-Ever Snapshot Of Black Hole Jets" was tenuous. This example was dropped. "NASA'S Chandra Finds Massive Black Holes Common In Early Universe" was moved to the second goal. It was an interesting example with nice results and good pictures. Dr. Dey took the lead.

At that point, APS had five examples for the first goal. Dr. Heap said that she had proposed moving up an example on dark energy and the detailed dark matter map. Dr. Martin took that one, bringing the number of examples up to six.

APS voted unanimously to grade this goal as Green.

Discussion of Goal 2

This goal had an example brought down from the proposed examples under Goal 1. Also for the second goal was "Surprisingly Young Galaxy Detected: Clues on the Early Universe Reionization." Dr. Heap took the lead on this example, and agreed to change "young" to "early." The Subcommittee did not feel that "SOFIA Successfully Observes Challenging Pluto Occultation: Clues to Pluto's Atmosphere Structure and Composition" was strong enough, as it was fairly recent and might be better suited for 2012 when something has been published about it. It was also agreed to drop "Hubble's Millionth Observation" in favor of mentioning it in the introductory paragraph.

Dr. Heap added "Hubble Captures New Life in Ancient Galaxies," which mentions GALEX and essentially states that NASA telescopes find life. She and Dr. Martin agreed to work on that example. Dr. Boss suggested that they find something involving Kepler on stellar seismology, which those present determined that Dr. Vicki Kalogera could write. Dr. Bernstein offered to find an example about Planck and Herschel. Another suggestion was the release of the database allowing astronomers to better analyze spectroscopic data, which supports lab astrophysics. These fundamental molecular data are critical. It was recommended that APS have at least one result for each active mission. Dr. Kaiser volunteered to write one on brown dwarfs and blue compact dwarf galaxies and the WISE program; Dr. DeVore offered to help.

With seven examples, APS voted unanimously to declare this goal as Green.

Discussion of Goal 3

For the third goal, APS agreed to include "First Carbon-Rich Planet Revealed by the Spitzer IR Observatory." Dr. Kasting agreed to be in charge of it, noting that the press release did not include the most interesting fact. Next was "Kepler Mission Discovers Its First Rocky Planet," which was taken by Dr. Boss. Dr. DeVore volunteered to write the piece for "Kepler Finds Earth-Size Planet Candidates In Habitable Zone, and a Six Planet System." It was agreed to drop "Free-Floating Planets May Be More Common Than Stars." In part because it is difficult to explain to the intelligent layperson, APS kept "Spitzer Sees Crystal 'Rain' In Outer Clouds Of Infant Star" as a reserve example. Dr. Martin suggested adding the GALEX result of nearby stars that are young and warm, which he offered to write.

There were four examples for this goal. APS voted unanimously to grade this goal as Green.

Summary of Assignments
Dr. Boss recapped the assignments, which he asked to have sent to him in order to share with the entire Subcommittee.

- Goal 1:
  - Mysterious Giant Bubbles in Our Galaxy Hint at Past Explosion in the Galactic Center - Dr. Sambruna
  - Fermi Catches Earth Thunderstorms Hurling Antimatter into Space - Dr. Oswalt
  - Evidence for Superfluidity in Neutron Star's Core, Unattainable on Earth - Dr. Hughes
  - Swift/Hubble/Chandra: Telescopes Join Forces to Observe Unprecedented Explosion - Dr. DeVore
  - High-Energy "Superflares" in the Crab Nebula - Drs. Ritz and Hughes
  - Dark Energy Is Accelerating the Expansion of the Universe - Dr. Martin
- Goal 2:
  - NASA'S Chandra Finds Massive Black Holes Common In Early Universe - Dr. Dey
  - Surprisingly Young (Early) Galaxy Detected: Clues on the Early Universe Reionization - Dr. Heap
  - Hubble Captures New Life in Ancient Galaxies – Drs. Heap and Martin
  - Kepler on Stellar Seismology - Dr. Kalogera
  - Planck and Herschel – Dr. Bernstein
  - Release of the database allowing astronomers to better analyze spectroscopic data - ***
  - Brown dwarfs and blue compact dwarf galaxies and the WISE program – Drs. Kaiser and DeVore
- Goal 3:
  - First Carbon-Rich Planet Revealed by the Spitzer IR Observatory - Dr. Kasting
  - Kepler Mission Discovers Its First Rocky Planet - Dr. Boss
  - Kepler Finds Earth-Size Planet Candidates In Habitable Zone, and a Six Planet System – Dr. DeVore
  - GALEX result of nearby stars that are young and warm – Dr. Martin

Day 2 discussion:

Discussion of JWST Status
Dr. Dey drafted sample text for the letter, stating the importance of JWST, recommending that NASA review its costing of large missions, and requesting a presentation on budgeting procedures and options at the next APS meeting.

APS members want to hear the outcome of the replan and learn how APD plans to handle flagship missions. Dr. Morse said that APS is free to make recommendations, though some budget information is embargoed. The embargoed FY13 budget may be tied to how NASA works with Congress on the FY12

budget. Dr. Boss refined the issue to state that APS is asking about the impact on astrophysics due to concern about the APD budget. Others were interested in what, if anything, APS can do to help. There was frustration with the lack of information about the future budget pictures for APD and JWST.

Dr. Heap said that APS members see themselves as the protectors of astrophysics. If the mission costs are too high, they want to review the situation to keep the portfolio balanced. Dr. Oswalt asked how sacrosanct the APD budget is, and whether NASA has a viable plan to implement JWST by 2018. It was noted that future budgets cannot be predicted. There was concern that APD was being sacrificed for JWST, and there was perception of a lack of balance. The Decadal Survey (DS) guides NASA, but it did not anticipate the present situation.

There was also concern about the evident lack of a "Plan B." Dr. Heap observed that the assumption is that money will be found, but that might not happen. It was not clear that Mr. Howard had considered JWST descopes. There is a lot of risk, and it is in OMB's and Congress's hands now. It was noted that budgets are always embargoed at one point, making it difficult if not impossible to obtain complete budget information. This inhibits APS's capacity to make decisions or recommendations. APS does have the ability to give scientific advice and suggest that a body be convened to look into how JWST will be continued without taking more funds from APD. Chandra was the result of a 1991 descope from a project approved in 1984. Incredible science is possible from a descoped mission, no matter how painful the descope may be.

The JWST launch date of 2018 assumes new funds. There has also been the message that there will be no new starts. It is possible that it could be 2027 before a new flagship mission launches. DS is completely moot in that regard. It was suggested that going forward, APS have a standard 2-hour time slot for JWST at all meetings. It was also suggested that APS members engage Dr. Weiler about the appropriate budget for APD. It would be good to find a positive, constructive way to support APD. It might help to have a broader community look at this, though assembling a new group would take time and could be complicated. It was noted that, after a point, a descope can cost more than going forward.

There was interest in finding ways to ensure that these problems do not occur again. NASA begins to have a credibility issue by proposing large missions that exceed costs. The letter should reflect this. It would be helpful to know there is a funding line to move things from lower TRLs to higher levels.

Q&A Session with Dr. Ed Weiler

Mr. Howard arrived with Dr. Weiler and addressed two points. He began by showing a top-level schedule chart for JWST that illustrated where the project could and could not move activities to save money. There is a period from 2016 to 2018 in which activities cannot be compressed. There are some gaps between completion and integration tasks that could realign the schedule by 6 to 12 months, but to do so would require revising the profile and would call for additional funding in the early years, starting with FY12. This is not likely to happen.

The program team has looked at different ways to descope. The team did loosen the testing requirements. In the current state of development, further descopes would either increase the risk greatly or would not save funds at all. Mr. Howard said that it would not save money to reduce the science objectives. The telescope is done and cannot be made smaller. To redesign the mission would cost more than implementing it.

Dr. Boss asked Dr. Weiler for his thoughts on how JWST is moving forward and his reaction to the replan going ahead. While APS members want JWST to move forward, a concern that the funding will negatively impact APD and SMD portfolios. Dr. Weiler explained that if JWST were on schedule and cost, there is still the bill the House of Representatives passed to cut 17 percent from all government programs. There are multiple activities occurring with the debt ceiling and the FY12 budget, and JWST faces a range of forces. The House has eliminated JWST from APD, as well as $150 million, or 10 percent, from SMD across all four divisions. The Senate has yet to address the budget. JWST is just one part of the problem. If SMD has to fund JWST, there will be a huge impact on all four divisions.

There are reports about what NASA should do, but in fact NASA cannot move more than $500,000 without Congress and OMB approval. He would not seek to save money by turning off Hubble and Chandra. On projects like New Frontiers and Discover, however, NASA does have the discretion to move funds. Those programs come in at cost or even under because of this flexibility.

Dr. Boss explained that APS has been grappling with the threatened termination of JWST. Dr. Weiler said that he does not know what direction the Administrator will take, but he has made his recommendation for SMD. The Administrator's decisions have to be approved by OMB and Congress. If he is told the FY12 funds for JWST must come from SMD, he (Dr. Weiler) will go to the committees and the science advisory council. If the debt ceiling is dealt with, the next issue is the fact that Congress rarely passes budgets by October 1. There will be Agency-level decisions, but he is not sure what OMB will allow NASA to decide. Some programs are Administration priorities and some are not. A Continuing Resolution (CR) will not necessarily support those priorities. Any anomalies would be in the CR.

Dr. Ritz thanked Dr. Weiler and noted that if he needs to bring these issues to APS, it would help the Subcommittee members to know as much as possible in advance so they can consider options. Dr. Weiler said that Dr. Morse would develop several options to present before APS. Dr. Morse added that SMD did not want to get the community involved unnecessarily or create unwarranted concern. He suggested that APS members follow Congressional proceedings and familiarize themselves with strategic plans, the DS, and other sources of guidance. Dr. Weiler pointed out that while there would be no guarantee that APS choices would be approved by OMB and Congress, those recommendations would give NASA credibility with OMB and Congress. He would accept their recommendations. He does not want to decide to kill missions.

Dr. Kalogera said that when JWST was moved from APD, APS understood the reasoning. However, one of their questions is whether there is any certainty that the funds will eventually come back to APD. That concern is intensified if JWST does not fly and the funds are already proposed to come from APD. While

she would like to make a statement in favor of continuing JWST, she was concerned that APD might be asked to cripple current programs in favor of JWST.

Dr. Weiler said he understood her concern but could not advise an advisory committee. It is one thing to suggest moving JWST if it does not affect APD, and another if it does or if it affects SMD. He is not sure what OMB, the White House, and Congress will do. Dr. Boss noted that the best APS can do under these circumstances is put forth a comment supporting JWST as long as it does not eviscerate APD.

Regarding the next APS meeting, the optimal timing was not clear. A September meeting would be optimistic; NASA will not yet be free to discuss the FY13 budget then. Dr. Weiler explained that much had to happen before they talk next. The debt ceiling situation will possibly affect the FY12 budget. A Senate mark-up would be JWST's best hope for support. It was decided to wait on the scheduling.

A Subcommittee member said that APS members need to explain this to their communities. They want to be able to tell their communities that everything possible is being done to reach the best possible balance. Mr. Howard said that the analyses APS was seeking had been conducted. If they want to do JWST with a high level of confidence on time and on budget, this replan is required. Cutting back on JWST will only lose the science capability and will not save any money. When it was suggested that there should be reports quantifying that statement, Mr. Howard said he would take that as an action item and will provide APS with the documentation.

Dr. Weiler observed that there were meetings like this on Hubble, which had a 400 percent overrun in the 1980s. It was too late then, and it is too late now. The pieces are built. The real cost is in putting it together. Dr. Boss said that if the 75 percent by mass (not cost) figure includes those elements that are ready to be fabricated, APS needs to know what is really completed. It may not affect what they do, but they need to take this information to the community. Mr. Howard said that the issue is the percentage of the cost that has been spent to build items and deliver them to the next level up.

Dr. Heap said that that information will not help her. It is believed that less than half the money has been spent, and that APS would therefore be making decisions about spending billions of dollars. The Subcommittee needs to know the money is being put to good use. Mr. Howard said that what is in the current budget through FY18 is a baseline. Dr. Weiler added that if JWST is cancelled, that money disappears from astronomy. Dr. Dey asked for the costs in different scenarios, and the long-term impact on APD. This is where convincing colleagues in the scientific community is worth pursuing, as this is where their concerns lie. The fundamental issue is the community not understanding the lifetime cost of the mission to APD.

It was added that this issue will continue to arise, and is the central issue for the coming years. Dr. Weiler said that Congress is the only unit that can cancel or start programs. He also confirmed that APS is an independent FACA, and its advice goes to the NASA Advisory Council (NAC). In looking at the four SMD division budgets over the long term, Dr. Weiler observed that when he returned to NASA in 2008, the APD budget had been reduced by his predecessors. Changing the balance among the divisions has

become increasingly difficult. NASA's science budget continues to decline. Astrophysics and planetary sciences are less healthy than they used to be, and heliophysics is low. On the other hand, earth science is healthier than ever.

In the Fall, there could be a range of options to discuss. That is often handled by a senior review process. Dr. Morse was asked how he would like to balance that, whether APS is the best body for that kind of advice, and how he would like APS to proceed. He replied that APD would work to get the Subcommittee members up to speed. It also depends on the funding amount that might be lost. The members' homework is to familiarize themselves with the plans and reviews.

Dr. Weiler added that the health of science at NASA has never been better. SMD launches many missions, and Hubble puts out great science, as do Swift and Chandra. These are the golden days of Astrophysics. Heliophysics and Earth Science are also doing great. Most of that is coming in at cost. In the near term, Dr. Morse has laid out a program where he cannot move WFIRST along in this decade, but Explorer and other programs are going strong. The near-term future is okay. The long term is what Dr. Weiler is worried about, especially regarding where the country is going in its ability to fund science.

Dr. Weiler answered a question about the implications of moving JWST program management out of SMD by stating that he remembers that other mission directorates contributed to science in one previous situation. It is possible that moving JWST under the NASA Administrator allows for more flexibility. Mr. Howard reminded APS that while JWST is now a completely separate division, the budget comes from APD, making it an Agency science priority. This happened with Hubble, though that program manager never reported directly to the Administrator. Dr. Weiler closed by stating his intent to provide more information to APS at the next meeting.

Public Comment Period

Dr. John Mather of Goddard was present and said that the Science Working Group for JWST wrote a letter. He asked the Subcommittee to read it and second the recommendations. Dr. Ritz said that he had read the letter, and asked Dr. Mather what major differences he'd seen over the past year. The science community wants to understand why this is not throwing good money after bad. Dr. Mather replied that the change in management structure changed the view of the project. The replan answers the question of whether this is the right program. He feels it is a better environment than previously. There is more flexibility and lower risk. Staff have come over from Hubble and added to the project. He had been concerned about detectors going bad on the shelf, but that has been addressed.

Discussion/Pending Issues/Meeting Report Writing/Briefing to Division Director

Because Dr. Morse was available to stay to the end of the meeting, Dr. Boss merged the report writing with the APD briefing. Dr. Morse said that he received a clarification on the Chandra safe mode issue, reporting that it was solved. APD will clarify what it wants the PAGs to provide in the way of helping APD with roadmaps. The current focus is on NASA's next strategic plan, which will include roadmaps for FY13. APD will need APS inputs in about a year. He thinks the PAGs are doing great work.

For future, there are things to keep in mind. First, how should NASA fund analyzing data from space-based missions in which NASA is not a partner? Researchers need to be provided with a mechanism for this. Other agencies are making their archives public. He asked APS to think about how to fund this. Second, he will get back to them on how to do a user group for the research portfolio. It could be a subgroup under APS, an ad hoc group, or some other type. Third, he wants to look at how to do long-term planning for archives. There are questions about how to take into account the next generation, the enormous data volumes currently in existence, and how to make databases talk to each other. It is more of a longer-range strategic plan, and he is not sure where or how this might work. He also reminded APS that JWST will eventually go back under APD like Hubble did. He will get the budget data for them. Post-launch, JWST will be a Division responsibility.

WFIRST

In answer to a question about WFIRST, Dr. Morse said that APD needs to get through the formulations to know what the mission and surveys look like. There is a difference between SDT's take on capabilities and that of the DS. Once it is known what ESA is doing about Euclid, APD will be better able to evolve WFIRST. He believes it will be possible to have a report by the end of 2012. If the project can establish an implementation in the budget horizon, APD can move to the next step. The budget plan has funds to support planning and even some technology and instruments. Dr. Morse believes NASA should move ahead and see how events affect the pace going forward.

The WFIRST SDT is still active through the next year. Dr. Morse answered a question about the worst-case scenario, in which JWST is lost, by noting that it would affect the DS goals, which would require assessment. He was unsure of the mechanism for doing that. It could change the tenor of the meeting with NRC. Dr. Heap referred to the JWST Science Working Group, which had studied how to accomplish the objectives through other means. That kind of report would be useful. Dr. Morse explained that they own that process. It is part of breach reporting, and he was unsure whether those reports are made public or not.

Dr. Bernstein expressed concern that they did not discuss the WFIRST report they received. He did not agree with everything in the interim design and was concerned that the designers tried to fit the elements into a concept rather than asking if all the science goals are truly worth pursuing. For example, the mission requirement is to survey a given area, but science would say to survey over a given time. As it stands, the design could fall short of optimal, and that leads to questions of whether there should be a 7-year mission up front. He thought the dark energy science was not dealt with sufficiently and quantitative goals were not put forth. He also thought that the lensing is clearly inferior. There are missions starting this year have that same power. The supernova aspect is questionable. Dr. Ritz wanted to commend the team for their work so far and ask them to consider a mission trade analysis. Dr. Boss asked Drs. Bernstein and Ritz to develop some language to circulate. Dr. Morse added that the WFIRST team is guided by the DS, and their charter is to find the best path for proceeding. They are looking at cost against performance.

PAGs

Regarding the next science plan, there were questions about the role of the PAGs in the process. Dr. Morse said that the PAGs need to address technical and analysis issues, not the budget. They should look at the steps that should occur between the present time and a mission launch. They need to come up with more than just an observation that the funds are insufficient. They should identify the key technologies and milestones they want to demonstrate in order to move a mission forward, and stay away from budgets. His group looks at implementation.

Dr. Hanany, participating by phone, offered to help broaden the COPAG executive committee candidate base. Dr. Boss said that COPAG's executive committee is smaller than its counterparts, so there is room to add new people. Dr. Morse added that the PAGs are relatively new and, for that reason, not pulling in a lot of participants yet.

Dr. Boss noted that there was a request for action from ExoPAG that was deferred until the PAG had further internal discussion. Dr. Cash of ExoPAG is interested in writing a document, possibly a white paper, with his thoughts. The PAG will decide whether to forward the report to APS. Dr. Ritz said that the only PhysPAG request was to note the statement about the x-ray and gravitational wave community, which he agreed to email to Dr. Boss. Dr. Boss reiterated that the two action items on COPAG. First, APS approved the proposed new members for the executive committee and encouraged COPAG to add more diverse members. Second, APS approved the four SAGs.

Additional Items

In reviewing other meeting items, Dr. Boss thought APS had covered GPRA well. It was not yet decided whether to add Dr. Dey's statement about JWST to the letter report. APS members believe that the Explorer plan is good and the program is running well. In discussing the senior review of R&A, Dr. Morse said he thought APS will find itself revisiting the metrics issue. Dr. Allamandola said that the metrics will be a serious issue in learning from NASA's history and should show how useful a program is before it is cancelled. Dr. Morse noted that there are models. Dr. Kaiser observed that there is the impression that an alternative is periodic reviews, and Dr. Ritz cautioned that there must be a balance between garnering community input and being overly prescriptive. Dr. Kaiser agreed to write something on this issue.

In discussing mission extensions, Dr. Boss reiterated that all four presenters stressed the great things their technologies could do. He asked if APS should get involved. With restricted budgets, it is difficult. It was noted that the RXTE program, at only $1 million per year, helps young investigators. Dr. Morse explained that in talking with the senior reviewers about borrowing against Chandra for RXTE, the reviewers said not to go in that direction and to maintain the Chandra funds. On the other hand, they did want to keep the GALEX missions going. However, the senior reviewers also told him not to cannibalize new missions to support old ones. The wave of cuts overtook NASA's expectations of the budget. The bottom line is that there is nowhere to go for help on this. The hope is that there are no further cuts. It was decided that APS would thank the presenters for their input and leave it at that.

Dr. Boss continued his summary of the meeting. The action items for Dr. Howard were that he will provide documentation for alternatives, documentation on descopes, refine some of the numbers he provided, and have a 2-hour period at the next APS meeting for JWST. APS will also look at Dr. Dey's draft text, which lauds JWST, identifies problems, brings up the potential impact on APD, and notes possible options. There was discussion about the details of the text, with a suggestion to say that APS considers JWST to be important and encourages NASA to find and implement a solution, then say no more. Other APS members agreed with this approach. At the same time, Dr. Dey's statement had language protesting the House effort to cut budgets, which some members also wanted to state. Dr. Boss said he would work on it.

Dr. Bernstein asked if APS should develop principles for tradeoffs on large projects and smaller ones, to provide guidance in the future. Dr. Morse suggested waiting until there is more information about the likely budget trajectory, adding that it is very difficult to be proactive in this situation. If APD needs community input, he will try to pull it in. He foresees going to NRC for additional advice about what to do with the DS recommendations. Dr. Boss said that the letter will also mention opportunity missions and the flexibility to consider a range of options.

In closing, Dr. Ritz wanted to acknowledge that the meeting took place during the last flight of the Space Shuttle, which has inspired many young scientists in their careers.

Dr. Boss adjourned the meeting at 4:17 p.m.

Appendix A
Attendees

Subcommittee members
Alan Boss, Carnegie Institution, *Chair Astrophysics Subcommittee*
Rita Sambruna, NASA, *Executive Secretary*
Louis Allamandola, NASA Ames
Gary Bernstein, University of Pennsylvania
Edna DeVore, SETI Institute
Arjun Dey, NOAO
Sara Heap, GSFC
John Hughes, Rutgers University
Mary Elizabeth Kaiser, The Johns Hopkins University
James Kasting, Pennsylvania State University
Chris Martin, California Institute of Technology
Terry Oswalt, Florida Institute of Technology
Steven Ritz, University of California Santa Cruz

NASA attendees
Marc Allen, NASA SMD
Jaya Bajpayee, NASA Headquarters
Joan Centrella, NASA/GSFC
William Danchi, NASA HQ
Chris Davis, NASA HQ
Michael Devirian, NASA/JPL
T. Jens Feeley, NASA HQ
Charles Gay, NASA SMD
Rick Howard, NASA SMD
Doug Hudgins, NASA HQ
Jennifer Kearns, NASA HQ
Chryssa Kouvelrotou, NASA MSFC
Thierry Lanz, NASA HQ
Lia LaPiana, NASA HQ
David Leisawitz, NASA SMD
John Mather, NASA GSFC
Julie McEnery, NASA GSFC
Mike Moore, NASA HQ
Jon Morse, NASA Science Mission Directorate, *Director Astrophysics Division*
Marian Norris, NASA HQ
Bill Oegerle, NASA GSFC
Mario Perez, NASA HQ
Rob Petre, NASA GSFC
Linda Sparke, NASA HQ
Tod Strohmayer, NASA GSFC

Tina Swindell, NASA HQ
Ray Taylor, NASA HQ
Michael White, NASA GSFC
Greg Williams, NASA SMD
Dan Woods, NASA SMD

Other attendees
Kaitlin Chell, Lewis-Burke
Dom Conte, Orbital Sciences
Randall R. Correll, Ball Aerospace
Lamont Di Biasi, Southwest Research Institute
Kathryn Flanagan, Space Telescope Institute
J.S. Gelefti, University of Wisconsin
Michael Goreill, SAO
James Green, University of Colorado
Eric Hand, Nature
Illana Harrus, NASA
Bethany Johns, AAS
Jason Kalirai, Space Telescope Science Institute
Marc Postman, STSCI
Massimo Stiavelli , Space Telescope Science Institute

Webex
Lorella Angelini, NASA Goddard
David Bennett, University of Notre Dame
Michael Bevain, Committee on Science
Michael Bicay, NASA Ames
Jay Bookbinder, SAO
Louis Caluzienski, NASA
Richard Capps, JPL
Carol Christian, STSCI
Stephen Clark, Space Flight Now
David Content, GSFC
Jean Cottam, NASA Goddard
Kathryn Flanagan, STSCI
Gabriela Gonzalez, Louisiana State University
Ines Gonzalez, Louisiana State University
Matthew Greenhouse, NASA Goddard
Thomas Griffin, NASA Goddard
Richard Griffiths , NASA
Shaul Hanany, University of Minnesota
Hashima Hasan, NASA
Ingolf Heinrichsen, JPL
Garth Illingworth, University of CA, Santa Cruz
Clifton Jackson, NASA Goddard
Vicky Kalogera, Northwestern University

Louis Kaluzienski, NASA
Michael Kaplan, Aerospace Consultant
Jeff Kruk, NASA Goddard
David Leisawitz, NASA
Dan Lester, University of Texas
Marie Levine, JPL
Jeffrey Livas, GSFC
Matthew Mazur, NASA Goddard
Stephan McCandliss, Johns Hopkins
Susan Meff, NASA Goddard
Stephen Murray, Johns Hopkins
Susan Neff, NASA Goddard
Malcolm Niedner, NASA Goddard
Cathy Peddie, NASA Goddard
Paul Ray, Naval Research Laboratory
Wilton Sanders, NASA
David Schiminovich, Columbia University
Jerry Skinner, NASA
Eric Smith, NASA
Robin Stebbins, Space Flight Center
Michael Turner, University of Chicago
Stephen Unwin, Jet Propulsion Laboratory
Michael Werner, JPL
Jennifer Wiseman, NASA

Appendix B
NAC Astrophysics Subcommittee Members

Alan P. Boss, Chair
Carnegie Institution for Science
Department of Terrestrial Magnetism

Rita Sambruna, Executive Secretary
Astrophysics Division
Science Mission Directorate
NASA Headquarters

Louis J. Allamandola
NASA Ames Research Center

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

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

Arjun Dey
Associate Astronomer
National Optical Astronomy Observatory

Gabriela Gonzalez
Professor, Physics and Astronomy
Louisiana State University

Shaul Hanany
School of Physics and Astronomy
University of Minnesota/Twin Cities

Sara R. Heap
ExoPlanets and Stellar Astrophysics Laboratory
Goddard Space Flight Center
National Aeronautics and Space Administration

John (Jack) P. Hughes
Department of Physics and Astronomy

Rutgers University

Mary Elizabeth Kaiser
Principal Research Scientist
Department of Physics and Astronomy
The Johns Hopkins University

Vicky Kalogera
E.O. Haven Professor of Physics & Astronomy
Northwestern University

James F. Kasting
Distinguished Professor
The Pennsylvania State University

James G. Manning
Executive Director
Astronomical Society of the Pacific

Chris Martin
California Institute of Technology

Terry Oswalt
Professor and Head
Department of Physics and Space Sciences
Florida Institute of Technology

Paul S. Ray
Naval Research Laboratory

Steven Ritz
Santa Cruz Institute for Particle Physics
University of California

Appendix C
Presentations

1. *Ethics Training,* Adam Greenstone
2. *Astrophysics Division Update*, Jon Morse
3. *2011 Review of Astrophysics Programs in Research, Analysis, and Enabling Technology* J. S. Gallagher
4. *R&A Update,* Linda Sparke
5. *WFIRST Science Definition Team and Project Interim Report Presentation to the Astrophysics Sub-Committee Update,* James Green
6. *JWST Update,* Rick Howard
7. *ATHENA: The Advanced Telescope for High Energy Astrophysics,* Nicholas White
8. *Status of ESA's Next Gravitational-Wave Observatory,* Robin "Tuck" Stebbins
9. *RXTE Update*, Tod Strohmayer
10. *ESA's INTEGRAL Mission*, Gerry Skinner
11. *Galaxy Evolution Explorer: Scientific Accomplishments and Impact of Mission Termination*, David Schiminovich
12. *Suzaku Science Highlights & Consequences of Mission Termination*, Rob Petre
13. *ExoPAG/PhysPAG/COPAG Updates,* James Kasting, Steven Ritz, Chris Martin
14. *GPRA Review Process,* Rita Sambruna

Appendix D
Agenda

Astrophysics Subcommittee meeting
July 13-14, 2011
NASA Headquarters
AGENDA

Wednesday, July 13
Location: 5H45

8:30-8:35	Welcome and Conflict of Interest Review	A. Boss/R. Sambruna
8:35-9:30	Ethics Training	J. Reistrup
9:30-10:45	APD Programmatic Update	J. Morse
10:45–11:00	Break	
11:00–11:30	R&A Senior Review Results	J. Gallagher
11:30-12:30	R&A Program Update	L. Sparke
12:30–1:15	Lunch	
1:15-2:00	WFIRST SDT Ad-Interim Report	J. Green/P. Schechter
2:00-2:30	JWST Update	R. Howard
2:30-3:00	Athena, NGO updates	N. White, T. Stebbins
3:00-3:15	Break	
3:15-3:45	RXTE Accomplishments	T. Strohmayer
3:45-4:15	Integral Accomplishments	G. Skinner/N. Gehrels
4:15-4:45	GALEX Accomplishments	D. Schiminovich
4:45-5:15	Suzaku Accomplishments	R. Petre
5:15-5:30	Summary Day 1	A. Boss
5:30	Adjourn Day 1	A. Boss

Thursday, July 14
Location: 5H45

8:30 – 8:45	Joint EXoPAG/COPAG Meetings and Activities	J. Kasting
8:45- 9:00	PhysPAG Activities Report	S. Ritz
9:00-10:00	APD Performance Plan Evaluation: Discussion	Committee Members
10:00-10:10	Break	
10:10-12:00	APD Performance Evaluation: Report Writing	Committee Members
12:00-1:00	Lunch	
1:00-2:00	Q&A Session with Ed Weiler	Committee Members
2:00-2:30	Public Comment Period	
2:30–4:00	Discussion/Pending Issues/Meeting Report Writing	Committee Members
4:00–4:30	Briefing to APD Division Director	A. Boss
4:30	Adjourn Meeting	A. Boss