NASA ADVISORY COUNCIL

ASTROPHYSICS SUBCOMMITTEE

October 6-7, 2008

Cocoa Beach, FL

MEETING REPORT

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Craig Hogan, Chair

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Hashima Hasan, Executive Secretary

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Monday, October 6

Introduction and announcements

Dr. Craig Hogan, Chair of the Astrophysics Subcommittee (APS), opened the meeting and welcomed members.

APD Update

Dr. Jon Morse, director of the Astrophysics Division (APD), provided a division update, noting progress on the Joint Dark Energy Mission (JDEM), the continuation of the Laser Interferometer Space Antenna (LISA) mission, some evolution of the Con-X toward an international mission, and Einstein Probe technology investments. The division is focusing on a new medium class Exoplanet mission, and has begun a technical study for a Space Interferometry Mission (SIM) and SIM-Lite. The Stratospheric Atmospheric Infrared Observatory (SOFIA) mission development is also being accelerated. The overall Science Mission Directorate (SMD) budget is reduced from FY09-13, reflecting the cost of launches as they occur over this period. Heliophysics (HP) and Explorer funds may go into the APD if a small Explorer (SMEX) mission is selected. Congress may act in the spring on the FY09 budget request and there may be have an appropriations bill for the remainder of 2009. A significant number of IPAs and civil servants are now flowing through Headquarters, exposing them to the decision-making process. This new infusion of talent can help to assure unbiased and objective reviews, and is good for communication with the community, making the Headquarters process less opaque and mysterious.

Dr. Morse reported on the Hubble Space Telescope (HST) Service Mission-4 (SM-4) delay. Atlantis is in the process of having its cargo bay emptied, while the Space Shuttle has moved mountains, trying to adjust the manifest, which means re-allocating a new rescue vehicle. Atlantis will be rolled back to the Vehicle Assembly Building (VAB) and wait for the HST mission, possibly in February 2009. Twenty-five thousand pounds of equipment had been readied and installed into the bay, and all of this equipment needs to be re-cleaned in preparation for the delayed flight. A new extra-vehicular activity (EVA) timeline is being prepared to include a new repair to address the current anomaly. The telescope gyros, two new instruments and battery modules were originally the top EVA priorities. The minimum success criteria have now been reconsidered, based on some EVA simulations. It is now desired that at least one of the instruments be repaired, followed by the fine guidance sensors (FGS), followed by a second instrument repair. There is no extra EVA activity planned in the event that some instruments are not repaired; the schedule is currently confined to 5 days only. It may be possible to extend one

EVA to more than 6.5 hours. The choice of instrument repair had originally prioritized the Space Telescope Imaging Spectrograph (STIS) above the Advanced Camera for Surveys (ACS), but there are strong arguments either way, and the decision will probably occur in real time, depending on the progress of repairs, based on the criteria for maximal success. The baseline plan is to repair both STIS and ACS, however repairing the failed data management system will have very high priority because without it, one cannot talk to the telescope's science instruments.

HST's current status is safed, following a complete loss of Science Data Formatter (SDF) side A on September 27th. (transcript of September 29th briefing is available at: http://www.nasa.gov/mission_pages/hubble/servicing/SM4/main/20080929_briefing_materials.html).

Each SDF box has a side A and a redundant side B. HST has been using side A for 18 years, and NASA has never tested side B in space. The SDF is a router, a conduit between instruments and the data storage unit. The boxes are not cross-strapped; if one side A fails, the telescope must switch all systems to side B, leaving HST in a single-string mode. Activities are under way to switch over to side B. There is a spare Science Instrument Command and Data Handling System tray at Goddard Space Flight Center (GSFC) that can be tested on the ground, after which it must be sent through a flight acceptance program. However, NASA does not want to leave HST zero-fault tolerant, so the plan is to return HST to a redundant state via the new repair to get 5-10 more years of HST life. Further information can be found on website. A pretty tight schedule will have to be met to make a February 2009 launch, with many flights on the manifest, including Soyuz. There is a trade space to consider for instruments; if the SDF hardware is ready to go, it will be installed, while some other repairs may be omitted.

Accomplishments and significant events

SOFIA is moving along and has finished installation of door actuators. The mission has received 27 white paper proposals for early science. WISE, a medium-class Explorer (MIDEX) infrared (IR) survey mission, is set to launch in late 2009 on a Delta II vehicle. The mission has completed dynamics testing for a SoftRide mode to avoid more vibration, and is ready to go. The Herschel-Planck launch is scheduled for no earlier than (NET) March 2009, after having been delayed due to helium contamination in the fill line of Herschel (requiring about a month to cycle). Planck is in relatively good shape by comparison. The balloon program had a campaign at Fort Sumner, with student instruments successfully flown. The James Webb Space Telescope (JWST) has been confirmed for phase C, and is taking delivery of flight hardware. The first of 18 primary mirror segments is being readied for shipment to Marshall Space Flight Center for cryogenic testing. CSA underwent a critical design review (CDR) of the tunable filter inside its FGS, adding science capability. Near-infrared (NIR) spectrometer flight sensor chip assemblies were made in conjunction with the European Space Agency (ESA). JDEM has released a call for letters, and there will be intensive activity in this program over the next months. Kepler has completed flight segment thermal vacuum testing and did very well; there was a small issue in electronics box that is being investigated. Otherwise Kepler has completed a simulation of one week in the life of nominal science operations. The Astrophysics Theory and Fundamental Physics Peer Review has been held. Future events include the installation of SOFIA's primary mirror and first science results in late Spring 2009, the JDEM Announcement of Opportunity

(AO) release, an assessment of the HST launch delay, and the Kepler and Herschel/Planck launches in March 2009.

APD currently has 10 or 11 operating missions, with several in development, representing a rich portfolio. NuStar will be in development in about a year. The Fermi Gamma Ray Space Telescope is already providing science data and has been spectacularly successful thus far. Asked whether HST may be operating in overlap with JWST, Dr. Morse felt that the Decadal Survey may want to keep this possibility in mind. In the meantime, Senior Review and the community will be able to assess whether HST is worth the effort in parallel with JWST. The suborbital program is operating a suite of rocket flights in both heliophysics and astrophysics, with multiple flights per month, including the next Antarctic campaign to test superpressure balloons for ultra-long duration flights. Missions in formulation and implementation are mostly green; the yellows in JWST reflect normal technical hurdles. There continue to be some cost challenges with JWST, as it still will face the new budget reserve challenges. APD will be unable to start any large missions until JWST flies. Addressing rumors about cost overruns on JWST, Dr. Morse felt that the cost estimates were well in hand. NASA was not planning any deviation from the preliminary design review (PDR) levels. Dr. Jack Burns commented that APD must keep reiterating this confidence level. Dr. Morse cautioned against terming increases as overruns, in view of the quite healthy reserves in the outyears. Additionally, the new Administration may have different ideas about what to commit. These numbers are in advance of the non-advocate review (NAR), which is the budget that is sent to the program managers.

IXO (formerly the Con-X concept) is now being planned as an international observatory with ESA. The mission has found a path forward and some compromises will be made. LISA is developing material for the Decadal Survey based on the original baseline mission; however it is red due to budget issues in Cosmic Missions. JDEM is working toward an AO release by the end of 2008. NuStar (2011) reds reflect the appropriations bill problems with the top line of the science budget; NuStar was supposed to be paid for with carryover funds. At present it is only three-quarters funded, but overall the mission planning is likely to go forward.

Operating missions are green, with the exception of HST. GP-B will be terminated per the 2008 Senior Review. NASA funding ceased in September 2008, but GP-B can continue with private funding. Technical and scientific papers on GP-B status are due in November. In the absence of an XMM GO budget, there are still other sources of funding for investigators. The bigger pressure will come when Spitzer stops and archival resources will be necessary. APD is trying to sustain the portfolio with limited funds and let investigators fight it out in ADP, which is currently at about $14M/year, with perhaps a rise to $16M in the near future. Dr. Morse noted in response to a question that SMD Associate Administrator Ed Weiler was not planning on increasing the Research and Analysis (R&A) budget along the lines of his predecessor's trajectory, and that this might be an item for discussion for the next meeting. For a robust technology program, it may be possible to use other dollars to accomplish R&A.

Archives Senior Review

The ADS/SIMBAD archive ranked highest in the Senior Review. Entertaining a question about one-stop shopping vs. virtual observatories, and NASA working with Google and Microsoft, Dr.

Morse suggested that APS might wish to examine the future path for these archives, especially in terms of seamlessness and transparency. The Exoplanet archive (NSTED) was ranked lowest. As it is organized according to a science data theme, rather than wavelength, the Review was not quite sure of its efficacy and usefulness to the community. It will be reviewed again, separately, in 2 years. ESA Corot data will go to NSTED.

The Exoplanet exploration program is somewhat modeled on the Mars/planetary program, in that there are missions of different sizes and opportunities. Therefore, APD has moved to establish an ExoPAG to report to APS. The chair would be selected from the non-NASA science community, and the group would conduct biannual public meetings, with the goal of having the community look at the future and provide feedback to APS for formal recommendations. Dr. Burns commented that current NAC Chair Harrison Schmitt does not support the idea, being concerned about the promulgation of subcommittees that originally impelled Administrator Griffin to restructure the science committees. Dr. Schmitt has instead suggested an expansion of APS to include more exoplanet members. The alternative is to appeal directly to the Administrator to allow an ExoPAG Griffin. Dr. Morse felt it necessary to form the group to help NASA with its forward planning for NASA. Dr. Burns planned to revisit the discussion with Dr. Schmitt. APS expressed support for the ExoPAG.
SMEX selections are currently in phase A studies. Concept studies will be concluded before Christmas 2008, with a downselect in Spring 2009, and a launch NET December 2012 for first SMEX mission.

Astrophysics (AP) Fellowships are currently comprised of the Sagan (Exoplanet Exploration program office), Einstein (Chandra X-ray center) and Hubble (STSci) fellows. All new fellows will receive a $60,500 stipend. There will be at least 5 post-doctoral candidates in the first class of Sagan fellows. There will be a net increase in the number of Einstein fellows, and Hubble will support same number as last year, plus Spitzer (17 new fellows every year). The program is aiming for about 100 fellows altogether. Dr. Morse felt that the increased number will not dilute the prestige of the awards; the intent is to support students. He noted that the named fellowships are more successful for garnering the tenure track jobs. Dr. Kathryn Flanagan expressed the concern that new missions might need help until they are established. Dr. Morse replied that he would hope the selections would be steered toward those newest missions such as GLAST/Fermi. The numbers may fluctuate dependent on the science support needed. NASA can think things through if oversubscription takes place. The cash is held at the program level in a budget line that is separate from individual missions. Other monies will come out of R&A. Dr. Morse reported no complaints thus far and cited prominent community members who have complimented the fellowship effort. Dr. John Huchra commented that he would prefer that the fellowships remain at the institutions with the scientific expertise. Dr. Morse felt that the program also represented a good opportunity for a press release.

Dr. Morse revisited the question of whether NASA should introduce Senior Fellowships in each program for mid-career and senior researchers, to capture the essence of what LTSA used to do. The Senior Fellowship is envisioned as a small version of a MacArthur grant, with a fixed-amount award. Dr. Suntzeff compared the idea to a salary buyout. Dr. Morse described the fellowship goal as a means to allow integrated science proposals through one program,

emphasizing people who may work on multiple problems. Dr. Huchra commented that a high proportion of named fellows have had a high success rate, compared to those from LTSA who ended up in soft money positions and had to leave the field. Dr. Morse replied that age discrimination at LTSA was dropped as a result of this effect. The idea is to move from project-based to people-based awards, to try to reduce the burden of writing so many proposals and chasing money. Mid-career researchers might spend the money one way and senior faculty another. Members contemplated whether the funds might be used to hire people.

Dr. Morse addressed some budget issues. Kepler is interleaved in the Department of Defense (DOD) launch queue and is challenged to make its launch date. The HST delay represents a $10M/month burn rate, with a total projected to be $40M. NASA has already given the GO program a warning that it cannot do science until at least May 2009. The institute will decide how to call for programs if they need them, otherwise the budget will be quite limited. This fiscal year, APD may reduce science funding to pay for the slip, to try to contain the extra expenditures in Hubble first, and the program second. Dr. Morse felt that division could absorb $30M before other programs are cut. There is also language in the authorization act on conference costs that may be limiting to travel. Responding to a question, Dr. Morse said he might consider a NICMOS restart, before SM-4, in the Fall.

LEAG Moon Roadmap

Dan Lester presented an update on LEAG Roadmap activities, introduced by Michael Salamon via telecom. Dr. Salamon began with a few comments, responding to NAC's request for the Lunar Exploration Assessment Group (LEAG) to generate a lunar roadmap. Input into the LEAG has come through the major lunar conference at Tempe, AZ, workshops, the Web, and various other community bodies. The purpose of the briefing was to have APS to consider the astrophysics priorities thus far identified.

Dr. Lester continued the presentation, discussing astrophysics that could be accomplished using the Moon as a platform for the science, and briefly reviewing the LEAG agenda. The LEAG understands its charge as using the lunar return as an enabler for non-lunar science. NAC wants these types of investigations prioritized and to keep them in line with Decadal Survey priorities, and not to be presented as overall astronomy community priorities. Science merit and Decadal Survey considerations are not explicitly in the LEAG charter at present. As the planning for the transportation system provided by the Constellation architecture is starting now, the astrophysics community might consider taking advantage of new, heavy-lift launch vehicles, and cited a conference report regarding Astronomy enabled by Ares V. There is also an NRC effort on science opportunities enabled by the Constellation system. Results from these varying efforts have been generally consistent. The new Lunar Science Institute also had a meeting. The launch vehicle, estimated at $2B per vehicle, can put 60 metric tons at S-E L2, with a launch shroud 10 m in diameter, which may enable new telescope structures.

Access to the radioquiet side of the Moon, especially at low radiofrequency (RF) bands, as well as *in situ* resource utilization (ISRU), and human access beyond low-Earth orbit (LEO), may be enabled by the lunar architecture. High priority science identified at the Tempe conference included low-RF detection of material formed during the pre-reionization "dark ages." Two

astrophysics-based Strategic Missions concept studies are under way: Dark Age Lunar Interferometer, and a Lunar Array for Radio Cosmology, and there is also a mission in planning to fly a dipole around the Moon to determine the environment.

Three frequency regimes are considered useful – 150 MHz (can be ground-based), 75 MHz, and 30 MHz. The 75 and 30 MHz studies cannot be done from Earth, leaving the Moon as a potential locus. A few proof-of-concept missions will be needed to determine just how radioquiet the lunar far side is. Environmental protection of quiet zone of the moon (QZM) is also a planetary protection issue in the US, while international rights must also be protected in this regard, as are technical issues surrounding lunar night operations and instrument survival. Data processing is also a major issue, thus nominal missions must choose whether processing is done at the Moon or on Earth (the latter necessitating a high-bandwidth, and the question of lunar traverse, possibly up to 1000 km, must also be considered.

Dr. Lester detailed some feasible scenarios. An improved lunar laser ranging array could uniquely test the Strong Equivalence Principle and detect movement of the Moon's liquid core. The array is envisioned as a network of high-efficiency laser retroreflectors on the near side, which could better measure lunar libration. Deployment of such an array would require little new technology development, and is relatively inexpensive suitcase science.

A lunar energetic observatory, compared to a gigantic GLAST mission, would use regolith as a calorimeter, and could detect dark matter annihilation and cosmological backgrounds in diffuse gamma ray radiation signatures. A total mass of 125 mT regolith would be necessary to accomplish this mission. A science case could be developed after the completion of GLAST. Issues with this mission are dust, cold traps, lunar civil engineering hurdles, and RF characteristics of the lunar environment.

Placement of a large telescope at the Earth-Sun Libration Point 2, using the Ares V capability, and using an Orion vehicle for possible servicing of the telescope, is another concept that has been in play. Other lower priority science concepts which were considered but ultimately not chosen were a lunar optical interferometer, for extrasolar planet detection and AGN energy sources; LIGO on the Moon for detection of gravitational waves and merging n-stars; and a Large Lunar Optical Telescope, with a spinning liquid mirror, for detection of the first stars in the early universe, formulation of globular clusters, and Eddington-limit black holes at high z. Another mission under consideration had been to search for exotic stable states of matter, using more than 6 geophysical stations on the Moon. The characteristics of these detectors are along the lines of what lunar geophysicists want, but an astrophysical investigation would require many more detectors. The science case for this last mission rests on the observation of unusual seismic events on the Moon that are correlated with its orientation.

A report will be presented at the LEAG meeting in late October and presented at the next NAC meeting. Comments were welcomed. If there are astronomy missions from lunar orbit, LEAG has not yet heard/found them.

Lunch Discussion JDEM

Dr. Morse gave an update on JDEM, administered under the Physics of the Cosmos Theme, in cooperation with DOE, noting Richard Griffiths as the new JDEM Program Scientist. JDEM has been selected to go first in what is hopefully a sequence of missions. A Science Coordination Group has been assembled and will meet for the first time on October 15-16. APD has` worked on identifying scientific figures of merit, which my require need more than one dark energy investigative technique. A present JDEM is not considering high-energy measurements (x-ray), with the understanding that other x-ray facilities would be developed, such as Chandra/XMM, and IXO (formerly ConX) in development, as well as other MIDEX opportunities.

In response to some objections on the JDEM characterization, Dr. Morse conceded that the reassessment of the mission is in response to community concerns, and assured APS of continuing community input through a pre-AO announcement in mid October. APD is striving to design an architecture that will not preclude particular investigations (jdem.gsfc.nasa). There is no flight hardware in the AO; researchers will be proposing against a reference mission architecture only. This AO will be analogous to the SIM AO. The plan is to consider ancillary science and GO-type science downstream. The function of the phase A studies will be, among others, to provide feedback to instrument design. The mission must be affordable and realistic, and in particular, have clean programmatic interfaces. APS noted some vociferous community disagreement with the current JDEM concept, which is now strategic and not PI-class, and which is considered to have less science content. Dr. Morse felt that by contrast, the industry studies were not a wasted effort, as they have helped NASA to map JDEM's technical content to the budget in hand. Committee members raised concerns about potential duplication of dark energy efforts at ESA, however Dr. Morse pointed out that NASA is already making decisions on detailed designs, about a year ahead of ESA, and that there will be time for feedback. The committee felt JDEM should be vetted by the Decadal Survey, while Dr. Morse cautioned against idle funds disappearing in the process.

The relationship between DOE and NASA is currently being clarified. DOE will have its own project office and its own appropriations from Congress for instruments, operations, and data analysis. DOE will support a certain percentage of scientists or instruments, but not specific individuals, however there will be an integrated science team selected through the AO. DOE will jointly participate in the selection process, and will jointly write the AO with NASA. The roles of the DOE scientists will be clear once the proposal is selected. JDEM data will be made public for immediate use. While there was some concern about prejudice against teams lacking DOE members, APS was satisfied with this arrangement. Dr. Polidan commented that a number of industry segments had put a lot of effort into JDEM studies; Dr. Morse agreed and assured APS that the request for proposals (RFPs) will take this into account.

Dr. Morse emphasized that the JDEM cost cap is firmly fixed at MIDEX levels, and that DOE will be similarly constrained. DOE also has a say in whether LSST happens. SCG will be considering many issues, including scientific figures of merit and ground-based assets, however NASA is not planning a new ground-based facility.

<u>Discussion on budget issues</u>

The committee discussed the possible utility of beginning to ramp down the Hubble community. The Spitzer budget is HST-sized and will be reduced to $1M in one year, thus there will be a change in opportunities. Any reduction in Hubble will be for just one year to absorb costs. There will be reduced science/ reduced funded science, representing the ultimate trade to have HST for another 5-10 years.

Dr. Morse asked APS to consider the proposed NASA Senior Fellowship, funds for which would be drawn from R&A. There was some disagreement over the effects on the community and whether such a fellowship might be more beneficial to those who rely on soft money, and that changing budget patterns have helped to increase science but have also hurt astronomers in other ways. Some members felt that the program would tend to build the elite community. Dr. Morse noted that the fellowship would be meant to support future planning, attract broader thinking, and address ambitious problems. He also planned to hold an R&A Senior Review to evaluate the investment strategy, whereby APD could be a guinea pig for the rest of SMD.

The committee addressed the funding required to absorb the HST servicing mission delay, citing the current problems in the Mars program. Dr. Morse felt that the funding issue, particularly in terms of reserve represented by uncosted carryover, was well in hand on both HST and Mars fronts, but that the Hubble science budget would have to help out.

Writing exercise- Astrophysics goals

Dr. Morse asked APS to help map the forward plan for APD in light of the approaching transition. Dr. Burns also requested language for the NAC Science Committee's transition paper that will address high-level, cross-cutting items. Specific items might include NASA's underinvestment in space technology, global competitiveness, NASA's ability to inspire the public, NASA's contribution to science leadership (and areas where it has been losing ground, defining new physics in the 21st Century, the question of cosmic origins, and technologies for national security.

Decadal Survey Update

Roger Blandford updated the APS on the progress of the Decadal Survey (DS) via teleconference. Thus far the effort has including assembling a committee, congregating panels, and assessing input from APS. Dr. Blandford felt that the survey would reflect the changing times, noting that the last survey had been criticized unfairly in terms of the costing challenges and new science. The current thinking is that the new DS should be organized around a hybrid of science and mission schemes, in order to inform mission choices. Cognizant of the time factors, the panel plans to adhere to an aggressive schedule to address the changing environment. The actual organization will consist of a central DS committee with a new and different suite of panels. Leaders of large programs will be kept out of the central committee and the suite of expertise will reside in the panels, to address past criticisms of insufficient inclusiveness. There will also be a larger budget and there will be significantly more people involved in order to reach out to the astronomical community.

The new DS will attempt to distinguish science form mission prioritization, and will be relatively inclusive of science in three interfacial areas- physics (dark matter), planetary physics

(exoplanets), and solar physics (ground-based facilities, not space-based). JDEM will be reviewed. The report will look at the programs in increasing, decreasing and flat budget scenarios, from a program manager's perspective. The output is not envisioned as a prioritized list, but something more nuanced. The first output of primary results is due in the Spring of 2010, which can help inform the 2011 Congressional budget. In response to a question, Dr. Blandford reported having interfaced with other relevant committees such as P5 and EPAP (sp)? Dr. Morse apprised Dr. Blandford of the SCG's schedule, per JDEM.

To coordinate with parallel processes in Europe, the DS committee will have a strong interface with the international community, and intends to reach out to European members, as well as to other agencies, and private astronomy funding. APS members will be asked to serve on various panels. Input, in the form of white papers, will likely be accepted by the Summer of 2009. It is not yet known how closely the DS will coordinate with Physics 2010, however it is clear that the DS needs a clear understanding of the jurisdictions, while planning to be relatively exclusive when comparing projects, but inclusive of science. There is no shortage of material to consult in the interfacial areas. Dr. Blandford also hoped that the DS can recommend to the NRC that agencies avoid the idea of keeping the "eternal flame" of the survey. The AAAC has been given a different charge; it can make recommendations directly to the government on fostering the recommendations of the DS, and find ways to deal with unanticipated developments. JWST is a major boundary condition and it is not clear what the HST delay will mean.

The committee discussed some areas of disconnection at AAAC, including lack of consideration of x-ray astronomy and areas of ground-based astronomy that have no overlap. There may well be a nomenclature problem, with "high-energy astrophysics" substituting for x-ray astronomy, Dark energy and exoplanets are other areas of concern, indicating that the AAAC is not going quite far enough in its interagency activity as a result. Literal recommendations will be needed to coordinate agency activities. Dr. Burns suggested that Dr. Morse proactively pursue NSF discussions to address these concerns.

Discussion

The committee resumed discussion of the APD Science Plan and allotted various assignments to members, noting cautions against the use of vernacular and jargon. Dr. Hogan took an action to send out emails on specific deadlines. Dr. Morse suggested APS borrow freely from the current Science Plan and to flesh out actual science opportunities. Members were polled for "Answers to the Big Questions":

Manning- how does understanding science of the universe help to understand science of the everyday. One definition of AP is the search for context. If it's just us, that gives us context.
Wilkes- why are we here?
Huchra- physics and astronomy have developed structures of physical principles−how wrong are we?
Kasting- are there earthlike planets around other stars and are they inhabited?
Lange- are we alone in the universe?
Ennico- astrophysics collects clues from the past−are we even close to whodunit?
Hasan- have we been alone since the universe started?

Hogan- how does matter, energy, space and time work? What are the mechanics?
Flanagan- what's out there?
Polidan- are we alone in the universe?
Rhoads- how can we understand formation of the structure of the universe from the beginning to its current state?
Suntzeff- how has the universe evolved since the beginning of the universe? We now have the technology to see to the end of the universe, identical to the epoch of Magellan. Five hundred years from now, we may have the capacity to destroy the universe.

The committee reached consensus on the phrase "From the Big Bang to the Future" as an overarching theme.

Tuesday, October 7, 2009

Incoming NAC Science Committee (SC) Chair Jack Burns briefed the committee on NAC changes, noting that Harrison Schmitt would be resigning shortly. Dr. Burns reported having spoken to each of the 4 division directors and each of the chairs of the science subcommittees. He cited the lack of regular communication between the SC and subcommittees, disconnection from the NAC, and lack of guidance, and his wish to rebuild the connection. To that end, all subcommittee chairs and division directors have been invited to participate in the SC itself. SMD AA Ed Weiler has expressed enthusiasm for this idea and is expected to support it actively. The SC as it stands has only 5 members, lacking breadth across scientific disciplines. It will be important to develop this breadth to address pending issues in science, develop cross-cutting findings to transmit to the Administrator, particularly in technology investment (e.g., the next generation of RTGs for powering spacecraft). The SC wants to hear from the community leaders. The SC will also be working to increase its meeting time with the science subcommittees. Dr. Burns has taken steps to ensure that the NAC SC agenda will have been shared with everyone ahead of meetings, and to ensure that the report will be seen by all. APS welcomed this positive development. In the context of impending SC discussion, Dr. Morse commented that MSL issues may percolate through the Planetary Science Division and impact Flagship missions, which in turn could affect the Cosmic Visions portfolio- thus MSL can affect the APD. Another issue that the SC might consider is the need for data communications, including optical communication systems.

ESA's Cosmic Visions Program

Fabio Favata gave an overview of the European Space Agency's (ESA) Cosmic Visions program. The program contains no separate budget line for astrophysics−all the disciplines are funded from the same budget, with a long-term commitment to a balanced program. Astronomy, Solar Terrestrial, and Planetary are the program legs. Gaia is the next large mission in planning, along with Bepi-Colombo, JWST, and Solar Orbiter (planned as an ESA-NASA joint activity).

The Cosmic Vision called for science themes in 2004 to formulate the 2015-25 plan. Grand themes are: life and planetary formation, how does the Solar System work, fundamental laws of the universe, how did the universe originate and what is it made of? Each theme is broken down into missions under temporal categories. Examples are:

- Life and planetary formation: Cassini Huygens, Venus Express.

- Solar System: Corot, Solar Orbiter, a future Interstellar Heliopause Probe.
- Fundamental laws: LISA, a future Gamma Ray Imaging Telescope.
- Universal origins: Integral, Terrestrial Planet Finder, and a future Astronometric mission.

The first call for missions was issued in 2007, with 50 proposals received (twice the previous call), and the final selection was made in October 2007. Three working groups representing the Solar System, Astronomy and Planetary community fed advice into the Space Science Advisory Committee, thence to ESA Executive directorship and Science Programme Committee, which is composed of a delegation of participating countries.

The Cosmic Vision currently envisions one medium-class mission for 2017 and one large mission for 2018. However, the first real opportunity for a large mission will likely be 2020. There are roughly 950M euros available for this first "slice": 650M euros for a large mission, and 300M euros for a medium mission. These funds represent the cost to ESA; payloads are funded separately by member states. The only hard constraint is the total budget; ESA can plan for different mixes of mission sizes if the large mission is delayed due to technical or other issues. The budget has a five-year horizon, and is revised every three years at a ministerial conference. The next ministerial conference will be held November 25-26 at the Hague, Netherlands. ESA is planning an ambitious request, a significant increase above inflation for 5 years (about 3%). The budget and plan may be readjusted depending on the outcome of the conference. Current planning is being developed on the basis of a flat budget, but missions will be increased accordingly if the budget increase is realized.
Mission concepts have been selected for assessment studies, which will go on until mid-2009. Further downselection for medium missions (which in astrophysics will be ESA-only) is planned for 2009 and 2011. Launch dates will depend on mission size complexity and cooperation scenarios. Downselection of a large mission, with all three candidates requiring international cooperation, is likely to take place in 2010. ESA would like to ensure mutual feedback with the Decadal Survey for this selection.

Large mission concepts include the International X-ray Observatory (IXO), a large-collecting-area x-ray observatory. IXO's objective is to study black holes and matter under extreme conditions, galaxy formation, and lifecycles of stars. The mission arose from NASA's Con-X and ESA's Xeus studies, and was decided jointly by ESA/NASA/JAXA to be a single tri-agency study. LISA, an ESA/NASA collaboration, is also under consideration and still has technical challenges to be met. Euclid is a dark energy mission, which is also recognized as the highest priority in astronomy for medium missions. Two highly ranked proposals, Dune and Space, were combined into the novel Euclid concept, which is currently under study. Other missions under study are Plato, a high-accuracy photometry mission to understand the evolution of stars and their planets; and SPICA, an IR telescope, being studied as a candidate by JAXA. SPICA would be two orders of magnitude more sensitive than Herschel in the far infrared.

Each mission concept has a science study team, ESA-appointed and ESA-funded. There will follow an internal convergence phase, an industrial system assessment study with 2 parallel contractors, and a payload assessment study, nationally funded and PI-run. Long-term technology development activities (high priority science goals with low TRL) will be subject to

joint evaluation. In response to a question, Dr. Favata explained that the Darwin mission was not selected due to its immature IR technology. The exoplanet advisory committee is currently examining a roadmap to such a mission in terms of time and technology. Thirty white papers have been received, but NIR/visible wavelengths are not currently being considered. Another concept study may be initiated in 6 months or a year. If Laplace is selected, and a budget increase is approved, Cosmic Visions will consider two large missions for the next launch slot− 2020 followed by 2023.

Dr. Suntzeff commented that none of the fundamental physics mission candidates were regarded as technologically feasible within the current timeline, and asked if ESA had an official relationship with CERN. Dr. Favata explained that CERN is not officially involved in selection process. SPICA will proceed on the same timeline as the other mission candidates, and will compete in some sense against other candidates in terms of budget. APS expressed approval of the Cosmic Visions coordination with the Decadal Survey, and asked that the Euclid mission be considered in the context of NASA's plans for JDEM to avoid duplication. The Euclid mission parameters (weak lensing, variant oscillation, clusters and supernovae) will be decided to some extent by the budget. Extension of operational modes is possible but the budget envelope is not infinite. Asked if Bepi-Colombo overruns would affect Cosmic Visions, Dr. Favata responded that the current view is to separate implementation of the ongoing mission budget from the Cosmic Visions plan, although there may be painful choices in ongoing mission plans.

The Laplace, Tandem, and LISA missions all require significant technology development, and have been proposed to ESA as international collaborations. For medium mission concepts, Plato (planetary transits and asteroseismology), Euclid, Marco Polo, and Cross Scale, and SPICA require no significant technology development.

Scientific Ballooning Assessment Group (SBAG) Update

Martin Israel gave an overview of a pending report from the SBAG. The SBAG last issued a report three years ago, and was asked recently to provide an update. The group is close to publication. SBAG examined the balloon program broadly, over all the NASA science disciplines. The majority of SBAG members are astrophysicists, this being the top area for balloon use (80-85% of the science payloads). While the outline of the report includes past contributions and future recommendations for all 4 divisions, Dr. Israel confined his presentation to astrophysics.

Significant past contributions of the balloon program include experiments in measuring cosmic microwave background (CMB) anisotropy, the first observation of CR antiprotons, spacecraft implementation development for craft such as Swift, GLAST, INTEGRAL, RHESSI (detectors), and NuStar. For future missions such as NASA/ESA IXO, the Beyond Einstein Program (BEP) believes balloon-borne instruments will be critical for developing large-area, high-resolution, x-ray telescopes and CMV polarization detectors, e.g. Other areas of importance include submillimeter studies and detection of high-energy neutrinos in Antarctic ice.

Many scientists were trained in the balloon program, most notably Mather and Smoot, co-Nobelists in Physics 2006. There is no substitute for this type of training. Substantial present

capabilities include conventional 1-2 day flights, and long-duration flights (1-6 weeks), the latter of which are zero-pressure balloons. Such balloons drop at sunset, limiting flight duration at most locations beside Antarctica and the Arctic, where one can pursue the white nights at each respective season. By contrast, for hard x-ray and gamma ray work, polar regions are not desirable.

The Antarctic balloon program started in 1990 and has thus far logged 34 flights. NASA/NSF cooperation has been excellent; the latest memorandum of agreement (MOA) covers 2003 through 2009. NSF provides facilities and logistics for 1 or 2 flights per year, and NASA has paid for a major rebuild of facilities near the McMurdo base in Antarctica. The FY08 Long Duration campaign recently claimed 3 successful flights in just over days. For the year, the program has logged 79 days total flight time with substantial science payloads and exposure to space. CREAM had its 3rd successful flight and has accumulated 99 days of data. Economics of balloon fight are quite favorable−$10M compared to a typical $100M SMEX mission. Incremental launch costs are $1M for each Antarctic flight, vs. a Pegasus launch costing $30M. Balloons can also carry larger instruments to compensate for shorter exposure time.

The SBAG identified several high-priority needs for the program, including strengthening the Antarctic long-duration balloon (LDB) program to assure a capability of 3 flights per year. The program would benefit from a third flight preparation facility, and an augmentation in operational costs. Dedicated recovery support would also increase the likelihood of timely balloon recovery, which currently requires use of aircraft shared by the McMurdo base. The program also needs reliable funding for new science instruments, which are getting more complex and stretching the SR&T program. The decadal flight rate across all disciplines has been decreasing, reflecting this lack of funding for new instruments.

SBAG recommends further superpressure balloon development, which would enable maintenance of stable altitude in nonpolar regions, and ultra LDB flights at any latitude. A successful flight of a 2 million-cubic-foot (MCF) balloon was accomplished in June, with testing of 7 MCF and 14 MCF balloons scheduled for the next fiscal year. Successful development of superpressure balloons can lead to 100-day flights at all latitudes, and will support larger instrumentation at higher altitudes for x-ray and gamma ray observations. SBAG also recommends developing a trajectory modification (not necessarily control) ability to steer away from populous areas, which is not currently funded. Dr. Lange commented that another way to have balloons avoid populous areas is to achieve enough experience and reliability with balloons. The issue involves lawyers and international agreements and does not reflect real risk.

The committee discussed specifics of altitude requirements for hard-x-ray, low-energy gamma ray work and agreed that the budget should be increased to an enable a more vibrant program.

Sounding Rocket Assessment Group (SRAG)

Chris Martin gave an overview of the latest recommendations of the SRAG, noting that the Astrophysics Sounding Rocket Program (ASRP) has enabled world-class science, such as the first all-sky map of the soft x-ray background, detection of x-rays from quasars, measurement of

the ultraviolet (uv) spectrum of comet Hale-Bopp, and the discovery of far-uv blue dust in IC405. ASRP also offers superlative support for students in graduate-level education, and enables new observational capabilities not available on orbital missions, such as three-dimensional spectroscopy, polarimetry and spectropolarimetry, high-resolution spectroscopy, and new wavelength ranges. The program is targeted to emerging science questions and is designed to exploit new technology developments, transient science and targets of opportunity, and multi-lambda calibration on bright objects that will be useful for other astrophysical targets.

ASRP is critical for developing technology for future missions. Because rockets must exploit the latest technology to be competitive, the program drives innovation, must be cost-effective, complements requirement-driven development, and fosters prudent risk taking. ASRP can also exploit COTS technology, and provide crucial experience for future applications of technology. Technologies first flown on sounding rockets include a variety of optical systems, coatings, etc. Major technology developments have ended up on NASA missions such as FUSE and HST. Aberration-corrected holographic gratings reduced FUSE costs by factor of 2. The program also tested x-ray calorimeters that eventually provided a 60-fold improvement in x-ray resolution.

The sounding rocket program provides end-to-end mission training, which is broad, deep, unique, and irreplaceable for new researchers. Students receive systems engineering, management, operations, and instruments experience. Dr. Martin noted that the intellectual foundation forged in the 1960s is now eroding, through retirement of current talent and the selection of alternate careers by upcoming scientists. The space workforce is a craft-based guild, harmed by the industry's profit-based philosophy, in contrast to the atmosphere at NASA.

Program support for sounding rockets has eroded, with a flight rate declining to an average of two per year, and research groups falling off correlatively. Missions are becoming large and complex, the cost of bad decisions has exploded, and many in leadership positions at NASA have no flight experience. SR flights have also been competed against conventional and long-duration balloons, with many established groups have lost funding as a result.

As a result, SBAG has recommended:
1. NASA should maintain bare minimum of 12 well-funded ASRPs, and set a goal of 20 over time, to help develop a critical mass for competition and collaboration, workforce renewal and support technology development.
2. NASA should balance short term and long term science potential and offer an alternative low-cost development track for strategic missions; NASA should realign the expertise level of review panels so that rebalanced criteria can be used effectively; and programs with new payloads should have 4-5 year durations, as 3 years is insufficient for new design.
3. NASA should initiate a Young Scientist program to train new talent, with stable funding for 6-7 years, to attract new ideas and new perspectives.
4. NASA should initiate a highly competitive program in orbital sounding rockets to launch 1000 lbs. into LEO at roughly one flight per year, at the lowest possible cost for 1-100 day durations. Selection would be based on merit, and operated out of the Wallops facility, at a cost of no more than $15M/flight, total. Such a program would increase exposure time, enable science breakthroughs, and enable workforce training. Building on the program's 85% success rate,

NASA could deploy a new generation of low cost small launch vehicles (Falcon I, Minotaur I) with a rapid development and test cycle. APS felt that the costs of this program should be assessed more realistically.

Discussion

Dr. Burns sought guidance from APS on the relative balance of the sounding rocket and balloon programs from a whole-portfolio perspective, and in the context of the training issue. Opinions varied but the general feeling was that training programs were not significantly different in both programs. Both programs met power, mass and schedule needs of scientists. Dr. Morse felt that a compelling reason to separate the programs in terms of strategy was that there was more emphasis on technology, rather than science, in the rocket program. It is also easier to recover a rocket payload and re-fly it. Dr. Morse also felt it would be useful to use the suborbital program more strategically than scientifically. Committee members discussed the utility of the suborbital program as a way to stay viable in a stringent budget scenario, considering its potential for providing low-cost access to space, secondary payloads, and niches between SMEX and conventional balloons. Issues remaining were to define the niches that sounding rockets and orbital can fill in science, technology development and training. Dr. Lange reminded APS that ballooning experiments, *per se*, required more responsibility of participants.

Working lunch discussion

APS considered any lingering issues. Committee members felt it important to encourage ESA collaboration in order to keep Flagship missions going, and to attend to sharing of data between international partners, noting that SOFIA's German data base tended to be more closed off than its U.S. partners. It was also noted in this context that member states will be contributing to JWST through ESA. Dr. Burns raised concerns that large missions may present conflicts between ESA and NASA.

Dr. Suntzeff noted that ESA seemed to be more aware of fundamental physics within its proposed dark energy mission and called for NASA to represent dark energy science in a similar fashion. Dr. Hogan agreed to take note of these concerns. Other members felt that valid dark energy science proposals could be trusted to attract funding through the peer review process.

Concluding the proceedings, Dr. Hogan adjourned the meeting.

Appendix A
Attendees

Attending Subcommittee members
Craig Hogan, Chair Astrophysics Subcommittee, University of Chicago
Nicholas Suntzeff, Texas A&M University
Kimberly Ennico (Smith) NASA Ames Research Center
Kathyrn Flanagan, STScI
Jack Burns, University of Colorado
Belinda Wilkes, Smithsonian Institution
Ronald Polidan, Northrop Grumman Space Technology
John Huchra, Harvard University
Debra Fischer, San Francisco State University
Andrew Lange, California Institute of Technology
James Rhoads, Arizona State University
James Manning, Astronomical Society of the Pacific
James Kasting, Pennsylvania State University

Other Attendees
Hashima Hasan, APS Executive Secretary, NASA HQ
Jon Morse, NASA Science Mission Directorate
Marian Norris, NASA Headquarters
Kathleen Turner, Department of Energy
Bill Reeve, Lockheed Martin
Dan Lester, University of Texas
Michael Deverian, NASA/Jet Propulsion Laboratory
Michael Werner, NASA/Jet Propulsion Laboratory
Chryssa Kouvelioton, NASA Marshall Space Flight Center

Appendix B
NAC Astrophysics Subcommittee Membership

Craig Hogan, Chairman
Fermilab
University of Chicago

Hashima Hasan
NASA Headquarters
Science Mission Directorate
Astrophysics Division Exec. Secretary

Kimberly Ennico-Smith
NASA Ames Research Center

Kathryn Flanagan Space
Telescope Science Institute

John Huchra
Harvard-Smithsonian Center for Astrophysics
Harvard University

James F. Kasting
The Pennsylvania State University

Andrew Lange
California Institute of Technology
Division of Physics, Math & Astronomy

James G. Manning
Astronomical Society of the Pacific

Ronald S. Polidan
Northrop Grumman Space Technology
Civil Systems Division

James E. Rhoads
Arizona State University
School of Earth and Space Exploration

Nicholas B. Suntzeff
Texas A&M University
Department of Physics

Belinda J. Wilkes
Harvard-Smithsonian Center
for Astrophysics

Appendix C

Presentations

1. *Astrophysics Division Update/Astrophysics Subcommittee*, Jon Morse
2. *JDEM Update/Astrophysics Subcommittee,* Jon Morse
3. *Astrophysics Input to the LEAG Moon Roadmap*, Daniel Lester
4. *Report of the Scientific Ballooning Assessment Group*, Martin Israel
5. *Report from the Astrophysics Sounding Rocket Assessment Team to the NASA Advisory Committee/Astrophysics Subcommittee,* Chris Martin
6. *Astrophysics missions in Cosmic Visions*, Fabio Favata

Appendix D
Agenda

Agenda
Astrophysics Subcommittee

October 6-7, 2008

Courtyard by Marriott & Conference Center

Cocoa Beach, Florida

Monday 6 October

9:00 - 9:15 a.m.	Introduction and Announcements	Craig Hogan
9:15 - 10:45 a.m.	Astrophysics Division Update	Jon Morse
10:45 - 11:00 a.m.	Break	
11:30 – 11:15 a.m.	Decadal Survey Update	John Huchra
11:15 – 11:45 a.m.	JDEM Update	Jon Morse
11:45 - 1:00 p.m.	Working Lunch	
1:00 – 2:30 p.m.	Astrophysics Goals Overview	Craig Hogan
2:30 - 2:45 p.m.	Break	
2:45 - 4:00 p.m.	Astrophysics Goals Overview discussion	ALL
4:00 – 5:00 p.m.	Astrophysics Goals synthesis and assignments	Craig Hogan

Tuesday 7 October

9:00 - 9:30 a.m.	Discussion of Senior Fellowships	All
9:30 – 10:00 a.m.	Astrophysics from the Moon	Michael Salamon
10:00 – 10:30 a.m.	Balloon Roadmap Update (via telecon)	Martin Israel
10:30 – 10:45 a.m.	Break	
10:45 – 11:15 a.m.	Sounding Rocket Roadmap Update (via telecon)	Christopher Martin
11:15 – 12:00 noon	International Collaborations (tentative)	?
12:00 – 1:00 p.m.	Working Lunch	
1:00 – 1:30 p.m.	Wrap-up, Recommendations, Actions	Craig Hogan

1:30 – 2:30 p.m.	Brief to Morse	Craig Hogan
2:30 p.m.	**Adjourn**	