NASA ADVISORY COUNCIL

ASTROPHYSICS SUBCOMMITTEE

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NASA Headquarters

Washington D.C.

MEETING REPORT

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Craig Hogan, Chair

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for Hashima Hasan, Executive Secretary

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Introduction and Announcements

Chairman of the Astrophysics Subcommittee (APS) Craig Hogan opened the meeting, and Andrew Lange joined by phone. Dr. Hogan briefly reviewed meeting processes, and reminded APS of its role as advising the NASA Advisory Council (NAC), restricting the committee to advising on Astrophysics (AP) science at NASA. Committee members introduced themselves.

Ethics Briefing

David Barrett gave an ethics briefing, explaining the laws governing special government employees (SGEs).

Astrophysics Division Update

Jon Morse, Director of the Astrophysics Division (APD), presented an update on recent activities of the division. He prefaced his remarks by expressing his wish for more interaction between scientists and industry, in part to help gain a better understanding of all the programmatic issues. Reviewing some FY09 budget highlights, Dr. Morse pointed to the division's funding a new start for the Joint Dark Energy Mission (JDEM); continuing the Laser Interferometer Space Antenna (LISA), Constellation X (Con-X), and Einstein Probe technology investments; focusing on a new medium-class ($450M cost cap) Exoplanet initiative; the initiation of a technical and cost study of Space Interferometry Mission (SIM)/SIM-Lite mission concepts; the acceleration of development for the Stratospheric Observatory for Infrared Astronomy (SOFIA) mission, which is to begin limited science operations in 2009; funding of a revitalized balloon and suborbital rocket program, and augmentation of the Astrophysics Research and Analysis (R&A) budget. The year-long Continuing Resolution (CR) has made life difficult for APD, but it is recovering. Dr. Morse briefly reviewed budget levels, indicating a shrinking budget from 2009 to 2011, followed by some outyear increases that reflected some planned budget transfers between divisions.

Dr. Jack Burns asked Dr. Morse for further details on the LISA/Con-X program, citing rumors that layoffs had been proposed for LISA. Dr. Morse replied that the proposed numbers for LISA and ConX were essentially flat for the next year, such that any expansion of activities was prohibited. However, with the new Decadal Survey (DS) under way, there may be some redirection and revectoring of resources for LISA and ConX. In the outyears, APD will be transforming the James Webb Space Telescope (JWST) budget to a 70% confidence level profile; JWST constitutes a lien against future missions, including Cosmic Origins, and especially large missions like LISA and ConX. There are not enough resources to support missions. The priority is to carry out the flight programs, and have the DS determine what comes after JWST. JDEM now has a medium-class mission cost envelope, with the goal of launching in mid-decade; there are resources available to accomplish this and APD would like to protect those resources. The management philosophy is to properly fund missions that are actually going forward. If a flight program properly is not properly funded, by definition the launch is slipped and the science is not done. Due to these budgetary pressures, APD asked the Beyond Einstein Program Assessment Committee (BEPAC) to prioritize missions, and was duly following BEPAC's advice. Dr. Huchra asked if APD would want JDEM to be considered in the new DS. Dr. Morse responded that it might be prudent to put that question to the National Research Council (NRC), adding that while the DS does not always phase well with the budget, BEPAC recommendations would be given heavy weight in the DS. The Administrator has also asked that JDEM be considered within the DS. In this context, Dr. Morse reiterated that funding, when put into a future mission line, can lead to the disappearance of resources, because the money appears to be un-prioritized. Dr. Burns expressed concerns that a large mission (approximately $2B) needed $200-300M to start up, and that these funds did not seem available. Dr. Morse responded that JWST must be launched before significant funding becomes available. However, he expected that JWST yearly operations costs would drop after the launch, opening up a wedge of about $300M/year. In this way,

Dr. Morse felt some other monies would become available, leaving room for a major initiative after JWST.

Dr. Morse returned to reviewing the status of APD. The most significant recent event in APD was the successful June launch of the Gamma-ray Large Area Space Telescope (GLAST), currently in orbit-checkout mode. In other mission development, WISE's rebuilt thermal mass dynamics simulator (TMDS) has had good vibration testing results, and its flight cryostat is next in line for vibration testing. WISE will use a SoftRide option to protect the cryostat. In addition, its spacecraft bus vibration test has also been successfully completed, as well as an end-to-end optical system test, which required some reserves to fix. However, subsystems look good. The SOFIA project is in the process of performing maintenance on the aircraft, working on realignment of the door tracks, which will be tested in late December under flight conditions at 40,000 feet. The SOFIA team is performing wonderfully, and the mission is on track to begin early science operations next year.

Kepler has had its solar array delivered, which is awaiting integration onto the bus. Currently the mission is doing system-level testing and a walkthrough of nominal science operations. A February 2009 launch date remains in place for Kepler, which will be the next free flyer after SM-4; APD is trying to ensure a ride on a rocket. With the impending launches of the Lunar Reconnaissance Orbiter (LRO) and the Solar Dynamics Orbiter (SDO), there is a lot of pressure on the launch queue, which may have implications for Kepler and WISE. JWST realized many technical achievements in the Spring, having finished a preliminary design review (PDR) and non-advocate review (NAR) in April; the Standing Review Board (SRB) has been working to ensure that the science is robust. SMD has reviewed the forward plan and is preparing to brief it to the Administrator. The next budget cycle will have some timing issues (election, etc.), and thus Dr. Morse did not feel it could be discussed in an intelligent way before the next committee meeting. A brief discussion ensued regarding informal discussions within the NAC about advising the transition in November, advice which could be as simple as identifying open work, or something broader. The conversation within the NAC was to take place the following week.

JWST has reached agreement on the number of science modes available at launch, and the plan is to keep adding capability at cycles 1 and 2. JWST has a 6-month cruise phase during which there will be testing of modes; these decisions were made with the input of the community, and with input and resources from the international partners. The mirrors are a long lead item, but there has been good progress, and smooth-out polishing is to be accomplished by the end of June. In response to a question from Dr. Burns regarding the JDEM timeframe, Dr. Morse explained that solicitation of dark energy investigations in 2008 is the plan. APD is preparing rules for a simplified Announcement of Opportunity (AO) process. In principle, JDEM could be the guinea pig for the new AO rules. APD has had inputs from JDEM concept studies on what the cost envelope would be, which is for a medium-class mission, and APD wants to ensure that it has a development time scale so that the mission can be launched in a timely manner. The other issue is that APD also has missions like Kepler, with its known costs. The scale and complexity of Kepler are comparable to JDEM concepts (a Kepler-size mission is $600M). It may be possible to do more with partnerships. NASA will make sure the AO will be feasible to implement and hopes not to have a disconnect between proposals and the budget. Dr. Morse emphasized once more that APD must match content to budget resources. Asked for a formal definition of a medium mission, Dr. Morse responded that it would be under a billion dollars, but a more reasonable breakout would be $800M. The New Frontiers budget is $600-700M. For JDEM and exoplanets, a cost envelope like that would support substantial science. Dr. Burns agreed that NASA can afford a midsized mission, but felt that if the concepts received in an AO indicated a large mission, leaving the DS to re-characterize JDEM as a large class mission is the way to go. Dr. Morse noted however, that NASA has been planning for the $600M range. The Department of Energy (DOE) may put in about $200M, expecting it to be a quarter of the mission cost. NASA does not want to get into a Discovery situation where there was a non-selection. Dr. Morse noted that many people believe JDEM can be done for under $1B. Asked about the potential

for an international partner role, Dr. Morse responded that APD was trying to limit NASA expenditure so that it can do other things- ESA has a dark energy mission concept in the medium class, but NASA is not planning to combine mission resources into larger one. JDEM should not be viewed in isolation; APD will attempt to do things in space that it can best do in space, with good synergy with other agencies (including ground-based efforts). The agencies are asking to consider the evolution of a figure of merit, such as how to integrate the constraints of W and W', for instance--a white paper due on this subject.

The mission to repair the Hubble Space Telescope (HST), SM4, has made good progress, and all major elements have undergone thermal vacuum tests. All the extravehicular activity (EVA) timelines are within standards. The Cosmic Origins Spectrograph (COS) has completed electrical life testing, and crew familiarization studies are being carried out. Other major upcoming activities include the initiation of GLAST science operations, a Program Management Council (PMC) for JWST, the installation of SOFIA's primary mirror, the launch of the Hubble SM4 mission no earlier than October 8th, and the launch of Herschel-Planck on October 31st, (which may slip by a few months).

There are 10 operating missions, with 6 coming along, including a major flagship in development; this constitutes a robust portfolio that covers the whole electromagnetic spectrum and the full range of science. Reviewing a stoplight chart, Dr. Morse noted that Herschel had a red grade relating to outyear budget projections, which has since been solved. JWST is yellow mostly due to complexity, and APD is working to solve technical issues within margins. It was noted that HST SM4 reserves are light for FY08. SOFIA is doing well overall, and SIM is all green. APD has received 13 SIM science proposals. Kepler is green except for one yellow in cost. LISA's long-term budget is insufficient for a minimum mission, and this has presented a challenge in keeping scientists engaged in the mission. ConX is green, and the x-ray coordination group is working with the European Space Agency (ESA) to see if there is a common platform to achieve science for both communities; compromises are being examined to deal with complementary science goals.

JDEM is working toward an AO release in late 2008. There have been offsets in FY08 in ConX to deal with the Hubble mission slipping from August to October, which may have affected ConX. A million dollars in a small budget means a lot. Dr. Burns asked, in the context of the struggle to put LISA within a $1-1.5B profile to accomplish minimum science, whether Dr. Morse saw a resolution before the initiation of the DS. Dr. Morse felt that a technically well-thought-out design, with a cost estimate in time for the DS, implied the understanding that LISA will require a large mission; the issue is that it has jumped bins. The community doesn't think LISA will be a medium-class mission; it will be a multibillion dollar mission, and the DS will have to look at it and see if that's what it wants. Dr. Morse encouraged the scientific community to continue to consider a less expensive LISA, nonetheless. The agencies want an emphasis on science priorities so that implementations can be adjusted as the mission goes forward, to try to get to ultimate science in a stepwise way. NASA also needs to consider how much fundamental physics the community wants, and does not want to put up fences.

Dr. Morse noted that NuSTAR, which was dropped in House Subcommittee proceedings, and then restored in the full committee, has a reduced budget, with some uncertainty about what its FY09 plan is and impact on development.

Operating missions are going well, with GALEX back to normal science operations. NASA's Senior Review process recently ranked a number of missions in APD, in order of priority on a science-per-dollar basis, and these were Swift, Chandra, GALEX, Suzaku, Spitzer, WMAP, XMM, INTEGRAL, Rossi X-ray Timing Explorer (RXTE), and Gravity Probe B (GP-B). APD is working hard to get Spitzer moving forward within the budget offsets, without closing top-ranked assets prematurely. RXTE is a functioning observatory, has a dedicated community, and is not that expensive to run, but $1M means a lot and is hard to find. APD will try to keep it going as long as possible; if the money is

there, the intention is to continue. The Senior Review has decided that any further investment in GP-B is not worthwhile; the funding for this mission is to run out by the end of the fiscal year. HST was not ranked because of SM4, which will completely change the nature of the HST, thus Hubble was deferred to the next Senior Review.

Small Explorers (SMEX) selections include JANUS, the Joint Astrophysics Nascent Universe Satellite, Gravity and Extreme Magnetism (GEMS) and Transiting Exoplanet (TESS), and a mission of opportunity (MoO), the SXS (Soft X-ray Spectrometer) for NEXT (a JAXA mission). SXS is an updated version of Suzaku, with lessons learned incorporated into the new design. There are some new developments in Astrophysics fellowships, in response to informal verbal feedback from the Senior Reviews suggesting concern for long-term stability for fellowships, due to unstable funding in projects. Thus APD is proposing to have fellowships in each of the themes—Cosmic Origins, Physics of the Cosmos, and Exoplanet Exploration—as named fellowships. The total number of fellowships is to be retained or increased. In addition, Senior Fellowships will be introduced in each program for mid-career and senior researchers, to fund highly talented members of the community for several years. The general idea of the fellowship is to tie them to programs, but not directly to missions, in order to address the instability issue- the program survives even if the mission does not. The fellowships will not be administered through NASA Headquarters. The idea is that implementation should be transparent to the community, sanctioning the breadth of fellows and missions, looking for the best and the brightest, using mechanisms already in place in the community. Kathryn Flanagan asked for reassurance that the same high-level review process and prestige, and number of fellowships, would be retained. Dr. Morse responded that is what the division was striving for. Details are still being worked out in order to use maximum leverage, streamline as much as possible, and avoid recreation of infrastructure.

In response to a question on whether a Hubble fellowship might outshine a Spitzer fellowship, Dr. Morse felt that this would not be an issue, in that APD is trying to elevate the prestige and visibility of the fellowships. He welcomed further comments from the committee on this issue. He added, for the committee's consideration, that an extra Shuttle flight for an Alpha Magnetic Spectrometer (AMS) launch to the International Space Station (ISS), could represent a threat to APD. There has been discussion of an expendable launch vehicle option, but Congressional debate has focused on the Shuttle as a solution. This flight would be in the FY10 timeframe at the end of the Shuttle manifest. AMS is heliospheric science, but there is some overlap with particle physics science goals. There is little APS can do to review its merits, at this point. NASA has received a letter from the National Academies as to whether AMS is relevant to astronomy or astrophysics- thus far the answer is no. Dr. Burns commented that the real threat is the undercosting of the mission (really more than $1B). Dr. Morse agreed that it was possible APD could bear the burden of some marginal costs of AMS.

Decadal Survey Update

John Huchra reviewed the preparations under way for the Astronomy and Astrophysics Decadal Survey. A selection/steering committee was formed in May, chaired by Dr. Huchra. The effort is funded by NASA, the National Science Foundation (NSF), and DOE. There are 5 members from the Space Sciences Board, 4 from the Board of Physics and Astronomy (BPA), and 4 members at large. The selection committee is seeking an Astro2010 Chair, whose credentials should include scientific eminence in astronomy and astrophysics, freedom from conflict and bias, experience with NRC studies, administrative experience in a research or academic institution, and a background in large project management. The chair should also be a consensus builder and possess judgment as well as a breadth of scientific interest and expertise. Follow up requirements include willingness to commit to a long-term (5-10 years) activity, the ability to attend a series of Washington, D.C. briefings over several years, and a flair for communicating the excitement of science. The committee expects to provide a short list of candidates to the NAS president by July 14th (agency points of contact have been invited to the morning session of the July 14th meeting), and a chair should be in place by end of

summer, with committee and panels in place by the end of year. Dr. Huchra welcomed suggestions for candidates in person or via the Astro2010 website by July 7th. Chris McKee added that the selection committee was working hard to obtain gender, regional and scientific diversity, and the proposed membership will be reviewed by BPA to ensure those issues are dealt with. Thus far the committee has received 40 suggestions for chair candidates. The NRC has not yet decided whether the Decadal Survey will be a science or technique-based survey.

Senior Review: Missions

Alan Smale gave an overview of the recent APD Senior Review, which was held with an eye to maximizing the scientific productivity of a suite of science missions. Missions included two Great Observatories (GOs), and one Data Analysis project. The Senior Review panel met from April 22-25, 2008 and issued a public report on May 14th. The review Charter addressed, in addition to goals and objectives, opportunity costs that were weighed against potentially increasing investments in R&A. Additional pressures were the budget constraints. The panel couldn't possibly extend all the missions, and had to make many hard decisions. The panel was very good, but suffered one deficiency, which was that it was all male but for one member. Missions were ranked for science value for the period of 2007-12, and the panel took into account opinions on mission funding. The final report is available on the Internet. Dr. Smale briefly reviewed the rankings and noted that the reviews can lead to reallocation of funding, thus it is important to keep in mind that some mission funding profiles can change dramatically.

Swift was extended to 2012 at minimal budget, with an increment of $400k in FY09. Chandra will be continued at in-guide to 2012, GALEX was extended to 2012, and Suzaku to 2011. Spitzer will be funded for one year of warm mission operations in FY10 at a reduced level, with some warm mission close-out funding in FY11. WMAP will be funded at current in-guide levels. XMM will be funded at in-guide levels, with its mission termination extended to September 2010, with limited close out funding in FY11. INTEGRAL will be funded at a reduced level for FY09 and 10, and RXTE operations will be extended six months in-guide to take advantage of synergy with GLAST; thereafter terminating in August 2009. GP-B received no extension to the Data Analysis effort, and support will end in September 2008. Dr. Burns felt XMM had been a great success and was curious that it ranked on the low end. Dr. Smale responded that the committee felt Suzaku was reaching a point where it has good spectral resolution, low background, and high-energy science coverage, which will be important over the next two years. It was not deemed as compelling as XMM over the next two years. However, one can still get observing time through ADP.

GLAST Update

Julie McEnery provided an update on the operations of the Gamma-ray Large-Area Space Telescope (GLAST) which launched on June 11th. Every component of GLAST is as expected or slightly better. The main instrument is a Large Area Telescope (LAT) with high energy channels, (20 MeV to 300 GeV) and the GLAST Burst Monitor (GBM) (8 keV to 30 MeV). GLAST has a huge field of view, and the flexible observing mode allows coverage of the entire sky every two orbits. GBM sees the entire unocculted sky. GLAST can also perform pointed observations of particularly interesting regions (gamma ray bursts, e.g.). GLAST science questions are very broad and are expected to transform high-energy, gamma ray astrophysics. The GLAST collaboration included France, Italy, Sweden and the U.S., and the GBM partnership is between the U.S. and Germany.

Dr. McEnery reviewed mission highlights: the instruments were turned on June 24-25, a process that went much faster than expected. The mission is continuing detailed instrument studies, and the burst alert path tested was tested June 26-28. Details may be found on the web at blogs.nasa.gov/cm/blog/GLAST. The data is not yet public but is being shipped to the Instrument Science Operation Center at the Stanford Linear Accelerator Center (SLAC) and is being routinely processed. The latency for bursts is 11 seconds, and GBM is fully configured. SWIFT and GLAST are almost completely in phase right now. GLAST first-light observations indicate high quality data thus

far, already better than previous observations. The team will continue instrument studies over the 60-day checkout period, LAT-to Observatory alignment observations, etc. The first-year observations will be devoted to creating the Sky Survey (but GLAST will be able to re-point to interesting bursts during this period), and extraordinary targets of opportunity will be supported. The first-year data release will include all GBM data. The LAT team will also produce a preliminary source catalog on a best-effort basis. Subsequent years are to be driven by guest observer proposal selections by peer review. Sources can be seen at glast.gsfc.nasa.gov/ssc/data. The GLAST fellows program also allows for 3 new fellows to be selected each year, for 3-year terms.

GLAST is providing excellent testbeds for all science analysis software- the users committee conducted a second beta test in Spring 2008. Year 1 will start at the beginning of August, with first pictures by that same month. The LAT was developed by NASA and DOE, and the plan forward includes $24M provided by NASA and perhaps $6M by DOE this year. A long-term understanding of the funding profile is in place. If funding changes, Dr. Morse added that this would be the peril of having a partner, but that GLAST has slogged through these issues before and will do so again. Budget instabilities exist for both agencies, and there may be some lessons learned from the GLAST management structure development.

HST SM4 Update

Preston Burch, the program manager (IPM) for the Hubble Space Telescope (HST) gave an update on the preparations for the Servicing Mission 4 (SM4) to repair and upgrade the HST. NASA is hoping SM4 will unleash the full potential of the 18-year-old telescope. SM4 will be installing 2 new instruments and doing *in situ* repairs for 2 existing instruments, the latter of which has not been done before. The STS-125 launch is scheduled for October 8, 2008; a potentially earlier date cannot be taken advantage of due to hardware delivery. The mission will carry a 3-D IMAX camera, and the Shuttle crew will perform inspection of the thermal protection system (TPS) in between orbit insertion and the Hubble grapple (this activity might delay EVA work or cause loss of mission content). The nominal eleven-day mission will include 5 EVAs, 6 hours long each, or up to 7.5 hours each, potentially. HST electronics bays 5 and 8 are of particular concern, and the crew will be applying more thermal resources to address concerns about critical temperature limits on important electronics (which may restrict pointing abilities at certain times of the year.) There have also been fine guidance sensor issues (FGS); LED sensor degradation on FGS-2R is the most pressing problem, and the current plan is to change out FGS-2R with a refurbished FGS. The mission will also perform repairs on the Space Telescope Imaging Spectrograph (STIS) and the Advanced Camera for Surveys (ACS), replace all 6 gyros and all 6 batteries, and replace the Wide Field/Planetary Camera 2 (WFPC2). ACS, the most powerful visible light camera, will receive a new module that wires around areas of a previous failure, thereby restoring power to the wide field channel, and perhaps providing power to a high-resolution channel. In addition, for the first time, a composite carrier will be used on the Shuttle, termed the Super Lightweight Interchangeable Carrier (SLIC). The priority of mission tasks in order is: Rate Sensor Units (RSUs; these contain the gyros), WFC3 and Cosmic Origins Spectrograph (COS), followed by batteries, FGS, STIS repair, ACS repair, and New Outer Blanket Layer (NOBL) thermal protection units. SM4 is not asking for a 6th EVA, contrary to rumor. There is some reserve retained for various Shuttle repairs, however. If HST EVA time is lost, a plan is in place for each increment lost. For example, if only 1 EVA is available, the crew will install WFC3 and all the gyros possible.

The flight hardware, mission preparations and Shuttle payload integration are at a high state of maturity. Mr. Burch reviewed some of the specialized tools developed for the mission, including a grid cutter tool and a fastener capture plate. The HST Ground System and Operations team is ready to support the flight and the mission is ready to fly.

David Leckrone, HST Senior Project Scientist, covered the heightened science capabilities of HST to be provided by the repair mission. Hubble continues to be vital to the community, serving 4385 PIs

and co-Is to date (observing time), 8000 different authors and co-authors of papers, and 9000 archive users. HST has supported 6402 scientific papers. The key science instruments on the HST are WFC, COS, STIS-R, and the Advanced Camera for Surveys ACS-R. The overall goal of SM4 is to leave HST at the height of its capability, with the first full set of instruments since 1993; however these instruments have benefited from another decade of evolution. HST will be capable of its most powerful imaging ever, and possess a the full set of tools for astrophysics to observe the life cycle of stars, life story of galaxies, planet building, dark matter and energy, and the architecture of the universe.

WFC3 will have improved performance parameters, including a sharpened UV response of charge-coupled devices (CCDs) in the near-UV, dramatically improved quantum efficiency (roughly 80%) of near-IR detectors, providing higher throughput than previous cycles. WFC3 will go deeper into the near-UV and IR, offering a 10-fold improvement in near-UV and IR "discovery efficiencies." It will focus on stellar populations and a deep field survey in IR. COS provides science and calibration data simultaneously, with high sensitivity in the far UV. COS will study hot stars, formation of galaxies, young stellar objects, and planetary atmospheres in the Solar System.

Results from the Cycle 17 proposal evaluation include 3411 approved orbits, broken down by Imaging (66%), Spectroscopy (31%) and FGS (2%). The science program includes searching for nascent galaxies in high redshift, followed by calibrating Ia supernovae, tracking star formation across cosmic time, probing hot gas in the intergalactic medium, mapping orbits of Milky Way satellite galaxies, measuring distance and ages of globular clusters/stellar populations in the Galactic Bulge, planet formation in circumstellar disks, and investigating the origin of plutoids in the Outer Solar System.

GPRA discussion

Hashima Hasan reviewed the purpose of the Government Performance Reporting Act (GPRA) ratings, covering 4 subgoal subject areas derived from the SMD Strategic Plan. The committee then evaluated the 4 subgoals.

3D1: The origin and destiny of the universe, phenomena near black holes, and search for Earthlike planets.

The committee agreed that this subgoal was supported by Chandra data on black holes, but asked to include a refereed citation. Spitzer and Chandra evidence doubling estimates of young black holes was considered to be overestimated and thus removed. Interesting discoveries by Swift had not been included, nor had some third-year WMAP data. Also cited as necessary were XMM and Sudaku's measurements of distortions of space-time around three neutron stars- there was some disagreement as to whether the WMAP result was more interesting in this respect. Results from the Rossi X-ray Timing Explorer (RXTE) archival data on the lightest known black hole were also suggested, along with a refereed paper. Other suggestions for inclusion were statistics on how quickly black holes emerge, as well as a specific SDSS paper, and 2MASS data on the tomography of Milky Way. The committee voted a unanimous Green on 3D1.

3D2- Progress in understanding how first stars and galaxies formed.

Data from HST and Keck on ultradense galaxies were considered to be overstated, with WMAP results perhaps being more appropriate here. The committee agreed to include Spitzer's "coming of age portrait" of stars in inner Milky Way. A GALEX image of baby stars found in the backwoods of a galaxy (extended galactic arms), was considered to make a good case for radio data from the Very Large Array.

A Spitzer image of a four galaxy "smashup" was included as a good example of a gas-poor merger, as well as Hubble and Spitzer results on a young star forming galaxy in the dark ages. The committee voted a unanimous Green on 3D2.

3D3. Progress in understanding how individual stars form and how these processes ultimately affect the formation of planetary systems.
The committee suggested including Tom Abel's simulations of first stars, and approved the inclusion of Spitzer findings of organic gases and water vapor in the region of young stars. A Spitzer finding of definitive evidence of the universe's first dust in Cassiopeia-A was considered overstated but modifiable by the inclusion of complementary two papers on the supernova remnant. Language accompanying Spitzer's infrared image of jets escaping from an embryonic sun-like star was considered overlong, and modified, and a GALEX finding describing a comet-like tail on the star Mira was retained as written.
The committee voted a unanimous Green on 3D3.

3D4. Progress in creating a census of extrasolar planets and measuring their properties.
HST's evidence for the presence of an organic molecule (methane) found in the atmosphere of a Jupiter-like star, as evidence of prebiotic chemistry, was accepted. HST's observation of high level haze in an eclipse of HD187933b was removed and replaced by a measurement by Spitzer of wind speed in planetary atmospheres (Knutsen et al.). Spitzer results on terrestrial planets that might form around many if not most sun-like stars in our galaxy were considered sound, but additional evidence was suggested to shore up support. The committee voted a unanimous Green on 3D4.

Dr. Hasan requested a list of edits by Monday, July 7.

Discussion
The committee discussed how to best carry out community guidance regarding named fellowships, a general endorsement of the Senior Review process and preliminary advice for the administration in transition.

Concern was reiterated on retaining the prestige and caliber of NASA fellowships, the potential for losing the ability to select fellows, the degradation of science, and for losing the ability to attract young talent at the beginning of missions. The committee felt it was unclear whether the new fellowships would be administered anywhere but NASA, and expressed concern about implementation and the idea of themes. The original reservation was that the new GO needed new allocations, but Chandra and HST appear to be going along the lines of themes. The committee did like the idea of the reduction of the Balkanization of missions. The committee also feared the effects of central bureaucracy, sleight of hand with funds, a lack of scientists on the selection panels, and loss of longevity. The committee regarded the newly proposed senior fellowships, however, as a good idea, and proposed that sufficient funds be set aside, with the caveat that an unintended consequence may be setting up a smaller number of elites at the expense of younger people.

The committee approved of the fundamentally robust process behind the Senior Review rankings, conceding that the community "hates it but respects it."

July 3, 2008

Re-cap of Day 1
Discussion began on formulating advice for the transition to the new administration, wrestling with how the NAC can feed information into the next administration via a potentially new NASA Administrator. Dr. Burns asked the committee to define the "30,000-foot" policy issues, the place for science and Astrophysics within NASA, synergy between the manned and unmanned programs, human exploration of the Moon and beyond, the Constellation program, and the science program. Dr. Hogan viewed the committee as a source of continuity and stability that is in turn driven by the NAS and science. APS has consistently recommended that NASA follow the advice of NAS, providing arguments on why this is so successful. Dr. Huchra suggested ensuring that the overall science program is discussed and vetted with the community at large, adding that the NAS is not the

only avenue; the new Administrator should not confuse strategic with tactical advice. The committee considered providing a white paper on the major strategic goals for Astrophysics.

The committee discussed the status of the updated Science Plan. Greg Williams addressed the fate of the next Science Plan, which had been put on hold owing to the abrupt departure of former SMD AA Alan Stern. A senior management retreat is being considered in order to jumpstart the process, providing an opportunity to have directorates weigh in on its future direction; SMD won't have an answer on how to engage the subcommittees until the Fall round of meetings.

Dr. Polidan offered, in the context of further transitional, administrative advice, that he would like to see the balanced program continue, including the suborbital program, small opportunities, Explorer-level probes, a robust technology development program, and a continued healthy R&A program, as a reminder of the important things NASA does. Dr. Burns added that the House of Representatives Subcommittee has leveled criticism at NASA, lamenting the lack of an Agency-wide technology development program; the Administrator has expressed his frustration with this situation, citing OMB as a barrier to a NASA-wide technology development program. Dr. Polidan suggested that NASA tap into industry expertise to integrate industry into the technology development arena: if NASA sees something it needs, a corporation such as Northrop Grumman could invest in it, and provide matching funds (a case for which there is precedent). Industry would be willing to invest if there is some sort of business case to be made. Currently, Dr. Polidan felt that the biggest problem is that NASA treats industry as a vendor.
Dr. Burns added that the nation's workforce issue also feeds into this dilemma: industry is hesitant to invest in expanding the workforce in relation to NASA activities because NASA itself has not had a stable view of itself. He worried that momentum was being lost in bringing new people into the field. The International Trafficking in Arms Regulation (ITAR) was raised as another roadblock to carrying out NASA missions; SMD's science is a product as much as launches, and NASA should work to minimize roadblocks to getting the science out. Dr. Polidan attributed some barriers to NASA's very heterogeneous, center-oriented approach, which made it difficult for industry to deal with very different interpretations. A more homogeneous policy could improve cost estimates and reduce mission costs. He added that when planning missions, NASA should ask about the measurement needed for a particular mission, not the instrument. In this respect, industry would love to see a high-level NASA Roadmap, which in turn could lead to benefits to the country through workforce development. Northrop Grumman regularly donates engineers to NASA programs to get hands-on experience, and also issues research grants to universities, and is eager to participate in NASA missions.

The committee supported a robust technology development program independent of the missions, in order to help reduce mission costs, retain valuable academic and workforce expertise, and generally stem the tide in the loss of U.S. proficiency at instrument-building.

Exoplanet Task Force presentation

Jonathan Lunine presented details of the published final report of the Exoplanet Task Force, *Plans for Detection of Extra-solar Earths*, in the hope that it would serve as a useful discussion point for input to the next Astrophysics and Astronomy Decadal Survey. The existence of earth-like planets is a fundamental question in the culture that drives astronomy. He cited discoveries of super-Earths (potentially less than 10 times the mass of the Earth), and the recent recognition that planet-forming is common and is a system phenomenon, with perhaps some bias towards with stars with metallicity. There seems to be a uniform distribution of planetary masses, and researchers are seeing smaller and smaller planets as techniques are refined.

Dr. Lunine went on to describe the background of the ExoPlanet Task Force, established in 2006 by the Astronomy and Astrophysics Advisory Committee (AAAC), to recommend a 15-year strategy to detect exoplanets and planetary systems, especially nearby Earthlike planets and their habitability.

These are generally defined as rocky bodies less than 5 times the mass of the Earth. The strategy was to be an efficient and adaptable plan (low-cost and responsive to discovery), however the charter did not call for detailed cost estimates. The Task Force held 5 meetings, considered 84 white papers from the community, and held open sessions during its first 4 meetings. The final report was published in May 2008 and can be accessed at www.nsf.gov/mps/ast/aaac.jsp.

Compelling questions, in order of importance, identified by the Task Force were:
What are the characteristics of Earth-mass/Earth-size planets in the habitable zone around nearby, bright stars?
What is the architecture of planetary systems?
How do planets and planetary systems form?
Given these questions and the current state of technology, recommendations were to intensify radiovelocity (RV) studies to reach down to Earth-mass planets around bright stars (more telescope time/higher precision, invest in IR spectrograph for late M dwarfs), and include ground-based studies. The next recommendation was to search for transiting Earth-size exoplanets around nearby M dwarfs and characterize these bodies via Spitzer in its warm mission phase and JWST, also using both ground-based assets as support.

Recommendations for new capabilities include developing a space-borne astrometic planet search mission (with submicroarcsecond astrometic signatures on the order of 100 stars) to find Earth-mass exoplanets with inhabitable zones, in nearby sunlike stars and their orbits. The previous recommendation paves the way for the second recommendation, to prepare for a space-based direct imaging characterization mission.

For planetary architectures/formation, the Task Force recommended microlensing for planetary masses and separations, using Kepler/Corot to inform strategy and to determine planetary architecture, and ground-based direct imaging along with the development and implementation of extreme adaptive optics (AO). The latter would include the construction of a 30-meter telescope with extreme AO capabilities. For circumstellar disk science, the Task Force recommended maintaining U.S. involvement in Herschel and ALMA, archives for Spitzer, Chandra HST and ground-based observations, investment in appropriate instrumentation on large-aperture telescopes, support for activities that maximize the knowledge return from data, and training new scientists in the field, including theoretical studies, stellar property surveys, and fellowships.

Dr. Lunine provided the definitions of eta sub-earth (η) and zodi, and how these variables influenced the choice of investigative tracks, as well as the strategies governing varying tracks- a short term track focusing on M dwarfs, or a long-term track investigating FGK dwarfs, the latter of which would require assets not available today. Recognizing the technology hurdles, the Task Force has also called for blue ribbon panels to determine astrometry needs before taking on the search. The Task Force regarded the astrometry technology needs as necessary whether or not Earth-like planets are discovered to be common or rare, as the value of eta may not be known before the astrometry technology is actually developed. Such a strategy would produce first-rate science, and make determinations out to a larger distance. The additional benefit of higher sensitivity is obtaining a larger sample. Dr. Lunine noted that he would be extremely surprised if Earth-size planets are rare, given the gathering evidence.

The report also provides a list of recommended missions, as well as suggestions for future considerations.

AAAC Exoplanet recommendation: discussion

The committee discussed the issues raised by the report, citing uncertainties that may or may not be answered by the Kepler and Corot missions, and the continuing importance of astrometry,

photometry, and determining the prevalence of stellar superflares. Dr. Morse was concerned that the Task Force output not be seen as a blanket endorsement of SIM, adding that the AAAC has recommended that NASA not proceed with an exoplanet survey without explicit direction from the Decadal Survey. This advice collides with a Congressional direction to NASA to conduct an Announcement of Opportunity (AO) to select a technique and architecture for a mid-sized mission next year. The associated risk is loss of funding if NASA does not move forward. Dr. Burns noted that he has not heard advice from the community that a mid-sized mission is the right approach, and counseled waiting for ongoing studies to be completed within a year from now, which will essentially provide the same advice as the AAAC. Dr. Morse responded with two issues- is the scale appropriate for the task force recommendations, and is a mid-sized planet finder what NASA wants to spend its money on? These answers will not be known until the next Decadal Survey is complete. Dr. Fischer commented that an astrometric mission would almost certainly be a Flagship-sized mission, even though some risk has been retired, partly through SIM work that has already been accomplished. Dr. Morse felt that two smaller missions could be phased better than a large mission; notwithstanding the fact that there are no funds for a large mission. Dr. Fischer expressed concerned about producing many small wedges, each growing in cost; the Decadal Survey is not going to solve the problem because NASA must still prioritize with respect to all other missions. Congress can also trump Decadal Survey recommendations. Dr. Hogan asked for thoughts elicited by the assumption that the Decadal Survey accepts the Exoplanet Task Force recommendations. Dr. Fischer felt that in that event, microlensing would be the first mission called for, but that this mission could not be weighed against a dark energy mission. Dr. Morse reiterated the dangers of having unprioritized funding while waiting for the outcome of the Decadal Survey. Suggestions for dealing with these uncertainties included asking the Decadal Survey for an interim report, and putting funds into a technology pool with some funds targeted to an exoplanet mission, investing more over the next three to five years. Dr. Morse noted that the issue is process; APD is now at the point where it needs to fish or cut bait. Drs. Huchra and Hogan agreed to draft a recommendation on this issue.

Discussion

Dr. Hogan asked for further email input to the letter to the NAC, and provided an action to Dr. Hasan- to set up a listserv or an email list to allow *en masse* emailing within the committee.

Dr. Suntzeff recommended that NASA support, through the Astrophysics Data System (ADS), for example, tools for astronomers, easy access to papers, and the general scholarly infrastructure. The committee also considered the potential of having a NASA new launch vehicle in 2020 (Ares V) and what that would signify to astronomers; the Ares V would provide an 8-m fairing and far greater upmass capability than is currently available. The astronomy community might do well to start thinking about more aperture, light-gathering power and resolution. Further consideration was given to planning of future Great Observatories, within the constraints imposed by continuing the lunar/manned program, and a Congressional bias toward the lunar program overall. Dr. Townsley commented that the purpose of NASA is to push back the frontiers of science, get the science out, therefore APS should make it clear that the science archives and ADP are underfunded, and that much great science can be advanced with panchromatic studies. Dr. Polidan requested a briefing from the roadmap groups on the suborbital and balloons to be scheduled for the meeting, tentatively scheduled for October 8th.

Wrap-up, Recommendations, Actions

Dr. Hogan briefed Dr. Morse regarding committee recommendations on fellowships, particularly anxiety about the dilution of science quality, vulnerability to politics and program volatility, and the sentiment that the Hubble fellowships should be maintained. Dr. Morse encouraged APS to write concerns that NASA can respond to, and reiterated that APD wished to build on the legacy of existing fellowships, maintain prestige and quality, and retain the structure and mechanism of the fellowships. He noted that current fellowships are administered through contractors, not Headquarters, and that this will not change. He assured the committee that his goal was to make

fellowships a practical management tool for forward planning, by constraining funds such that they cannot be raided to pay for overruns. The program level is the right level for distributing prestigious support, and NASA is really trying to fix something before it breaks by covering scientific breadth with long-term stability. It also helps to institutionalize and document themes so that Congress can use the nomenclature.

The committee felt that the proposed Senior fellowship would affect the sociology of the field, and that it needed more discussion, with a suggestion to tie the fellowships to a tenure-track position. Dr. Morse replied that he was trying to move people away from writing proposals toward doing research, and reduce the burden on the community, historically comparing the proposed fellowship to NSF block grants. He further argued that big discoveries are now coming at the interfaces of traditional fields; these fellowships could provide the tools to look at larger and more holistic, synthetic projects, with multi-facility, multi-technique, multi-wavelength analyses.

Concerning APS advice to the next Administrator, in addition to considering comments about advisory committee structure, Dr. Morse cited the tension between science push vs. developing capabilities first (JWST is an example of science push), and the suggestion that a program at the directorate level within SMD to do cross-cutting technology development be developed. The New Millennium Program was not that successful; few instruments actually made it onto flights. Dr. Morse preferred to pursue directed LISA and ConX technology lines, whereby detectors and optics can find their way into other missions and percolate up from the grass roots. He did concede that the opposite reasoning path had been valid with HST. The committee considered writing a recommendation to consider some sort of hybrid approach, perhaps involving the production of specific, prioritized technology list for industry to consider. Dr. Morse thanked the committee for their input. Dr. Flanagan thanked Dr. Morse for his exceptional efforts on facilitating international partnerships and administration of programs. 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
Kathyrn Flanagan, STScI
Leisa Townsley, Pennsylvania State University (pending)
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

Other Attendees
Hashima Hasan, APS Executive Secretary, NASA HQ
Wilton Sanders, NASA Science Mission Directorate
Sara Spreitzer, Lewis Burke Associates
Sam Cowin, Lewis Burke Associates
Jon Morse, NASA Science Mission Directorate
Dom Conte, General Dynamics
Alan Smale, NASA HQ
Jennifer Kearns, NASA HQ
Kimberly Ennico Smith, NASA Ames Research Center
Jim Spann, NASA Will Sanders, NASA HQ
Greg Williams, NASA HQ
Lia LaPlana, NASA HQ
James Spann, NASA Marshall Space Flight Center
Christopher McKee, University of California at Berkeley, by telephone
Andrew Lange, Caltech, by telephone
David Barrett, NASA HQ
Bill Oegerle, NASA Goddard Space Flight Center
Rob Boisseau, American Institute of Physics
Jennifer Wiseman, NASA Goddard Space Flight Center
Sara Heap, NASA Goddard Space Flight Center
David Leckrone, NASA Goddard Space Flight Center
Preston Burch, NASA Goddard Space Flight Center
Garvey McIntosh, NASA HQ
Katy Dacey, NASA HQ
Marian Norris, NASA HQ
Joan Zimmermann, Harris Corporation

Appendix B

Agenda
Astrophysics Subcommittee

July 2-3, 2008

NASA Headquarters, Washington D.C.

MIC 5

Wednesday 2 July

8:00 - 8:15 a.m.	Introduction and Announcements	Hogan
8:15 - 9:15 a.m.	Ethics Briefing	Barrett
9:15 - 10:45 a.m.	Astrophysics Division Update	Morse
10:45 - 11:00 a.m.	Break	
11:00 – 11:15 a.m.	Decadal Survey Update	Huchra
11:15 – 11:45 a.m.	Senior Review: Missions	Smale
11:45 – 12:15 noon	Discussion	ALL
12:15 - 1:00 p.m.	Lunch	
1:00 – 2:00 p.m.	HST SM4 Update	Leckrone/Burch
2:00 - 2:15 p.m.	Break	
2:15 - 4:00 p.m.	GPRA discussion	ALL
4:00 – 5:00 p.m.	Discussion	

Thursday 3 July

8:00 - 9:00	Re-cap of Day 1	Hogan
9:00 - 10:00	Exoplanet Task Force presentation (via telecon)	Lunine
10:00 - 10:45	AAAC Exoplanet recommendation: Discussion	All
10:45 - 11:00	Break	
10:45 - 11:45	Wrap-up, Recommendations, Actions	Hogan
11:45 – 12:00	Brief to Morse	Hogan
12:00 - 1:00	Working Lunch	

1:00 **Adjourn**

Appendix C (membership list)