NASA ADVISORY COUNCIL

ASTROPHYSICS SUBCOMMITTEE

February 2-3, 2010

NASA Headquarters
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MEETING MINUTES

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Craig Hogan, Chair

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Hashima Hasan, Executive Secretary

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February 2, 2010
Dr. Craig Hogan, Chair of the Astrophysics Subcommittee (APS), called the meeting to order, noting it would be his last meeting as Chair. Introductions were made around the table and meeting room.

Astrophysics Division (APD) Update
Dr. Jon Morse, Director of APD, provided a status of the Division. He noted that the Science Plan would be released in late Spring of this year, and asked the APS to briefly review the draft, which he regarded as quite mature in its development. He also noted that the recent NRC report addressing the Science Mission Directorate (SMD) Research and Analysis (R&A) program would require a response, with feedback from the subcommittee.

Dr. Morse pronounced 2009 a banner year for Astrophysics launches, with all operating missions returning good data. The Stratospheric Observatory for Infrared Astronomy (SOFIA) will soon enter the early science phase, while the next APD launch will be NuSTAR, a small Explorer (SMEX) mission due to be launched in January 2012. The NuSTAR launch will need to avoid conflicts in the launch queue with three major missions- JUNO, GRAIL and Mars Science Laboratory (MSL). In the Suborbital program, the Cosmic Ray Energetics and Mass (CREAM) V recently finished a successful 37-day campaign. Unfortunately, the latest Superpressure (SP) Balloon test failed at altitude and is now being analyzed for the root cause of failure. In the Suborbital Australia campaign, 3 science payloads are scheduled for March and April 2010. A Senior Review of operating missions will be held in mid- to late April. A community announcement has been made for the Explorer Announcement of Opportunity (AO), with the AO to be released late in this calendar year. In response to a question, Dr. Morse noted that the Alpha Magnetic Spectrometer (AMS) experiment is currently manifested for flight in late summer 2010, on the second to last Space Shuttle flight in roughly the August timeframe. The Department of Energy (DOE) is the lead science agency on this mission.

2009 Year in Review
Dr. Morse reviewed highlights of 2009. The first open-door flight test of SOFIA took place in December, and a highly publicized Star-Gazing Party was held at the White House in October. Science highlights include Fermi data on millisecond pulsars, which are believed to be possibly spun up as "black widow" pulsars. The pulsars also function as good, isotropically distributed clocks which might eventually be used to detect gravity waves. Another notable Fermi result involved photon timing from a gamma-ray burst (GRB). High- and low-energy photons, separated by a large energy difference, were detected within a second of each other, leading to the question: what viscosity did they encounter on the way if they left the source at the same time? Kepler science output included 5 exoplanet discoveries that were announced in August 2009. An unexpected result was the very low density of Kepler 4b, essentially equivalent to Styrofoam, which is challenging current exoplanet theory.

The SM-4 Hubble Space Telescope (HST) repair mission was highly successful, with HST now able to see some of the highest redshift objects known; thanks to instrument upgrades, HST is now seeing in a few orbits what previously took hundreds. HST is finding populations of high redshift proto-galaxies which will help pave the way for the James Webb Space Telescope (JWST).

The Wide-field Infrared Survey Explorer (WISE) mission was launched in mid-December 2009. The spacecraft began its 9-month survey on 14 January. Thus far the images have been stellar, revealing polycyclic aromatic hydrocarbons (PAHs) glowing in dust clouds. WISE has also detected a near-Earth asteroid, which showed up in thermal IR bands. It is expected that several hundred new near-Earth objects

(NEOs) will be detected by WISE. The warm WISE phase will not have thermal IR, and thus may not see asteroids, but it will still be capable of brown dwarf detection.

SOFIA has had several tests since its successful open-door test in December, and plans a 40% Door Open Envelope expansion test for 2 February. In April/May, SOFIA will attempt a first-light observation. The JWST mission is making progress, with much flight hardware and many subsystems being delivered. The JWST mission Critical Design Review (CDR) is scheduled for April.

The NuSTAR optics team has completed its first 7 layers of flight optics. Assembly has commenced after a successful Spacecraft Structure Assembly Readiness Review. Astro-H mission Engineering Peer Reviews are currently being undertaken in preparation for a March 2010 Instrument Preliminary Design Review (PDR). JAXA is now considering an early 2014 launch date for Astro-H.

The stoplight chart for missions is green for the most part. HST has experienced several lock-ups that shut off the Near Infrared Camera and Multi-Object Spectrometer (NICMOS) cryocooler. A response plan to enable a 24-hour recovery period is in place. Mr. Mike Moore explained that the problem seems to lie in the redesign from the original hardware- the sequencing of the older installation timing is read as an error with respect to the new hardware. In the next two weeks, the mission will have a recommendation whether to turn off the NICMOS cryocooler altogether.

The Galaxy Evolution Explorer (GALEX) far-ultraviolet (FUV) channel has been down since May 2009; troubleshooting continues. The near-ultraviolet (NUV) channel is nominal, and most data volume is from the NUV band. The Swift mission is in discussion with the Italians to install a second antenna to support tracking. The Italians will partner on NuSTAR with this capability; the second antenna is expected to be back up later this calendar year. Kepler has transitioned management to the Ames Research Center; the mission recently experienced had a charge-coupled device (CCD) anomaly which if permanent, will mean a loss of 5% of its field of view (FOV). The problem is being analyzed by a team at Ball Aerospace. The anomaly appears to be localized to the electronics of the particular CCD.

Herschel now has 3 of 3 functioning instruments after recovering a diode anomaly, which may be attributed to radiation. The Heterodyne Instrument for the Far Infrared (HIFI) instrument was successfully turned on 12 January 2010.

Mission timeline
Fifteen missions are operating at present, a record for the division. ST-7 is moving toward a new 2012 launch window, and NuSTAR will undergo a CDR this week. The Gravity and Extreme Magnetism (GEMS) mission is a new SMEX slated for 2014, and JWST has a mid-2014 launch date. WISE has a short operating lifetime, comprising 1.5 sky surveys over 10 months. One sky survey requires 6 months. Herschel has cryogens designed to last for 3 years, but may extend to 5 years. Planck was supplied with one to 1.5 years worth of cryogens. The future of these missions is not certain. Spitzer ran out of cryogens last May, just before Herschel launched. Spitzer remains scientifically productive with reduced capability. Fermi continues to perform well in its 5-year mission. Some missions have drift-away orbits and will be eventually too far to communicate with, and APD will not be replacing them as fast, although some extensions are expected. As a result, NASA expects to have a total of 6-8 AP missions in operation by mid-decade. Tough decisions will need to be made about the portfolio.

APD press releases were numerous in early January, particularly in association with the AAAS meeting. Administrator Bolden attended the meeting and spoke to many graduate students. Education and Public Outreach (E/PO) activities throughout the year included WISE teacher workshops, Kepler activities at the 4-6th grade level, and the unveiling of a Hubble-Spitzer-Chandra image of the Galactic Center. “Baby pictures" of the universe were featured in *Cosmic Times*, WISE was featured in the December 2009 issue of *Sky and Telescope*, and *Aerospace America* featured Kepler in its January 2010 issue. 2010 Fellowships will be announced in February.

Dr. Morse noted some personnel changes: Linda Sparke is the new lead for the AP Research Program and Felicia Jones-Selden is acting Deputy Director of APD while Rick Howard is detailed to the Office of the Chief Engineer (OCE) through May 2010. Drs. Hogan, Kathryn Flanagan, Nicholas Suntzeff, Kimberly Ennico, and Frederick Y. Lo will be rotating off APS; Dr. Morse offered his appreciation for their service.

Studies in progress include the Senior Review of Operating Missions, which will evaluate RXTE, GALEX, INTEGRAL, XMM Newton, Suzaku, Swift, Spitzer, Chandra, Planck, WISE, and WMAP. The Senior Review will consider strategic objectives for 2011-12, and preliminary guidelines for 2013-14. HST will be reviewed in the next Senior Review. Astro2010, the NRC Astronomy and Astrophysics Decadal Survey, will be released in late summer, followed quickly by the Planetary Decadal Survey. A new NRC study of NASA's Suborbital Research Capabilities expects to report in Spring 2010.

Dr. Morse requested that APS consider the issues of uncosted carryover in grant funding, NASA response to the NRC/Fisk report on R&A practices, a final framework for the proposed Technology fellowships, funding for soft money researchers and early career faculty, and the upcoming Explorer AO/Stand Alone Mission of Opportunity (SALMON) strategy.

NASA plans to release an Announcement of Opportunity (AO) in the last summer/early fall of 2010 that will solicit proposals for Explorer (EX) missions. NASA also plans to release simultaneously a solicitation for Explorer Missions of Opportunity (MO) through the Stand Alone Missions of Opportunity Notice (SALMON). A draft EX AO and draft SALMON amendment is expected to be ready for release for comment in Spring 2010. The cost cap for an EX mission is expected to be no greater than $200M, not including the cost of the Expendable Launch Vehicle, and the cost cap for an Explorer MO is expected to be no greater than $55M. NASA expects to solicit MO science investigations as either Partner MOs or Small Complete Mission MOs, including investigations requiring flight on long-duration balloons or the International Space Station. Dr. Hogan asked what type of launches would be available to the ISS after the Space Shuttle retires. Dr. Morse replied that the ATV, HTV, and Progress vehicles would be available, as well as U.S. efforts in the commercial space transport sector. Up to four missions may be selected for one-year Phase A concept studies, with up to $1M per study. Down-selection in late 2012 is the target. Dr. Morse asked APS to consider the best strategy for dividing these funds for the best balance, while avoiding significant gaps between AP missions.

Dr. Chris Martin asked what the APS role might be in helping APD respond to the Decadal Survey. Dr. Morse hoped that APS would provide tactical advice on implementation of Decadal Survey priorities within budget constraints. He was not sure a recommendation would be merited as there will be overlaps between the Heliophysics Division (HPD) and Astrophysics missions. APD will also consider its technology roadmaps as recommended by the Program Analysis Groups (PAGs) for accomplishing mission initiatives. The division will need concrete recommendations on short-turnaround issues. In this context, Dr. Morse also requested that APS review the Science Plan, which describes the current program, provides the structure of the budget in science themes, and covers existing and upcoming missions as well as areas of science. The Plan may need rewrites on new initiatives and a response to Decadal Survey priorities. Dr. Arjun Dey asked for clarification on the division between Heliophysics and Astrophysics funding profiles for Explorer level missions. Dr. Morse explained that within the future mission line (out to 2016-18) in the HP funding bin, available funding would accommodate two missions. The program is joint and thus both divisions participate in the proposal review process. There is no prescribed outcome.

The selecting official is the SMD Associate Administrator. Dr. Morse noted that he would plan for at least one AP mission, but without a guarantee that an AP mission would be selected.

PhysPAG/CORPAG Update

Dr. Eric Smith gave a brief status of the Physics of the Cosmos PAG (PhysPAG). Work is under way to have Chairs selected and ratified, and the next task is to obtain an endorsement of these PAGs at the Science Committee meeting. Dr. Smith reported having attended the ExoPAG meeting, and related that the new PAGs will be structured along the lines of the ExoPAG.

Astro 2010

Dr. John Huchra reported on the progress of the Astro2010 Decadal Survey report. The draft report will probably be submitted to the NRC for review in April 2010 and is expected to be out of review in July. The report will probably not be ready at end of July, despite an Agency desire for a mid summer release. It is hoped that the final report would be released in early September. The Astro2010 committee recently held a meeting in Irvine, at which it discussed the final reports from the prioritization panels. Another meeting is scheduled for the end of February, at which time a nearly final set of priorities will be assembled. The drafting group has been formed.

LISA Program

Dr. Michael Salamon initiated the update on the ESA/NASA Laser Interferometer Space Antenna (LISA) mission, reviewing personnel, and introducing Dr. Tom Prince as the mission scientist on the U.S. side of the mission. Project management is at the Goddard Space Flight Center. The LISA concept was first described in 1985, becoming a mission when proposed to ESA in 1993; it is now a large-class mission in the ESA Cosmic Visions program. A collaboration between agencies was agreed to in 2001, and a NASA/ESA division level understanding was reached in 2004 (not an Agency agreement). LISA has entered Phase A at NASA, with tentative roles assigned to each agency. There is no formal memorandum of understanding (MOU) as yet. The mission awaits prioritization in the upcoming Decadal Survey as well as a Cosmic Visions L-class down-selection. A precursor mission, LISA-Pathfinder (LPF), will be a critical issue in how LISA proceeds; NASA has contributed to LPF through an ST-7 (New Millennium) package providing micro-Newton thrusters and drag-free controls. Launch of LPF is scheduled for 2012.

Dr. Prince gave an overview of the mission architecture and science objectives. LISA is a 3-spacecraft mission in an Earth-trailing orbit, each spacecraft separated by 5×10^6 km. A joint project team oversees the effort, and requirements and architecture have been stable for a decade. Technology development and risk reduction are continuing through the LPF mission. Recent and future meetings have involved and will involve the international science team and working groups, culminating in an International LISA Symposium at Stanford University in June 2010.

LISA observational objectives include massive black hole binaries, ultra-compact binaries, capture of stellar mass black holes by massive BHs in normal galactic nuclei, and cosmic background from superstring phase transitions. LISA will observe a richly populated universe of strong gravitational wave sources. LISA will cover a very broad range of physics and astrophysics, including black hole/galaxy evolution, test of dynamical strong-field theory, precision tests of General Relativity, endpoints of stellar evolution, contributions to cosmography and Hubble constant, and the unexpected.

LISA's payload includes 1W lasers for metrology; each spacecraft has two 40 cm telescopes. Prototype subsystems are being fabricated. Laser metrology between spacecraft comprises 6 laser Doppler signals between spacecraft, and 6 reference beams between spacecraft assemblies. Many LISA payload components already exist in prototype form as hardware developed for LPF, such as the lasers and optical benches. Mission readiness has achieved phase A level maturity in all technical aspects, payload components are on track to reach technical readiness level (TRL) 6, and risk factors being retired on several subsystems. Microthrusters and laser lifetimes will require additional ground testing.

LPF is designed to validate LISA flight subsystems; hardware exists for all major subsystems such as proof masses, optical benches, lasers, and thrusters. LISA mission formulation in Europe is aggressively moving forward. The current ESA technology plan is extensive and is scheduled for each component.

NASA risk reduction activity for LISA includes phasemeter development at the Jet Propulsion Laboratory (JPL): digital components are at TRL 5 and photodiodes at TRL 4, to achieve TRL 6 by FY12. Micro-Newton thrusters are at TRL 7 for LPF and TRL5 for LISA. Risk reduction at Goddard Space Flight Center is being pursued for the optical assembly tracking mechanism, arm-locking studies, and telescope spacer design. Current science community activities include Mock LISA Data Challenges [modeled on a galaxy containing 30 million compact binaries with 5 massive black hole (BH) mergers and 5 compact-object captures], and science team working groups are addressing sources and requirements, data analysis, interferometry, disturbance reduction (gravitational reference sensor), and outreach and advocacy. Activities are posted at list.caltech.edu.

The LPF/LISA notional chronology is as follows: LISA SRR in 2013, and PDR in 6/2015, with formal approval phase C/D in 2016/17; these milestones are dependent on budget and Decadal Survey prioritization. The mission is costed at $1.2B on the NASA side, in real year dollars. The total cost to both agencies has not been assessed. Estimated NASA contributions are based on the presumed division of responsibilities. ESA contributes within its technology development, LPF, and Cosmic Visions cost caps and is roughly equivalent to that of NASA. ESA's LPF contribution is very substantive.

Education and Public Outreach is in planning phase. Dr. Heap asked if there would be missions that will be co-monitoring supermassive BH mergers at the time of the LISA mission, and if there would a rapid data analysis system to capture these events. Dr. Prince reported the mission was studying latency requirements to respond on a less-than-a-day timescale. There would be a large number of ground-based telescopes available for monitoring. Dr. Suntzeff expressed concern about an open data policy and recommended an international committee to decide on this matter. Dr. Prince noted that a data plan would be a phase A product.

Asked about the cost of mission operations, Dr. Moshe Pniel, via telecom, estimated that it would be on the order of $100M on the U.S. contribution side. Mission operations *per se* are expected to be in the U.S. as well, but there will also be a data center in Europe. Dr. Pniel noted that one needs to distinguish between science and mission operations center, and that operations are currently to be assumed at JPL (and therefore not up for competition). The science center may or may not be competed. Dr. Salamon felt it was premature to assume allocation of centers and that the Decadal Survey would weigh in on both center allocations as well as the data distribution policy. Dr. Suntzeff reiterated his concern on data policy and community input on MOU. Dr. Salamon replied that NASA favors immediate data release if the data are properly calibrated and saw no reason that this policy would not apply to LISA. Dr. Suntzeff differed on the subject and claimed data had been withheld in NASA missions. Dr. Prince commented that he expected the data to come down as whole-sky, therefore science would drive the data policy. Dr. Hogan asked if there were any major issues with mission progress. Dr. Prince noted that the key milestone was to reduce noise in the gravity sensing mechanisms, and that LPF is not yet down to the sensitivity required for LISA. Another issue is that of lifetime of lasers and microthrusters. A meeting participant commented that human factors were seen to be more difficult than the technological. Dr. Prince added that verification and validation during integration and testing would also need an "A team" of engineers.

<u>Working lunch discussion</u>

The APS discussed the large vs. small mission dichotomy in regard to the Explorer AO. Dr. Heap recommended relying on peer review and the best science outcomes. Dr. Chris Martin commented that the dichotomy was not a simple comparison; smaller missions of opportunity have historically not been selected. The choice was to either maintain a vigorous Astrophysics program vs. to choose missions with value of science to mankind. Dr. Huchra suggested striking a balance between long-term and short-term science goals. Dr. Manning commented that both sides (HPD and APD) may not benefit equally from the competition. Dr. Hogan agreed that the larger missions tended to look better, therefore it would be advantageous to divorce the processes and integrate them later. Dr. Polidan noted that when balloon missions had been peer reviewed for SMEX, the bigger missions did tend to get selected, traditionally. Dr. Kimberly Ennico recommended that access to space also be considered in this context; smaller launch vehicles (LVs) are being retired, and larger missions need large LVs, driving up the cost. Secondary payloads should be considered. She suggested considering Astrophysics payloads on commercial vehicles (small vehicle).

The subcommittee debated the efficacy of competing Heliophysics and Astrophysics Explorer missions. Dr. Polidan felt the matter was best left to the decision process of the SMD AA. Dr. Hasan reminded the subcommittee that the science for the missions is separately reviewed by the appropriate expertise, while the technology is reviewed by the same panel for risk reduction and technical readiness. Over time, the competition comes out 50-50, generally. Dr. Hogan suggested considering MOs on the International Space Station (ISS). Dr. Manning felt that the bigger missions usually have the advantage in capability, and that one might best deliberately engineer the spectrum from small to extra-small. Dr. Hogan agreed APS could recommend good competitive missions worth $50M. The final decision must be made on merits. APS should decide what programmatic balance can maximize science. Dr. Ennico suggested focusing on the next medium-class Explorer (MIDEX) opportunity. Dr. Moore responded that an 18-24 month cadence is generally recommended for MIDEXes if there are sufficient funds. Dr. Prince added that the Decadal Survey may comment specifically on large vs. small missions. Dr. Hogan noted that the community has always endorsed frequent Explorers. Dr. Prince remarked that LV costs and the general budget are limiting MIDEX opportunities at present. Dr. Kasting leaned toward supporting one mission and several MOs, opening up the competition to a wider range of science.

<u>ExoPAG Update</u>

Dr. Kasting gave an update on the Exoplanet Program Analysis Group (ExoPAG), which was chartered by APS in Fall 2009. The first ExoPAG meeting took place at the AAS conference in early January. Exoplanets were of great interest at AAS, and much enthusiastic interest from young people was noted. ExoPAG is in the process of identifying potential topics on which to establish specific Science Analysis Groups (SAGs), has received input from the well-regarded Mars Exploration Program Analysis Group (MEPAG), and is in the process of patterning itself after this group. Dr. Kasting suggested that APS members examine the MEPAG website.

Potential topics for the ExoPAG to consider are:

- A small coronagraph to determine the characteristics of debris disks and exozodiacal dust, which need to be known for a Terrestrial Planet Finder (TPF) mission.
- The potential for exoplanet science measurements from Solar System probes, taking advantage of astrophysical concerns overlapping with those of planetary science. The purpose would be to characterize local zodii, e.g., sending a spacecraft beyond 5AU and looking back at Earth with a photometer. In that light, the ExoPAG is proposing a SAG to establish a link with the Planetary Science Division. A relevant mission would be EPOXI, yielding time-resolved light curves that can be used to infer land/ocean distribution, the presence of clouds, and planetary rotation rates. In principle, this could also be done with exoplanets.

- Planetary architecture and dynamical stability: study the effects of planetary systems on planets within the habitable zones of nearby and distant stars using ground-based techniques, microlensing, and astrometry. This could produce a list of nearby systems that may or may not harbor habitable planets.
- Planetary measurements needed for exoplanet characterization: what to know first- atmospheric and surface modelers, ground and space observations, exoplanet mission teams.
- Description and technology status for external occulter concepts: this investigation could produce top-level instrument concepts, published estimates of exoplanet science harvest, known technology challenges and plans for addressing them.

Dr. Kasting requested that APS charge the ExoPAG to pursue some of these topics. Dr. Heap felt that some of the proposed topics were too broad and asked which specific task might be most useful to NASA at present. Dr. Kasting thought the time frame of a typical study would be more like one or two years, with different issues having different time scales. The occulter question would be shorter (months), for instance, and would be helpful for directing JWST science. Asked whether ExoPAG was planning to address technology development, Dr. Kasting replied this has not yet been thoroughly discussed. A meeting participant commented that the PAGs should lean toward science questions, seeing that technology discussions could easily spin into premature mission priorities. Dr. Kasting noted that some "minor" changes would be needed to line up JWST and a proposed occulter, and that simultaneously there was much community reluctance to further drive up the cost of JWST. There have been many occulter studies- this notional one as expressed by ExoPAG would be an information-gathering exercise to amass the available information, digesting the data so that it is useful. Dr. Heap agreed, noting that NASA has funded two studies of occulting missions, which should be publicly accessible. Another participant commented that the occulter studies are not uniform and needed to be normalized so that they can be compared equitably. Dr. Huchra noted that the reports were available on the NRC website. Dr. Martin added that a set of weighting factors must be developed to judge the studies, and that this was not the purview of the ExoPAG. Dr. Leisa Townsley applauded Dr. Kasting's efforts. Dr. Hogan felt that APS could endorse the study with generalized caution.

Van Allen Early Career Fellowships

Dr. Chris Martin provided an update on the fleshing out of the proposed Technology Fellowship initiative, now termed the Van Allen Early Career Fellowships, details of which are nearing consensus. The goal of the fellowship is to attract and develop new talent, maintain a workforce of experienced technologists/instrumentalists, create new opportunities, and bridge the gap between Ph.D. and tenure track positions (particularly hard for instrumentalists). A strawman proposal and counter-proposals have been developed, resulting in 3 options to be discussed by APS.

Recognizing that one can't devise a one-size-fits-all program, and the existence of an overly-large post-doc community, the program should not just perpetuate the status quo; the program elements should be tested early and adjusted accordingly. In general, the option closest to acceptance contains the following features: The fellowship should be eligible at all institutions, including NASA centers, so long as there are no overlaps. The fellowship should be 4-5 years in length and nonrenewable, with possible mid-term review. Stipends can be tied to other NASA fellowships. For independence, a fellow would need capital equipment support for technology demonstrations or instrumentation, at a target of about $500K (FY11) as a maximum amount, allowing for smaller amounts as appropriate.

One main issues remaining is: at what point in the career path are recent Ph.D.s or post-doctoral students ready for this fellowship? Consensus has been reached on requiring institutional support; i.e. there should be an institutional gesture that represents a commitment to the program. This support could take the form of equipment purchases, support from staff, engineers, telescope time, etc. The type of support is meant to be flexible and to be judged in a case-by-case evaluation. Partnering with business or government laboratories, NASA centers, etc. would be encouraged. The rationale of the fellowship is to promote synergies and early development of necessary relationships. Selection criteria would include overall scientific and technical merit, experience and the promise of the candidate. Only one candidate per institution would be permitted at any given time, similar to the criteria of the Hubble fellowships. The selection process would include a pre-proposal workshop and must include experienced reviewers.

Contentious issues remain. Dr. Martin presented the 3 options and highlighted option 2 as a compromise between options 1 and 3. Option 2 identifies eligibility as having Principal Investigator (PI) status at the proposing institution, being 0-7 yrs out from the Ph.D. Post-docs could apply as well as junior faculty. Capital support of up to $500K would be provided, and partnering encouraged with independent contribution. Assuming 1-2 people per specialty at steady state, the fellowship would support about 9 individuals each year. Dr. Morse commented that as NASA supports about 75% of the astronomy workforce (JWST supports 1100-1200 on $450M), Dr. Martin's presented numbers were a good estimate.

Dr. Martin felt it important that the program size be matched to the overall R&A program. Another issue is that there are already too many post-docs; the Van Allen fellowship should not increase the total number. It may be necessary to subtract Hubble/Einstein fellowships, e.g., if the Van Allen fellowship is adopted. Dr. Kathy Flanagan objected to this approach, noting that the fellowship group had not been asked to weigh in on the other fellowships unless it is weighing in on a source of funding. Dr. Martin asked that his observation be construed as a comment only. Dr. Huchra noted that this concern arose from the long-term employment prospects expressed by young talent; it is a worry for the future workforce and soft money positions. Dr. Morse felt that while one must deal with expectations, one must also consider Astrophysics as an avenue of innovation for other areas of science. Dr. Martin agreed, having heard comments that these types of people are "golden" in any field.

Option 2 represents a total cost of $7.5M, 60% post-docs and 40% faculty; a stipend of $103M for post-docs and $20K for faculty; and a total of 9 fellows. The term was to be 5 years with no renewal, and to include a midterm review. Dr. Shaul Hanany identified himself as the last holdout on votes, feeling that the program was not well balanced. He did not feel that there was a sustainable throughput of people who will mature as desired. Recent high-level faculty (Jones at Princeton, Devlin at the University of Pennsylvania, e.g.), have come through the same track, joining existing experiments instead of applying for large capital funds. Dr. Hanany feared that option 2 would cause a bias in the review committee. He felt that options 2 and 3 could be merged, taking 2 of 5 faculty positions and make them "super post-docs," reducing the number of fellows and making some of them Einstein fellows. Dr. Townsley suggested, alternatively, keeping the equipment capital amount low. Dr. Hogan felt it was possible to write the program intelligently so that it is not just filling gaps in proposals. Dr. Martin agreed that the fellowship would have to rely on the review process to work as well as it does. Dr. Hanany felt options 1 and 2 were too expensive. Dr. Polidan commented that industry could be a big contributor to this effort if the proposal is written properly- a stipend could attract equipment from the industry.

Research and Analysis Programs

Dr. Linda Sparke provided an update on the R&A program. Currently the total of R&A and the Astrophysics Data Analysis Program (ADP) is funded at a total of about $75M/year; since 2004 this amount has decreased, but is nowhere near the bottom, historically. FY10 funds for technology development stand at about $40-45M. In FY10, total R&A is down about 1% down from FY09. At 2004, the transition to full-cost accounting obscures the real history of funding. Changes for ROSES 2010 are that co-PIs must register with NSPIRES, and proposals from approved guest observers with XMM, RXTE, and INTEGRAL must go to ADP.

Dr. Sparke raised the significant concern that Congress feels NASA leaves too much money unspent, thus the program is now also worried about cost and outlays. Grants and cooperative agreements are 5% of the NASA budget, but account for half of unspent funds. NASA has promised Congress it will do better in 2010. Dr. Morse reminded APS that going to one-year funds would be crushing, and that the threat of rescission must be taken very seriously. Grantee institutions typically report 14 months of funds unspent. A possible remedy would be to have PIs let NASA know their spending rate to rephase funding appropriately; university administrators can do the same. Having done so, NASA could defer sending any more funds until 6 months of funds remain. Dr. Sparke reported a good response from universities in reaction to these concerns. NASA can also get tough about no-cost extensions.

Costs can also be managed by changing the funding profile for Guest Investigators/Guest Observers (GIs/GOs). Currently, many guest investigations are split among multiple PIs, thus generating multiple grants. The costs for processing grants at NSSC run about $2000 per grant, with another $1000 for each money transfer. It may be useful to alter the current observing grants by accepting fewer proposals, conducting fewer reviews, lengthening the grant period, and combining smaller GO grants with longer proposals and multiple data sets.

SMD will respond to the NRC/Fisk Report recommendation to ensure that mission-enabling activities are clearly linked to strategic goals, using metrics (such as tying missions to specific theories) to actively manage the NASA portfolio in fulfilling its stated requirements. Carrying out this recommendation could provide a knowledge base to explore new frontiers and a wide range of technologies for future missions, as well as result in a robust, experienced technical workforce. However, this may mean collecting more data on grants and their recipients than NASA currently does. The Fisk Report also recommended paying special attention to innovative high risk/high payoff research and technology as a means of developing the workforce. Dr. Sparke asked APS to consider the tradeoffs of funding more graduate students at the equivalent expense of a balloon payload or 2 detector development programs; supporting more Technology fellows; or creating centers of excellence to encourage high-risk, high-payoff research, as recommended in the NRC/Fisk report.

Dr. Hanany commented that the Graduate Student Researchers Program (GSRP) had been a great program that suffered too many funding cuts, and suggested that the NASA Earth and Space Science Fellowship (NESSF) could be packaged with the Technology fellowships. Dr. Morse noted that the Earth Sciences Division funds about 42-45 graduate students each year; APD is very low by comparison. The cost of doubling our current level of NESSF fellows is about $3.5M, but it means going to the model of paying graduate students for more than one year. Dr. Morse asked if this was preferable to year-by-year GO grants. Dr. Hanany advocated multiple-year grants to help fill in tuition and health care costs. Dr. Kasting suggested that PIs put a graduate student on R&A money to help NASA spend money cost-effectively; the award letter could specify a graduate student through NESSF. Dr. Huchra recommended following the National Science Foundation (NSF) model for graduate fellowships, which provides more support for tuition and health care. Dr. Hogan commented that for the model to work, the institution must be able to trust that NASA will send the money at a given time. He agreed that centers of excellence are a good idea, as they have been able to take risks. Dr. Dey felt that cutting out GO funding might hurt small colleges and shut out students, unless NESSF funding was vastly increased.

Dr. Morse again cautioned that there is real pressure from Congress for better fiscal management vs. rescission, and there is now a push on costing, in addition to obligation of funds; the Decadal Survey will be looking at this also. Dr. Morse seriously questioned the prudence of the GO program due to costs per grant and duplicating infrastructure. The pendulum may have swung too far on small grants, and it may be time to spend more money on larger grants to larger groups. Obligations that are unspent are now just as bad as unobligated funds.

Dr. Heap spoke in favor of small GO grants, thinking that they served a useful purpose and provided a one-to-one mapping between observing proposal and result, and giving everyone (individual or large institution) a chance to compete in a feasible project. Dr. Martin felt that small investigations provide scientific richness within the balance of large vs. small. Dr. Suntzeff noted that Hubble grants have gone to small institutions, encouraging support in focused science areas, spreading science out in revolutionary. fashion- HST has become, in effect, the People's Telescope. Dr. Manning suggested making smaller grants with an option of renewal- obligating fewer funds effectively. Asked what percentage of this unspent money could pay graduate or undergraduate students, Dr. Morse replied that half the cost of some grants cover graduate students, and that NASA should examine what percentage of money from R&A is actually going to graduate students. Dr. Sparke felt that there may be delays in university bookkeeping that is also contributing to the problem, and wondered whether Congress realizes that half of NASA's uncosted money is sitting at universities. Dr. Morse felt that this was common knowledge and that the issue is larger than NASA, and needs to be looked at systematically. He reported encouraging staff to find ways to improve things on their side, and to examine the merits of the GO model, and long-term grants such as those overseen by NSF and DOE.

Dr. Dey remarked that NASA metrics are linked to publications and are surely connected to GO grants. Dr. Sparke mentioned the fact that to track publications, the US National Radio Astronomy Observatory pays page charges as a small incentive to link publications to observations with its telescopes. Dr. Huchra observed that universities have the same problem with unspent start-up funds, as faculty and students tend to hoard these funds; he agreed that small grants have made a tremendous difference in supporting scientific publications. Dr. Morse theorized that NASA could also double the amounts of individual GO grants and times, and thereby bring down overhead rates. Dr. Martin felt that one year was too short for any grant. Dr. Sparke remarked that she had yet to see if the large grants are the biggest problem, but that the total number of dollars is the real problem, and no-cost extensions would not move the money any faster. Dr. Morse expected this issue to be discussed over the course of several APS meetings. He added that ESD spends about 40% of its budget on research ($265M for R&A, $400M in total for research in FY10; for Astrophysics, R&A is $60M and the total for research is ~$130M), and he felt sure that APD is unique in the way it dispenses money (for relatively small sets of pointed observations, with the funding released coincidentally with the observations being taken).

<u>SR&T Update</u>

Mr. Michael Moore addressed Supporting Research and Technology (SR&T) activities such as funding for the Sagan, Einstein and Spitzer fellowships, coordinating development of technologies necessary for missions in formulation or development, development of new technologies, and providing responsible transparent management, etc. The SR&T Technology Element Guidelines call for bridging the divide from TRL 3-4 to 5-6, providing funding for infrastructure development and sustainment, and allowing for directed funding to NASA centers and others for effective focused technology development. There is no absolute division of funds- the philosophy is that technology development should be driven by need with no guarantee of continuation if strategic planning changes direction. SR&T has a focused competed element, supports Technology Fellows, and adheres to Decadal Survey results with guidance from APS and the various PAGs. In judging how a facility investment validates its need, Mr. Moore asked APS to think hard about where industrial partners/contractors come in; they have some bright ideas in addition to academic sources and should be used effectively. He also asked the subcommittee to consider budget pressures in relating the new fellowship program to balloon and suborbital rocket program activities. Dr. Heap commented that unique facilities usually do not have the money to operate and maintain instruments, making them costly to researchers, and asked what measures could be taken to support the facilities that serve the Astrophysics community at large. Mr. Moore replied that NASA does support specific testbeds and provides competitive funding to those that use the facility; it is the community's place to argue for resources and the facility's value to future projects. Dr. Hanany noted that instruments often fail when integrated into spacecraft and asked how best to predict how they will work in orbit. Mr. Moore felt that flight testing was key and should be done if there are adequate resources.

SIM Lite Mission

Note: Dr. Polidan recused himself from this discussion.

Ms. Lia LaPiana provided a SIM Lite (formerly known as the Space Interferometry Mission) Astrometric Observatory project status. The current parameters of SIM Lite, de-scoped from the original SIM concept, include one 6-meter Michelson Stellar Interferometer; one 4-meter Michelson Stellar interferometer and one 30-cm telescope as a guide. The science remains the same for both mission concepts. The SIM Lite science team is comprised of 15 PIs, with 50% of available science time on a broad array of topics. Additional science areas where SIM-Lite may be useful have been considered. Nineteen study proposals were recently selected, 7 of which were entirely new science topics (two in exoplanet and 5 in general Astrophysics topics). The other 12 topics are extensions of previous topics. SIM Lite can determine the mass of planets it finds, which is a unique feature: a double-blind study has demonstrated that astrometry can do this in complex planetary systems. The mission will also provide data needed to derive secondary and tertiary measurements such as planet density, surface gravity and pressure, etc. SIM Lite and ESA's Gaia mission will be complementary. Gaia will survey over one billion stars, while SIM Lite is a pointed mission that will look at specific targets, for example the nearest 60-100 stars for its exoplanet key projects.

In February 2008, SIM Lite was tasked to present its science case and rationale. It was concluded that the rationale remains strong and that the mission would not be duplicative of Gaia science. SIM Lite Science was also reaffirmed in the Exoplanet Task Force report. A more cost-effective mission architecture as well as an optimized budget profile has been developed. An ideal funding profile would allow SIM Lite to launch in July 2015. However , FY10 dollars are not available to support a July 2015 launch date. Independent cost estimates were carried out: these were $1.65B (Aerospace) and $1.41B (project) in FY09 constant dollars. The difference in cost between the estimates is in the instrument and project held reserve. Aerospace gave credit for only $250M towards Phase B costs, whereas $400M has already been spent by the project.

The project completed its last technology milestone in June 2005; engineering milestones were completed in December 2007. SIM Lite is now engaged in engineering risk reduction activities and is continuing to validate brassboard (as opposed to flight hardware) testing. Significant brassboards have been delivered for the Astrometric Beam Combiner, the heart of the system. These brassboards are in the process of being integrated and tested. SIM Lite is ready to enter implementation, pending the results of the Decadal Survey, and availability of funding.

Dr. Wesley Traub described the results of the Astrometric-Radial Velocity (RV) double-blind study, designed to demonstrate whether SIM Lite can detect nearby Earth analogs, measure mass, and provide a full inventory of planets around nearby stars, in realistically-complex systems. The study was based on 108 sets of simulations of astrometric and RV measurements of model planetary systems around nearby stars, in order to see the detectability of Earth in the presence of gas giants and other planets. The study took about one year to complete. In response to a question on sensitivities, Dr. Traub explained that by comparison to SIM Lite, Kepler would detect planets that are too far away to measure with spectroscopy, so with the goal in mind of spectroscopy, it is necessary to be able to detect and measure the orbits and masses of planets around nearby stars.

In February 2008, 5 modeling teams were engaged to provide theoretical input planets for the study. Each team provided model planetary systems that were consistent with current observations, but aside from that commonality the systems that were provided reflected a broad range of theoretical opinions regarding the expected masses and orbits of exoplanets. The study assumed that SIM had a 5-year lifetime, 250 visits at a single-measurement accuracy of 1 microarc-second, and a Sun exclusion angle of 50 degrees. The study also assumed that there were 15 years of radial velocity data for each star, at an average of one observation per month, with a single-measurement accuracy of 1 meter per second, and with a 45 degree sun exclusion angle. The study selected random systems and arranged them at random angles.

A second set of 5 teams was competitively selected, for the purpose of analyzing the simulated data sets, in a way that was as close as possible to the analysis of real-life data. In particular, a double-blind procedure was used. Solutions were based on chi-square statistics, and required less than 1% false alarm probability.

Dr. Traub reviewed criteria for correct solutions. To be considered correct, a planet had to have an estimated mass and period that was within 3 sigma of the true values, where sigma was defined by a Fischer matrix calculation that produced Cramer-Rao bounds on the uncertainty in each estimated parameter. One important result of the study was that these Cramer-Rao bounds were found to be extremely good predictors of the actual errors (estimated minus true) for key exoplanet parameters, including mass, period, eccentricity, and inclination. In a plot of fractional errors vs. signal-to-noise ratio (SNR), the median error in period was ± 1%, representing 61 planets detected with an SNR of over 5.8 and a period less than 15 yrs. The corresponding median errors for other parameters are 3% in mass, 4 degrees in inclination, and 0.02 in eccentricity. At SNR >5.8, the measured completeness is excellent (around 90%), as predicted. (Completeness = detected/detectable planets). Trend planets are distant gas giants with long periods; the RV data was especially helpful in recognizing these planets, and removing their effect from the data. High eccentricity planets were found to be hard to detect, in part owing to potential confusion with steeply inclined circular orbits. A planet with a period that is a multiple of another is also difficult to extract. A long set of RV data will be very helpful for solving orbits with a short set of SIM Lite data. The study concluded that Earths can be detected in multi-planet systems, with excellent average completeness and reliability, paving the way for a Terrestrial Planet Finder (TPF) mission that would characterize the planets using visible or infrared spectroscopy. Dr. Heap asked if any target stars used for reference had star spots. Dr. Traub replied that the study neglected star spots because a separate study had indicated that all star spot noise would be below instrument noise. Dr. Ennico asked if SIM Lite were immune to questions like zodiacal light. Dr. Traub answered in the affirmative; Dr. Kasting added that SIM could discern planets even with big exozodii signals. Dr. Suntzeff was concerned about the availability of PIs to work on this long-lived project. Dr. Traub felt that the task was really a matter of waiting for data to come back and that to his knowledge, the interest of PIs remained very high. Dr. Suntzeff counseled him to look carefully and make sure the PIs guarantee their time. Dr. LaPiana noted that PIs are required to make a time commitment or risk being removed from the mission.

In response to a question, Dr. Traub reported that there would be a one-year proprietary period, as per the AO. Dr. Ennico asked if RV could improve its accuracy to better than one meter per second. Dr. Traub replied that the technology at ground-based facilities could provide a few tenths of a meter per second accuracy on selected stars, and that ammonia line calibration can also be used in the near infrared for late-type stars. However, as stars are intrinsically variable (star spots and stellar oscillations can be problematic), it seems to be generally accepted that the limit for average stars is still one meter per second.

Public comment period

Dr. Dey asked if all planets had been assumed to be coplanar in the modeling studies, to which Dr. Traub replied in the negative. Asked if SIM-Lite could detect an Earth-size moon around a Jovian planet, Dr. Traub felt that transit researchers were closest to this type of evidence, which he did not think could be done astrometrically or via radial velocity measurements.

Discussion
Dr. Hasan left the meeting, and Mr. Moore sat in as the requisite civil servant.

APS further debated the pros and cons of the Van Allen Technology fellowship. Dr. Hanany proposed recognizing with an explicitly stated proposal 3 classes of fellows: high profile Einstein-like post-docs, early faculty, and regular prestigious post-docs, with a caveat against bias. Dr. Heap commented that some feel the approach can begin as a smaller scale effort, to avoid breaking the bank at the start. Dr. Huchra agreed to write a one-page draft AO for consideration, to include options for PIs from industry, and to include a modest, phased ramp-up, with monitoring of proposal quality. Dr. Morse thought the steady state numbers and modest funding proposed in Dr. Martin's presentation had been reasonable. Dr. Townsley- should not go below half of number proposed; too rarefied, becomes an award. A description of the proposal mechanism would be deferred pending a more substantial discussion with the host institution/mentor/partners.

Dr. Dey suggested holding a workshop that brings the participating groups together, to which Dr. Martin agreed. Dr. Morse agreed that the fellowship could follow a model already in place for APRA, and felt it could be administered through ROSES or contractors. Dr. Polidan suggested the fellowship be shared with other mission directorates/divisions as it addresses a NASA-wide problem. Dr. Morse agreed, with the stipulation that the proposals be aligned with NASA activities.

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Dr. Hasan joined the meeting via telecom and webex, and Dr. Vernon Jones sat in as the requisite civil servant.

JWST Update
Note: Dr. Polidan recused himself from the discussion.
Dan Blackwood, the Program Executive for the James Webb Space Telescope (JWST), provided an update on the project, and began with a review of the spacecraft assembly. The telescope sunshield passed its CDR with two liens. Full-scale core thermal test hardware, which contains a mockup of the sunshield bus, the Integrated Science Instrument Module (ISIM) assembly, and other major components, has been completed. Core test integration is complete as of May 2009. A 1/3-scale sunshield completed thermal testing in December 2009. The Optical Telescope Element (OTE) Pathfinder center section bonding is complete, and a full composite buildup of the OTE backplane will be used for mechanical and optical ground support equipment checkout before the flight model OTE is tested. Primary mirror segments are in varying stages of grinding, polishing, and cryodeformation testing. Many mirrors have finished the polish phase and have been shipped to BATC to have actuators attached. Six primary mirror segment assemblies (PMSAs) are being installed and have finished their first cycle of testing; data should be available in two weeks. The PMSA engineering development unit (EDU) will be coated in April 2010, and the fine steering mirror (FSM) and three-mirror anastigmat (TMA) will be coated in February 2010. The aft optics bench assembly has been completed. Asked about wavefront error, Mr. Blackwood reported primary mirror segment temperatures will be between 40-45 K to 30K, well within specifications for error requirements.

Other mission progress includes installation of 32 systems across the world to support science instrumentation and spacecraft flight and ground software. Updates are ongoing. The mission will be using the Deep Space Network (DSN) to communicate with JWST at Lagrange Point 2. The ISIM-level CDR was completed successfully in 2009, and the ISIM Thermal Vacuum chamber is currently undergoing photometric instrumentation and thermal system testing. Flight Model Instruments are in the process of being integrated. All the secondary structures have been installed on the flight ISIM structure, and mechanical ground support equipment (MGSE) has been installed for ISIM structure cryotesting. Major milestones for 2010 include a number of major near-term reviews, and a Mission Critical Design Review in April 2010. In response to a question about cost and schedule reserve, Dr. Blackwood replied that there are 5 months critical path slack, whereas guidelines indicate this figure should be 6 months. The program is currently evaluating the schedule.

JWST Science

Dr. John Mather reviewed the science aspects of JWST, remarking that as of this date, it has been 14 years since the origin of the mission concept. JWST will be operated along the same lines as HST, focused on four main scientific themes: first light of the universe, the assembly of galaxies, the birth of stars and protoplanetary systems, and the study of planetary systems and the origin of life. Instrumentation will include a wide field near-infrared camera (NIRCam) equipped with a dichroic filter, a coronagraph, a near-infrared spectrometer (NIRSpec), a mid-infrared instrument (MIRI), and a fine guidance system (FGS)/tunable filter imager (TFI).

Stars and protogalaxies or proto-clusters associated with first light are generally of 10^7 to 10^8 (luminosity) L, with low metallicity and a magnitude in the 30/31 range. In hunting for galaxies, JWST should have vastly superior sensitivity over HST infrared (IR) instruments. Possible campaigns for JWST include ultra-deep surveys, in-depth source studies, and surveys for Lyman-α sources. In the study of galactic assembly, theorists would like to verify that small galaxy mergers actually do create larger galaxies. JWST will also extend HST science out to higher redshifts, and will enable deep, wide surveys with 3nJy-sensitivity at 3.5 micron.

It is hoped that JWST can be used to determine acceleration parameters now and in the past. JWST cannot do what JDEM is designed to do, but it can perform precursor science- i.e., measuring very distant supernovae (SNe) and SNe rest-frame IR light curves, learning about influence of dark matter in the environments of SNe, and providing data about cosmic archeology at high redshift. Dr. Morse interjected that absolute photometric calibration across the wavelength range has about a 5% error, which meets mission requirements, but asked APS to ponder the ramifications of much better calibration. Answers might be obtained through some relatively inexpensive suborbital launches. Dr. Suntzeff recommended that one must do an *ab initio* flux calibration for JWST, rather than bootstrapping off HST; this figure should be a factor of 10 better by now.

Dr. Mather noted that SN 2006 gy, the brightest supernova thus far recorded, could be the first observation of a pair-production instability. Light curves from these are very different from typical SNe. JWST can easily detect these types of supernovae at very high redshift (but not as transients), and may see a gamma ray burst at tremendous distances once in awhile. JWST would take a day or two to respond to a target of opportunity (the telescope requires an hour to slew all around the sky).

It is also expected that JWST will broaden knowledge about the birth of stars and planetary systems, life cycles of gas and dust, see cloud collapses, massive stars, and provide data on astrochemistry. In the study of planetary systems and origins of life, JWST will be able to follow up on WISE targets, providing insight into how planets and brown dwarfs form. Transiting planets, asteroids and Kuiper Belt objects (KBOs), circumstellar disks, exosolar giant planets, and satellites will also be observed. As of November 2009, there are 403 total exoplanet targets to explore. Kepler will also provide a finding chart in Cygnus, and the Transiting Exoplanet Survey Satellite (TESS) mission, if selected, will provide some brighter objects to follow up. JWST will be able to track moving targets at 30 milliarcseconds per second, thus all bright objects beyond Mars can be tracked, providing opportunities for science observations in the outer Solar System. In comparison to HST SM4 instruments JWST will have a much larger mirror to collect IR data, and its position at L2 is in a darker location than that of HST at L1.

Operations will be similar to HST operations, but JWST will not have to deal with Earth occulting. Guest observers (GOs) will get 80% of the 5-year mission. There is a new JWST advisory committee (JSTAC), international in scope, which will be replaced by a user committee once the telescope has been launched. Operations are expected to commence 6 months after launch. Dr. Mather invited APS to view relevant white papers at www.stsci.edu/jwst/science/whitepapers. The ELT-JWST Synergy Conference will be held in Garching, Germany in April 2010.

Dr. Heap asked if JWST had a diffraction-limited performance at 2 microns, to which Dr. Mather responded in the affirmative. Asked how JWST might aid in studying the origins of life, he explained that JWST can view the carbon and water distribution in the Solar System and hence, in the transit spectroscopy of exoplanets, may detect conditions that are thought to lead to supporting life. Asked about schedule, Dr. Mather reported that JWST has been successful at keeping to a tight schedule, but will have to resolve more engineering problems before a better idea of schedule margin can be obtained. Currently the mission is adhering to a 70% probability model for budget and schedule.

Asked if there were any plans to use spare mirrors, Dr. Mather reported that until launch, there are no spare mirrors. Fortunately, no components have yet been broken in testing. The primary issue will be in the spacecraft integration phase. The critical path is through the NIRCam, and generally all instruments are competing to be on the critical path. Dr. Ennico asked if the project was capturing any spinoffs to future instruments and projects, such as MIR detectors and microshutter arrays. Dr. Mather noted that HST has already used JWST detectors and associated ASICs. In answer to final questions, Dr. Mather noted that the short wavelength cutoff for JWST is 0.6 microns (the image does not have a single central peak at this wavelength), and that the plan for running key projects will be formulated in the future.

2010 SMD Science Plan

Mr. Greg Williams provided an update on the SMD Science Plan, which will follow publication of NASA's new Strategic Plan, the latter of which is published every 3 years. Anticipating the rollout of the various Decadal Survey reports, while trying to synchronize new directions from a new Administration, the Science Plan is updating the last three years and is attempting to make a limited statement about future directions pending those Decadal Survey releases. A concept draft has been developed, and will be presented at the NAC Science Committee meeting (February 16-17, 2010), with input from APS. Proposed contents include an introduction (Our Journey of Discovery), National Agenda for Science at NASA, A Plan for Science at the Frontiers, Detailed Plans by Science Area, EPO and Appendices. Common contents for science chapters are linkages to Agency goals, key science questions, and program structure. Mr. Williams requested that APS consider whether the plan as written will serve the needs of NASA stakeholders and partners (Office of Management and Budget, Congress, domestic and international partners, science community), whether the Astrophysics chapter contains necessary information, and is easy to read from a non-NASA perspective. Dr. Martin expressed concern that the Science Plan would not be useful given the current situation; i.e., pending Decadal Survey release. Dr. Heap reiterated previous APS concerns about proprietary data. Dr. Paul Hertz noted that NASA's default policy is that data is made available as it is validated, and that exceptions to this policy must be requested on a mission-by-mission basis. He professed no familiarity with SIM Lite's purported limited period of access, adding that rules are written into the AO and in agreement with the community for a policy for a particular mission. The policy is very strongly written especially for missions with international partners, and is not crafted to be Astrophysics-friendly.

Asked about any potential sensitivities, Mr. Williams suggested that APS consider the NRC/Fisk report recommendations on R&A and judge whether the Science Plan adequately reflects a balance between science and mission explanations. Dr. Ennico commented that the Science Plan didn't address the dwindling number of missions over the next decade and the preponderance of large missions; she suggested the plan elaborate on the present richness in other platforms such as suborbital programs, and focus on the future rather than the past and not on the future. Dr. Manning suggested a more proactive tone, and Dr. Huchra noted that exoplanets were conspicuously missing from future missions.

SOFIA Program Update

Note: Dr. Manning recused himself from the presentation.

Dr. Paul Hertz, Program Scientist for SOFIA, reported on the status of SOFIA, recounting the recent and successful open door testing activities. The mission has since entered the phase of aircraft testing and modification at increasing altitudes and differing angles to "clear the envelope." The SOFIA Science Project Council has reviewed the program and issued 3 findings, slim schedule margin notably among them. The program is now working on ways to increase schedule robustness and identifying items that can be worked in parallel.

SOFIA is now preparing for early science, developing just the capabilities needed for early science, followed later by developing more aggressive capabilities. A call for proposals and selections for the first phase of early science have been made. These will use the Faint Object infraRed CAmera for the SOFIA Telescope (FORCAST) imager and the German instrument, the German REceiver for Astronomy at Terahertz frequencies (GREAT). A second call for GO observations during early science will be issued this spring. Following these two developments, SOFIA will complete avionics and other systems, over a six-month downtime period, in order to ultimately support SOFIA for its 20-year program. The Council expressed concern about aircraft downtime and has asked the program to consider breaking it up. A third recommendation from the Council involves determining whether the first-generation instruments' science case is still justified. The German instrument Far Infrared Integral Field Spectrometer (FIF-LS) has been discontinued, and the project has been working with DLR on ways to complete this instrument.

Early science on SOFIA will involve 3 instruments, FORCAST, GREAT, and FIFI-LS. The remaining first generation instruments are well ahead of their need date, which will be years from now.

SOFIA's instrument suite can be upgraded and enhanced throughout the life of the laboratory. Funding for NASA selections will be available in FY12, thus planning is now underway for an FY11 solicitation. Science flight hours using SOFIA will steadily increase as all 8 first-generation instruments are commissioned and flight tests are completed.

Dr. Erick Young, USRA Science and Mission Operations Director, described the science mission operations of SOFIA. The SOFIA Program office is located at Dryden Flight Research Center, the Science Center at Ames Research Center, and science mission operations are managed by USRA/DSI. The Science Mission Operations (SMO) office oversees grants to the community, telescope operations and mission planning, the E/PO program, and integration of new instruments into the observatory, or in summary, scientific productivity. SMO is the primary interface between SOFIA and the scientific community. The German science counterpart Deutsch SOFIA Institut (DSI) will be managed in Germany and integrated with the U.S. through SMO; the counterpart will also provide staff for German activities on SOFIA. Dr. Young reviewed the organization of SMO, which is primarily populated through the USRA contractor. The SMO Director is selected by the NASA contractor (USRA) and has overall responsibility for operation of SMO. The SMO Deputy Director is selected by the DLR German contractor (DSI), who acts in place of the Director during absences and represents German interests in the

SMO organization. Advisory groups are the NASA Standing Review Board, the SOFIA Science Project Council, and the SOFIA Users Group, the latter of which provides technical advice on both hardware and software underlying mission performance.

The operating paradigm states that SOFIA is a single organization composed of both U.S. and German elements in an 80/20 partnership, with German participation at 20%. The mission is working to fully integrate both groups into this single organization. In 2008, the Science Mission Operations Review–II (SMOR-II) reviewed the mission planning and operations approach and has made recommendations to NASA that were generally received as desirable. USRA has been asked to develop plans in response to the review. Key recommendations of SMOR-II were to make data products usable to general astronomers, and to provide and support a uniform standard for PI-class instruments. NASA is working to evaluate the scope of the response. The importance of user support and archival access has also been recognized in mission planning and operations.

The SMO is currently developing a detailed pipeline/archive plan that takes into account calibration and standard formatting to ensure a usable SOFIA data set. Other near-term activities include SMO sponsorship of an instrumentation workshop in advance of a Second-Generation Instrument AO to identify key science investigations that would benefit from new instruments, helping to increase the capability of SOFIA. The workshop is planned for June 6-8, 2010 at Asilomar Conference Grounds in Monterey, CA.

The Basic Science phase (phase 2 of early science) for SOFIA is comprised of 12 flights which will be available to the community via an open Call for Proposals and 3 flights that will be available to the German science community. The mid-infrared imager FORCAST will be available (5-40 microns), as will GREAT, a heterodyne spectrometer with a range between 1.25-1.50 THz and 1.82-1.92 THz. A Call for Proposals will be released in March 2010. Basic Science flights will take place in early 2011.

The SOFIA Archive will be located at Ames Research Center, with a mirror archive at IPAC. Dr. Suntzeff asked if he had any insights into future detectors. Dr. Young reported that consideration is being given to photoconductor arrays, and very large bolometer arrays, however there is no military or commercial interest in the greater-than-30 micron wavelengths. Far-infrared focal planes at larger than 10 kilopixels may be possible but only with support by NASA centers or universities. PSD may possibly be interested in these detectors for Pluto, and for some aspects of atmospheric studies in the Solar System. Heterodyne spectrometry may also be of interest to the planetary community. Dr. Hogan asked about the impact relative to Herschel, to which Dr. Young replied that there a few unique capabilities on SOFIA. Imaging at 30-50 microns, and heterodyne observations of hydrogen deuteride, and far-IR spectrometry are areas that may be relevant. Dr. Martin inquired about the operating budget and plans for Senior Review of SOFIA. Dr. Morse noted that the mission would go to Senior Review at some point after establishment of the prime science phase (2018-20 timeframe, maybe 2016). Technology development for SOFIA will be done through both competed and directed opportunities.

<u>FY2011 Budget</u>

Dr. Morse provided details of the newly released budget. Science funding will increase substantially. Astrophysics will get about $1.1B for 2011, representing a slightly decreasing budget which turns somewhat upward after FY2011, and these numbers are basically the same assumptions that are being considered by the Decadal Survey. APD is coming to the nadir of the budget run-out, as the a number of missions in the division go from development to operations, and also reflecting the transition of GEMs to APD. The next Explorer will inject more funds into Astrophysics in future budgets. FY11 also covers a re-flight of the Orbiting Carbon Observatory (OCO), a new climate initiative for Earth Science, small augmentation to PSD for the study of NEOs, and reductions for Agency issues (APD will foot the bill for about 25% of that reduction). FY11 marks the first time in several budgets that brand-new money has been provided for science. Asked if NASA would fund LSST for NEOs, Dr. Morse replied that PSD came in with its own money to analyze WISE data for NEOs, and OMB has provided resources for additional NEO research that may involve data analysis from existing or planned ground-based observatories funded by other sources. But the question should be addressed to the Planetary Science Division.

The FY10 enacted science budget was close to the budget request, but included a $59.2 general reduction to SMD. APD's share is about $15M, which will affect the portfolio. The new budget fully funds JWST for launch in 2014, and SOFIA towards full operational capability. Funds are also available to operate HST and other operating missions. The budget Fully funds NuSTAR, Astro-H/SXS, and GEMS. Dr. Morse reiterated that APS should consider new Explorers in this light.

Major changes include augmentation of SOFIA and JWST towards 70% Joint Cost and Schedule Confidence Level (JCL), and funding for the Gravity and Extreme Magnetism (GEMS) SMEX for launch in 2014. APD also wants to grab a place in the queue for NuSTAR for an early 2012 launch. The Kepler funding augmentation in phase E was made in response to lessons learned from COROT. Herschel and Planck are now in routine science operations, and HST is performing at or above expectations post-repair. The new budget has also rebalanced future missions to support Senior Review results. R&A and suborbital payloads have been allocated steady funding at FY10 levels. Missions and grant programs have been re-phased to reduce unobligated funds and uncosted carryover. LISA, JDEM, IXO, and SIM-Lite continuations will depend on the outcome of the Decadal Survey (there are no funds in 2011). JWST launches in 2014, and SOFIA Full Operations Capability (FOC in 2014)- these items remain the same.

Budget Details
The R&A program was given $60.0M, and had requested $61.1M. Balloons have received steady funding. ADCAR (maintenance of archives), data analysis, and Senior Review funding are on an increasing line in the outyears. There is no funding for operating Explorers in 2013-15, pending Senior Review outcomes. JDEM, SIM, IXO and LISA will be similarly adjusted once the decadal survey results are known. APD budget changes include the GEMS transfer from HPD; JWST and SOFIA; an HST augmentation in 2012 for assessing operations; and internal reductions/adjustments under future missions, SR&T and management.

Dr. Morse stressed that he was structuring Cosmic Origins future missions line conservatively to adjust for recommendations from the JWST Critical Design Review, expecting that this line may be liened by JWST in the future. In addition he was trying to plan to have a robust set of future mission expectations, with real money becoming available in 2013. APD is now at its peak of its capabilities, spanning the entire electromagnetic spectrum with its operating missions. As cryogens run out on some missions and spacecraft drift away by mid-decade, there will be a reduction in operating satellites, but extensions will most likely be approved for some missions given their successful performance and scientific utility. APD will need to assess new missions and international partnerships.

Under R&A, the plan is to grow the SR&T lines in each science program and effect a modest increase in the balloon program. APD uses sounding rockets, but the infrastructure budget is held in HPD. The budget splits technology lines under each SR&T theme (Cosmic Origins, Physics of the Cosmos, Exoplanet Exploration) between core and competed activities. APD intends to support mid-TRL technology development for Explorer missions in ROSES/APRA. Any strategic future missions recommended by the Decadal Survey would be covered by the SR&T lines.

Discussion

Dr. Hanany asked how cross-cutting technologies would be developed. Dr. Morse replied that the proposer needs to figure this out and allow scientifically driven binning of ideas. Generally, details on the process are hammered out as they arise, looking across all disciplines in SMD and looking for flight opportunities where they are useful. Mr. Moore encouraged participation with technology investments in other divisions, or X-Prize type competitions. Dr. Hanany felt it critical that the new Technology fellowship would not come at the expense of R&A. There was general consensus on this sentiment. Dr. Morse noted that in such a case, one must consider that these funds may come from future mission lines. Dr. Martin asked about wiggle room for responding to Explorers proposals. Dr. Morse explained that this room would be in future mission lines, which would also require community endorsement in the Decadal Survey. Dr. Martin lamented the sobering picture and asked how mission lines might be augmented. Dr. Morse suggested providing compelling arguments related to benefits for the nation, workforce, and educational opportunities. He recommended considering the budget priorities of the President; the fact is that NASA received an increase in the face of other freezes in the federal budget. Dr. Huchra commented that as a community, Astrophysics needs to keep working to convince people of the value of Astrophysics and fundamental physics, adding that the America Competes Act lacks particle physics and other important aspects of astrophysical science.

Kepler Update

Dr. Padi Boyd, Kepler Program Scientist, gave a brief programmatic overview. Kepler was launched as a Discovery mission in March 2009. The spacecraft stares at a single patch of sky, covering 150,000 targets in its field. The mission's purpose is to observe transits of primarily sun-like stars, with sensitivity to Earth-sized planets with Earth-sized orbits. Kepler flies in an Earth-trailing, heliocentric orbit, and downloads data monthly. Monitored stars are processed on the ground for transit signatures. Kepler provides occasional full frame images, but the majority of the data are time-series sets of pixels for each target star with a 30-minute cadence.

Kepler's first light image occurred in April 2009. Shortly thereafter Kepler discovered visible emission from a known transiting planet and published the result in August 2009. The first Kepler planets (4 hot Jupiters plus a hot Neptune) were announced 8 months after the end of commissioning in January 2010. The Kepler Cycle 2 proposal deadline for Guest Observer proposals was January 2010. Kepler has been maintaining its performance and schedule. Quarterly rolls of the spacecraft have been executed smoothly, and data has been successfully downloaded and processed through the pipeline. The follow-up team was well organized in its activities to confirm exoplanet detections.

Upcoming work for Kepler includes several open anomalies that are being investigated by the Anomaly Review Team. Kepler has lost fine-point guidance 3 times. Consequently 2 stars used by the star trackers have been replaced and the mission has increased the frequency of contacts. A module that represents 5% of the instantaneous field of view (FOV) has failed. Efforts are under way to ensure the quality and completeness of the archived data, and to complete the pipeline development. Beyond exoplanets, Kepler has also obtained data on many different types of variable stars, including a dwarf nova requested by the Guest Observer (GO) office. The lifetime of the mission is dictated by amount of hydrazine fuel, and budget.

In Kepler's future, there will continue to be GO slots for non-exoplanet science, ADP program activities, and a Senior Review in 2012. Dr. Suntzeff asked why a dwarf nova would be dropped. Dr. Boyd answered that targets are dropped if they are too variable and are not likely to be planet-bearing. William Borucki (Kepler Science PI) added that the mission does not have the resources to look at everything desired and therefore concentrates on the best targets. However, GOs can look at any star they wish to and it was their decision to drop the dwarf nova.

Dr. William Borucki reviewed the instrumentation and science of Kepler. The mission uses photometry to detect Earth-size planets via a 0.95m aperture. Kepler will observe targets for several years to detect transit patterns, obtaining statistically valid results by monitoring at least 100,000 stars with a 95 million pixel detector array, and a 1.4-m primary mirror. Kepler has found a strong separation in photometric variability between dwarfs and red giants. It is expected that about 50% of dwarfs will have low enough noise to see Earth-like planets; the goal is to correct for stellar variability to so that 2/3 are useful. Kepler observations of HAT-P7 showed that, the depth of occultation is similar to that expected from an Earth-sized planet orbiting a Sun-like star proving that the instrument has the precision necessary to detect Earth-size planets. Kepler also made the first detection of light from this planet. The measured light curve near the time of occultation indicates that the star is very hot and that the shape of the star is distorted by the planet.

He reviewed the characteristics and transit light curves of Kepler's first five exoplanet discoveries. He also showed the measurements radial velocity measurements of the host stars that were used to rule out false positives and to confirm the orbital period and phase of planet, thereby confirming the planet discoveries. Kepler 7b has a density of 0.17 gr/cc, essentially that of Styrofoam; many planet densities are below theoretical predictions. In addition, Kepler 4b, has an irradiation level 800,000 times that of Neptune but has a similar mass and density. Kepler results are a major improvement over all prior observations in asteroseismology. An additional 8 months of data are now available to search for smaller, longer-period planets. Dr. Kasting asked how many Kepler targets are bright enough for radial velocity follow-up. Mr. Borucki explained that there is range of candidates, some with apparent magnitudes as large as 15 or 16, but Kepler is expected to be able to detect see super-Earths only around the brightest stars. Difference-image analysis is believed to work better than any other method and will be used in later versions of the pipeline to discern small planets. Thus far, the number of possible transit candidates is reasonably consistent with the number of Jupiter-sized planets expected from previous observations.

JDEM Update

Dr. Neil Gehrels reported on progress in the Joint Dark Energy Mission (JDEM). JDEM is designed to determine the nature of the dark energy that is driving the accelerated expansion of the universe, in a 3-5 year mission. JDEM will survey large areas in near-infrared and visible wavelengths. A precision cosmology experiment will be necessary to make an order of magnitude improvement in the Dark Energy figure of merit. The three most promising techniques for reducing the current error in this figure of merit are: baryon acoustic oscillation (BAO) (large area spectroscopic survey), weak lensing (large area imaging and photo-z survey), and type 1a supernovae (monitoring, light curves and spectroscopy). Ancillary science possible with JDEM includes orders of magnitude improvements in NIR and redshift surveys.

The JDEM experiment will benefit from its space location, allowing wide field spectroscopy of the bright H-alpha line to a z-value greater than one for BAO, and supernovae observations to better than $z > 1$. Two mission architectures were presented to Astro2010 in June 2009, and the project offices are currently studying Probe-class architectures with a cost goal of $650M plus launch services. The JDEM Probe study has been requested by NASA and DOE with varying levels of emphasis on the three techniques (two techniques are affordable at this cost range). Telescope study contracts have been awarded to ITT and Ball Aerospace to determine design feasibility.

Dr. Richard Griffiths described JDEM's mission formulation. As reported to the last APS review, an MOU is currently in place between NASA and the Department of Energy (DOE), and project offices have been established at Goddard Space Flight Center and Lawrence Berkeley National Laboratories (LBNL). There is also an oversight group at the Agency level chaired by Dr. Morse and Dr. Dennis Kovar, which are updated with weekly tag-ups. An Interim Science WG (ISWG) was formed in late 2009 and was tasked with advising agencies on JDEM, assisting projects in defining JDEM-Probe concepts, and assisting in down-selection of concepts for further development. Several JDEM-Probe concepts have preliminary cost estimates which come within the $650M cost cap. Independent Cost estimates will begin in mid- to late April 2010. The ISWG is chaired by Drs. Warren Moos and Charles Baltay, who have been traditionally funded by NASA and DOE respectively.

JDEM's future will be determined by Astro2010. It should also be noted that the ESA dark energy mission, Euclid, was recommended by ESA's Space Science Advisory Committee in Jan 2010 for consideration by the Science Programme Committee in February 2010 as a candidate for Phase-A study. At the present time, NASA/DOE and ESA are working on the respective missions independently. The current JDEM-Probe master schedule is very tight to stay within the cost cap. The time is right for JDEM; new technologies are space qualified (HgCdTe and silicon CCDs, e.g.). The mission is awaiting Decadal Survey endorsement.

Asked about the scale of Euclid, Dr. Griffiths replied that it was more Medium/Large-scale than Probe-class, about the equivalent of $1B. Most JDEM-Probe mission concepts do not include all three techniques, but the Project Offices would like to be ready for whatever options come up. CCDs are preferred for weak lensing, for its relatively small pixel sizes (needed to measure shapes of 24-25th magnitude galaxies). There is a requirement for the system PSF to be smaller than the galaxies under study, and a second requirement for the pixel sizes to be as small as the PSF. HgCdTe has pixel-size difficulties that might be solved by dithering. The problem of persistence in HgCdTe is being studied and efforts are being made to calibrate it out. Dr. Suntzeff asked if all original proposals had been dropped. Dr. Griffiths replied that the answer was yes, but the methods used in the older concepts are the same as those currently under study. Essentially, the mission studies are starting with a clean slate, including new industrial studies. Asked if NASA still considered a joint mission with ESA, Dr. Griffiths reported that discussions with ESA were initiated in late 2008 and discontinued in February 2009 because of time-phasing difficulties with the down-selection processes. There was some risk with attaching the JDEM mission to the ESA program, which was still in the process of down-selection. A similar risk was felt on the ESA side. If JDEM is rated highly by the Decadal Survey, NASA may re-open discussions with ESA. Dr. Morse noted that there is an upcoming bilateral meeting between NASA and ESA in March 2010 at which the subject could be raised.

<u>IXO Status</u>

Dr. Wilt Sanders presented on a status on the planning of the International X-ray Observatory (IXO), a facility-class mission with a well-recognized science case. Two concepts have been merged, XEUS (ESA/JAXA) and Constellation X (Con-X; NASA), as they had similar science goals but different implementation approaches. The concept was merged in 2008, after which IXO formed an internationally based Study Coordination Group, various working groups and science definition teams (SDTs). IXO awaits a recommendation from the Decadal Survey.

Dr. Jay Bookbinder detailed the science goals of IXO: studying the life cycle of black holes, large-scale structure growth, and the transference of energy within black holes, and the formation of active galactic nuclei (AGNs), among many others. IXO has the ability to characterize the extragalactic universe; determine redshift autonomously in the x-ray band; make spin measurements of AGNs to a similar redshift; and to uncover the most heavily obscured, Compton-thick AGN, out to a z-value of 9. IXO will use the relativistic iron/potassium line to determine black hole spin, and will also be able to characterize missing baryons. Starburst superwinds are thought to be a major contributor to intracluster and intergalactic metals; the IXO spectra will measure velocity, abundances, etc., of these starbursts.

The mission payload includes a wide field camera and hard x-ray imager, microcalorimeter spectrometer, grating spectrometer, polarimeter and a high time resolution spectrometer. Compared to XMM and Astro-H, IXO's effective area increase is several orders of magnitude better. The mission also represents a comparable improvement over XGS (300-400X) in spectroscopic sensitivity. NASA's concept of IXO is that of a moveable instrument platform. Components on both the ESA/JAXA and NASA concepts are at TRL 6 or higher. A decision must be made in 2012 on how the components will be divided between agencies. For the mirror assemblies, NASA uses segmented glass, while ESA uses silicon micropores. Both concepts are making process. For the glass segments, the resolution is now down to 7.5 arcsec (need to be at 3.3 arcsec for IXO requirements). Both active and passive approaches are being considered for glass mounting and alignment improvements; TRL 4 should be reached this Spring on alignment and bonding efforts. The ESA approach of stacking silicon pore optics slabs can be hindered by dirt between the layers, propagating error. Better cleaning in this area has led to just under 10 arcsec resolution.

The x-ray microcalorimeter is progressing toward TRL5 this Spring. A 32 x 32 flight-like core array has been built, and FOV-extending larger pixel designs are being developed and tested. Both sides are developing mission definition requirements and instrument phase A studies; efforts will be combined in a "Yellow Book" to be presented to ESA in September 2010. Dr. Bookbinder noted that the critical path goes through the optics, and that the estimated phase BCD schedule has turned out to be conservative.

The future IXO mission will bring a factor-of10 gain in telescope aperture and a 100-fold increase in throughput for high resolution spectroscopy. Dr. Townsley noted that IXO would be an observatory-class mission, essentially the x-ray version of JWST, and would thus serve a large community. Dr. Suntzeff commented that JDEM seems to be blind to the fact that x-ray study of clusters is the fourth method for discerning dark energy, and asked whether IXO had had discussions with JDEM. Dr. Bookbinder replied that the techniques were very different for the two missions, however he felt that a sufficient number of white papers on the subject had been submitted to the Decadal Survey for consideration. Dr. Morse agreed that the Survey should weigh in on the approach, while the independence of x-ray measurements through IXO is also very important. The total cost of the mission has been estimated at $1.6B in FY09 dollars, for a total of $3.6-3.7B.

Discussion

Dr. Morse asked to have comments on the SMD Science Plan emailed to Dr. Hasan. Dr. Ennico suggested that the SR&T program create a bridge for Astrophysics payloads between the suborbital program and getting rides on foreign rockets, perhaps competing for prizes or using commercial suppliers to support technology for Astrophysics in general and support for the workforce. Dr. Morse agreed to formulate a presentation on peapods, cubesats, and payloads on ISS, for consideration at the next meeting. Dr. Polidan remarked that the SALMON opportunity could be an example of how entrepreneurial NASA wants to get.

The subcommittee briefly reviewed Dr. Huchra's one-page output on the Van Allen Early Career Fellowships. Dr. Hogan agreed to distribute further contributions to the Fellowship language. No public comments were noted. Dr. Hogan adjourned the meeting.

Appendix A
Attendees

Subcommittee members
Craig Hogan, University of Chicago, Fermilab, *Chair Astrophysics Subcommittee*
Arjun Dey, NOAO
Kimberly Ennico, NASA Ames
Kathryn Flanagan, STScI
Shaul Hanany, University of Minnesota
Sara R. Heap, NASA Goddard Space Flight Center
John Huchra, Harvard University
John Hughes, Rutgers University
James Kasting, Pennsylvania State University
Fred K.Y. Lo, National Radio Astronomy Observatory
James Manning, Astronomical Society of the Pacific
Chris Martin, California Institute of Technology
James Manning, Astronomical Society of the Pacific
Ronald Polidan, Northrop Grumman Space Technology
James Rhoads, Arizona State University
Nicholas Suntzeff, Texas A&M University
Leisa Townsley, Pennsylvania State University
Hashima Hasan, APS Executive Secretary, NASA Headquarters

NASA Attendees
Jaya Bajpayee, NASA Headquarters
Padi Boyd, NASA Headquarters
Joan Centrella, NASA Headquarters
Holly Degn, NASA Headquarters
Michael Devirian, NASA JPL
Richard Griffiths, NASA Headquarters
Ilana Harris, NASA Headquarters
Paul Hertz, NASA Headquarters
Cuong Huynh, NASA Headquarters
W. Vernon Jones, NASA Headquarters
Chryssa Kouveliotou, NASA MSFC
Thierry Lanz, NASA Headquarters
Lia LaPiana, NASA Headquarters
David Leisawitz, NASA Headquarters
John Mather, NASA Headquarters
Robin Stebbins, NASA GSFC
James Marr, NASA JPL
Michael Moore, NASA Headquarters
Jon Morse, NASA Science Mission Directorate, *Director Astrophysics Division*
Marian Norris, NASA Headquarters
Mario R. Perez, NASA Headquarters
Tom Prince, California Institute of Technology/JPL
Michael Salamon, NASA Headquarters (teleconference)
Wilton Sanders, NASA Headquarters
Vernon Jones, NASA Headquarters

Felicia Jones-Selden, NASA Headquarters
Mike Shao, NASA JPL
Eric Smith, NASA Headquarters
Linda Sparke, NASA Headquarters
Robin Stearns, NASA GSFC
Stephanie Stockman, NASA Headquarters
Jean Swank, NASA GSFC
Wes Traub, NASA JPL
Ray Taylor, NASA Headquarters/SMD
Greg Williams, NASA Headquarters

<u>Other Attendees</u>
Jay Bookbinder, SAO
Dom Conte, General Dynamics
Randy Cornell, Ball Aerospace
Lamont DiBiasi, DiBiasi Associates
Don Kniffen, USRA
Anita Krishnamurthi, AAS
Dan Lester, University of Texas
Stephen Merkowitz, OSTP
Ken Sembach, STSci
Denise Smith, STSci
Randall Smith, SAO
Joan Zimmermann, Harris Corp.

<u>Webex</u>
Jennifer Wiseman, NASA GSFC
Peter Roming, PSU
Stephen Unwin, NASA JPL
Michael Turner, University of Chicago
Michael Bicay, NASA ARC
Harvey Tannenbaum, SAO
John McCarthy, Orbital Sciences Corporation
Marie Levine
Moshe Pniel
Peter Priggon, NASA HQ/Lockheed
Robert Lockwood
William Borucki, NASA Ames
Kathy Turner, DOE

Appendix B
NAC Astrophysics Subcommittee Membership

Craig J. Hogan, Chairman
Fermilab
University of Chicago

Arjun Dey
National Optical Astronomy Observatory

Kimberly Ennico
NASA Ames Research Center

Kathryn Flanagan
Space Telescope Science Institute

Shaul Hanany
University of Minnesota/Twin Cities

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

Sara R. Heap
Goddard Space Flight Center/NASA

John Huchra
Harvard-Smithsonian Center for Astrophysics
Harvard University

John (Jack) P. Hughes
Rutgers University

James F. Kasting
Pennsylvania State University

Fred K.Y. Lo
National Radio Astronomy Observatory

James G. Manning
Astronomical Society of the Pacific

Chris Martin
California Institute of Technology

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

Leisa Townsley
Pennsylvania State University

Appendix C
Presentations

1. *Astrophysics Division Update*, Jon Morse
2. *PhysPAG/CORPAG Update*, Michael Salamon/Eric Smith
3. *Astro2010 Decadal Survey Update*, John Huchra
4. *LISA Update*, Michael Salamon/Tom Prince
5. *ExoPAG Update,* Doug Hudgins/Jim Kasting
6. *Van Allen Early-Career Technology Fellowship Update*, Chris Martin
7. *R&A/SR&T Program Update*, Linda Sparke/Mike Moore
8. *SIM Update*, Lia LaPiana/Wes Traub
9. *JWST Update*, Dan Blackwood/John Mather
10. *2010 SMD Science Plan*, Greg Williams
11. *SOFIA Update*, Paul Hertz/Erick Young
12. *Astrophysics Division Budget Update*, Jon Morse
13. *Kepler Update*, Padi Boyd/William Borucki
14. *JDEM Update*, Richard Griffiths/Neil Gehrels
15. *IXO Update*, Wilt Sanders/Jay Bookbinder

Appendix D
Agenda

Agenda		
Astrophysics Subcommittee		
February 2 – 3, 2010		
NASA Headquarters Room 8R40		
Tuesday 2 February		
8:45 a.m.	Introduction and Announcements	Craig Hogan
9:00 a.m.	Astrophysics Division Update	Jon Morse
10:00 a.m.	Update on recommendation items from October ApS meeting	Craig Hogan
10:15 a.m.	PhysPAG/CORPAG Update	Michael Salamon/Eric Smith
10:30 a.m.	Break	
10:45 a.m.	Decadal Update	John Huchra
10:50 a.m.	LISA Update	Michael Salamon/Tom Prince
11:35 p.m.	Working Lunch	
12:30 p.m.	ExoPAG Update	Doug Hudgins/Jim Kasting
1:30 p.m.	Technology Fellowship Update	Chris Martin
2:00 p.m.	R&A/SR&T program Update (Part I)	Linda Sparke/Mike Moore
2:45 p.m.	Break	
3:00 p.m.	R&A/SR&T program Update (Part II)	Linda Sparke/Mike Moore
3:30 p.m.	SIM Update	Lia LaPiana/Wes Traub
4:15 p.m.	Discussion and Public Comment Period	
4:45 p.m.	Wrap up of Day 1	Craig Hogan

5:00 p.m.	Adjourn	
Wednesday 3 February		
8:30 a.m.	Re-cap of Day 1	Craig Hogan
8:50 a.m.	JWST Update	Dan Blackwood/John Mather
9:35 a.m.	2010 SMD Science Plan	Greg Williams
10:05 a.m.	Break	
10:15 a.m.	SOFIA Update	Paul Hertz/Erick Young
11:00 a.m.	Astrophysics Division Budget Update	Jon Morse
12:00 p.m.	Working Lunch	
12:30 p.m.	Kepler Update	Padi Boyd/William Borucki
1:00 p.m.	JDEM Update	Richard Griffiths/Neil Gehrels
1:45 p.m.	IXO Update	Wilt Sanders/Jay Bookbinder
2:30 p.m.	Discussion and Public Comment Period	
2:45 p.m.	Wrap-up, Recommendations, Actions	Craig Hogan
3:00 p.m.	Brief to Morse	Craig Hogan
3:15 p.m.	**Adjourn**	