NASA ADVISORY COUNCIL

ASTROPHYSICS SUBCOMMITTEE

April 12, 2010

Telecon/Webex

MEETING REPORT

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Alan Boss, Chair

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Hashima Hasan, Executive Secretary

Table of Contents

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Harris IT Services Corp.

April 12, 2010

Dr. Hashima Hasan opened the telecon/webex meeting at 2:00 PM EST, noting that the meeting was being recorded.

Dr. Alan Boss, Chair of the Astrophysics Subcommittee (APS), called the meeting to order, and called the subcommittee roll, asking members to state whether they had either personal or institutional conflicts. Drs. Alan Boss, Ron Polidan, John Huchra, Leisa Townsley, and Steven Ritz mentioned their affiliations with NASA missions. It was determined that Dr. Alan Boss should recuse himself from the discussion of the Kepler mission. No conflicts for the other members were identified for this meeting.

Astrophysics Division (APD) Update

Dr. Jon Morse, Director of APD, announced the *new subcommittee members*: Drs. Alan Boss, Louis Allamandola, Mary Beth Kaiser, Vicky Kalogera, and Steven Ritz. He provided a status of the Division. As a demonstration of the spectacular data being returned from Astrophysics Division missions, he presented science highlights which included photos of Brown Dwarf Star 2MASS J044144 and its planetary-mass companion (Hubble Space Telescope); HIFI spectrum of water and organics in the Orion nebula (Herschel); infrared image of the Orion nebula (Spitzer-Warm mission); radio galaxy Centaurus A (Fermi); Berkley 59 cluster (WISE).

Studies/Reviews in Progress

A Senior Review of operating missions —RXTE, GALEX, INTEGRAL, XMM-Newton, Suzaku, Swift, Spitzer, Chandra, Planck, WISE, and WMAP - was held the previous week. A report will be delivered in May 2010, on the basis of which APD will prioritize and develop an implementation approach for 2011 and 2012 with initial guidelines for 2013 and 2014 for the best portfolio with restricted funding.

A report of *Astro 2010,* the National Research Council's (NRC's) Astronomy and Astrophysics Decadal Survey (Roger Blandford, chair) is expected late summer 2010. A letter has been sent to Dr. Ralph J. Cicerone, National Academy of Sciences (NAS) president, about the timely release of the report so NASA can react to it and incorporate results into this budget cycle; and a letter to *Astro 2010* authors describing potential partners on the European Space Agency (ESA) Cosmic Vision M-class mission candidates Euclid and Plato.

A recently released NRC study, *NASA's Suborbital Research Capabilities* (Steven Bohlen, chair), recommends incorporating new technology.

Potential Partnerships on ESA's Euclid and PLATO Missions

ESA completed a down-selection phase of the Cosmic Vision process: M-class finalists were, Euclid (map geometry of the dark universe), Plato (bright nearby stars, looking for transit and to study the host stars; 2018 launch), and Solar Orbiter (2017 launch). ESA invited NASA to discuss possible partnerships for the first 2 at the joint NASA/ESA meeting March 23–24, 2010. ESA will select 2 of the 3 missions for implementation; their decision is scheduled for June 2011.

ESA is looking for a contribution of 20% of the total mission value (in the €100 million range, similar to Herschel). They seek opportunities to contribute in payload, the science mission, ground segment, launch segment, data processing, and calibration. There is a possibility of U.S. contribution through the member states proposing to the ESA announcement of opportunity (AO). All data, consistent with previous partnerships (e.g., Hubble), will be archived and made available to the scientific community. Euclid offers options to conduct additional surveys and guest observer investigations after the primary weak lensing (WL) and baryon acoustic oscillation (BAO) surveys are completed. That will be studied during the definition phase. Techniques for dark energy research could also be contemplated.

The United States could contribute in 3 ways:

- Scientific investigations and payload or instrumentation contributions competitively selected through an open NASA-sponsored AO shortly after the release of the Decadal Survey; or
- Non-payload space vehicle or mission components, e.g., spacecraft subsystems or ground- or launch-segment contributions to be provided by the appropriate NASA program; or
- Additional U.S. scientific or institutional contributions (not funded by NASA) to European-led proposals selected via the ESA AO process.

For U.S. participation in mission optimization studies, ESA will send 2 scientists per study team to guide concept development and ensure consistency with mission science goals, and those scientists would be eligible to submit proposals. At the same time, NASA engineering support will guide concept development and identify niches for NASA-contributed hardware and ground support; these engineers are not eligible to submit. NASA will receive the *Astro 2010* decadal survey recommendations before committing to contributing to the Euclid and Plato missions (so noted in the letter to ESA).

In summary, JDEM, SIM, and other scientifically related efforts will continue with FY2010 activities as planned. Each partnership is affordable within projected resources at mid-decade. A clear path to paying for such partnerships is necessary, an issue we will return at the next meeting.

Discussion

The ESA cap for Euclid and Plato totals some €475 million or more. The Department of Energy (DOE) could participate in Euclid by competing in the NASA-sponsored AO, which is open to all categories of organization. DOE could also pursue their own contributions with European member states propsing to the ESA AO.

Dr. Huchra said that we should proceed with caution since the Decadal Survey is expected to provide advice on both dark energy and exoplanet initiatives. Dr. Morse stated that this framework was laid out by ESA through its Science Programme Committee (SPC) and agreed to at the NASA-ESA bilateral meeting in March. He noted that he suggested that the Decadal Survey may want to contact ESA directly regarding any potential partnering arrangements that may be assumed based on inputs from a year ago.

Kepler Presentation and Discussion

Dr. Alan Boss recused himself from the discussion at this point and handed over the meeting Chairmanship to Dr. John Huchra for this part of the meeting.

Summary of Kepler Request for Extension of Data Proprietary Period : Data Policy

Dr. Doug Hudgins, Kepler Program Scientist, presented a background of the Kepler data policy and the Program Scientist's perspective of the request of the Kepler project for an extension of the data release date. Under the current policy all Q1 data for all 156,000 stars are scheduled for release June 2010; Q2 data, June 2011; Q3 and Q4 data, June 2012; Q5 and Q6 data, June 2013; and all remaining Q7–Q14 data, November 2013. This policy has been labele "Option 4" by the Kepler project, which has has proposed three other options that would allow better and more critical analysis of the data:

1. Option 1: The end of mission (EOM) scenario. Data for most of the target stars would be released as scheduled, but the science team would identify and withhold data on as many as 500 objects of interest and be given more time to validate their observations, i.e. as many as 400 items of interest and as many as 100 Kepler objects of interest from the Q2 release. These 500 (or fewer) would be released when verified or at the end of the mission (2013).
2. Option 2: Intermediate scenario. Most data would be released as scheduled, but investigators could withhold as many as 400 Q1 and 100 Q2, which would be released December 31, 2011, regardless of follow-up status.
3. Option 3: Minimal scenario. The science team would select as many as 400 Kepler objects of interest from the Q1 release, which would be released February 1, 2011, regardless of status; and 100 Kepler objects of interest from the Q2 data release, which would be released February 1, 2012, regardless of follow-up status

Request to Increase the Proprietary Release of Kepler Data Policy: Project

Dr. William Borucki, Kepler Principal Investigator, presented the Project's rationale for requesting a change in the data release policy for Kepler. Current policy calls for the release all 156,000 target objects on June 15, 2010. The problem is that the schedule does not allow the time necessary to validate candidate planets. The late launch date and the long commissioning period delayed the start of observations, and to confirm these planets, mission scientists need ground-based observations. One full season is May to September, but those data must be followed-up and the false positives identified, and that time was not available before the star field set. Furthermore, the original data-processing pipeline could not handle the idiosyncrasies of real on-orbit data and the unexpected number of false positives so, much of the newly processed data has not been reviewed by the science team. Each candidate is validated using active optics, An example was shown to actually be 2 stars. Thus, a comprehensive validation procedure is critical to reliable announcements of discoveries. Data release on June 15 will produce a less reliable exo-planet catalog, damage mission credibility, and detract from the precedence of the competitively selected science team.

The solution is to change the data release policy to allow sufficient time to validate planetary candidates and announce them in a peer-reviewed journal to provide a reliable catalog of exo-planets. Use of a longer time series and proper inclusion of follow-up observations will allow publication of high quality papers, minimize spending mission resources to confirm or debunk erroneous claims, maximize

efficient use of resources by avoiding duplication of effort, and preserve the precedence of the competitively selected science team.

To validate the data stream, the team needs: a signal-to-noise ratio (SNR) greater than 7 sigma to rule out statistical fluctuations; 3 or more transits to confirm orbital periodicity; light-curve depth, shape, and duration; and centroid motion to identify and reject background stars. They team must be able to recognize astrophysical events that mimic planetary transits: use radial velocity (medium precision to rule out stellar companions, high precision to confirm discovery or place upper limits on masses, and R-M effect to confirm orbiting planets); high spatial resolution imaging to identify extremely close background stars, and spectral analysis and modeling to detect bends due to hierarchical multiple stars. If you do not have the size of a star, you do not have the size of a planet. Therefore the team must get spectra for each star and derive their size. Uncertainty of each discovery is assigned based on the abundance of background eclipsing binaries.

For planets of greatest interest, ground-based follow-up requires many months to several years of observation, and follow-up observation can only be conducted during summer when the star field is not behind the Sun. Modeling the totality of data for each candidate takes a long time. A single test can be done in a few days, but then the statistical validity of the results must be established which takes several weeks to a month. Furthermore, only limited amounts of telescope time are available for follow-up observations. Telescope time is needed on a series of telescopes to make AO, speckle, and radial velocity observations. Hubble Space Telescope (HST) and Warm-Spitzer observations are also very important, but are available sparingly and observations from both are not yet available. A fair number of objects are triple stars containing eclipsing binaries. Time is also needed for analysis of follow-up observations, modeling of combined results of many different types of observations, and writing papers. Confirmation of small planets in multiple-planet systems by the timing method requires long periods with dozens or hundreds of transits.

The current amount of telescope time should be sufficient for the discovery of 30 or 40 objects this summer; the team will validate the remaining candidates in the coming seasons. Arrangements for Keck time are made through the Astrophysics Division, and for both HST and Warm-Spitzer are made through regular peer review. Observations are being made with the Hobby-Eberly Telescope (HET), which was undergoing refurbishment last season. HET generally can find the field twice each night, so efforts are being divided between the 2 telescopes. More time is needed for observation and analysis because it is a major piece of what is needed to confirm this large number of candidate planets. In addition, the radial velocity (RV) of smaller planets is difficult to measure because they interact with each other and the transit times differ. For a dozen or so objects, the mass will be determined after a year or 2 of data have been collected.

The data release policy (section L.7.6.1. Data Rights and Release Policy of the Concept Study Report) is in accordance with the Discovery Program. There is no period of proprietary data rights for Kepler. The data release schedule was made up prior to launch, and after launch, dates were plugged in. Kepler science analysis is performed on contiguous 3-month data sets. While the next 3-month data set is being acquired, the prior set is being calibrated, processed, annotated, and archived. The archive volumes will be transferred to the Kepler archives at the Kepler Data Management Center (DMC), which will make them available to the science community.

The matter of the early release of data has been discussed with Headquarters, where they recognized the importance of not announcing false positives. Kepler is now a strategic mission, a designation applicable to finishing the development and launch, relevant to phases E and D. Q0 data taken during the first 43 days showed many candidates, but most were false positive events.

Option 1, which Dr. Borucki favors, would postpone the release of 500 objects of interest until the team can make a reliable determination of what they are, while releasing data on all the other 155,500 objects. This option allows time needed to determine reliable values of number and characteristics of the planets detected. They expect about half to be false positives. In an efficient use of resources, currently 10 moderate-aperture telescopes are used to identify and characterize each star and to recognize false positives prior to using HET and Keck to confirm whether they are planets. These telescopes do reconnaissance spectrometry and speckle interferometry, and use active optics to identify stellar companions and background eclipsing binaries. Discoveries will be published as quickly as the objects are confirmed. This option is consistent with the earlier request to Dr. Morse.

Option 2 would keep back data on the 500 Kepler objects of interest for 2 years and release all data by February 2012.

Option 3 would keep data for 8 months (until February), allowing 20 to 30 planets to be confirmed during the summer of 2010.

Option 4 is no change in policy.

At the *Exoplanets Rising* meeting, March 29, 2010, some participants stated that releasing unreliable data merely confuses the issue. Data should be released after papers have been submitted. Keck data will always be released about a year after Kepler data, an improvement over the current protocol of releasing all data after 18 months.

In sum, the Kepler science team requested a postponement of data release for as many 500 of 156,000 stars that will be released on June 15, 2010. Data on those 500 will be released as soon as possible. This will provide the most efficient use of resources and equipment and would preserve scientific precedence.

Dr. Hudgins summarized strengths and issues of each of the proposed options:

Option 4 strengths:

- It is most consistent with other Astrophysics missions, although it deviates from a 6- to a 12-month standard.
- It avoids establishing a precedent for modifying future approved mission data release policies.
- It incentivizes the Kepler team to publish their candidates.
- It allows the largest number of scientists to access and follow up all Kepler data as soon as possible.

Option 4 issues:

- There is a disconnect between AO policy and criteria of 4 transits to verify planets.
- Follow-up observations are essential.

- It dilutes validated exoplanet–Earth discovery announcement and places the Kepler team in competition with the community.
- It risks chaos in the field.
- Shortcuts could lead to incompletely vetted discoveries and damaging high-visibility retractions.

Option 1 strengths:

- It provides the maximum protection for the mission's credibility.
- It maintains a quality control standard for follow-up.
- It protects the precedence of the science team and NASA.
- The vast majority of science data is released to the community according to the established data release policy.

Option 1 issues:

- It establishes precedent for allowing significant modifications to approved data release policy very late in the process. (However, it was noted that the terms for COBE data release were renegotiated, as were they for the Derby instrument. But, those are not very similar issues.)
- It removes motivation for the team to publish as quickly as possible—lack of competition removes urgency.
- It represents an unprecedented variance to established data release policy.
- The broader science community gets no guaranteed access.
- It sequesters data on the basis of its potential scientific content, not on the basis of quality issues.

Option 2 strengths:

- It is not inconsistent with past practice.
- It provides the science team with 2 additional observation seasons for ground follow-up.
- It improves the reliability of the Kepler science team's results from Q0/Q1 Kepler objects of interest.
- It protects the credibility of the Kepler mission.
- It protects the precedence of the science team.

Option 2 issues:

- It sequesters data on the basis of it potential scientific content, not on the basis of quality issues.
- It varies significantly from established Astrophysics Division data release policy missions.
- It establishes precedent for allowing significant modifications to approved data release policy very late in the process.

Option 3 strengths:

- It is not inconsistent with past practice.
- It provides the science team with 1 additional ground observation season for the 2 first quarters.
- It improves reliability.
- It protects the credibility of the Kepler mission.
- It offers modest protection for precedence.

Option 3 issues are the same as for option 2.

Discussion

Dr. Huchra led the discussion by commenting that much has been learned since Kepler selection about the importance of follow-up observations. He re-stated that the charge to the committee is to offer guidance in weighing the various factors and defining the data release policy that best supports the science goals of the Kepler mission. Everyone wants to do what is best for the mission and best for the science. Does releasing results with caveats about false positives constitute half-baked science, especially given the historic nature of discoveries anticipated?

In response to a question on the size of the science team, Dr, Borucki responded that the team consisted of 28 people on the formal science team and another 25 who do data reduction and data archiving. Others do mission operations and scheduling. The scientists are fully supported, either part-time or full-time, until end of mission. However, some are only supported to come to meetings and function as advisors. While acknowledging the importance of false positives, a member asked if withholding 400 candidates eliminate this risk. Dr. Borucki stated that data would be released if the object proved to be a false positive. Certainly there are false positives in the 155,000 objects not withheld, and there will be some candidates among them. If the team found new transiting planets, they would also like to hold them back. A transit signature consistent with an Earth-like makes an object an active candidate; but that may still be a false positive. An object must be a candidate to be a false positive. The team would just be keeping back the candidates that have a reasonable chance of being planets, and the easier and larger ones will be confirmed this summer. The smaller ones and the ones with only 1 transit will take at least another season or longer. All of the objects with larger velocity will be fully validated or rejected by the end of mission,

A Kepler users' group is now being formed. A user group would like to use all the different data in various ways, which would be available to them through ADP (Astrophysics Data Program). There will be a wide variety of people, so a user group will be a big help.

The program has been reviewed extensively, including a series of reviews leading to launch, and a management review this past fall. Mission protocol for operations is well set and performs well. Increasing mission duration to find more small planets in long-period orbit is the only thing that would change. Continuing beyond 3 years would maximize the ability of the mission. Launch delay affected the observing program, so telescopes to do the necessary observations may not be available. Additional observers on the team would help get the needed follow-up observations, but if data are to be released in 2 months it is too late to add people for this year. It would, however, be helpful to revise the scheduling of telescope use to get more time by June 15, 2010. Many objects are dim and take more time, and the team would like reliable observations for all these targets.

Precedent might be found in WMAP in which data were sequestered until a few full sky surveys could be obtained. Data release usually relates to how data are obtained, not to scientific content. Data requested to be sequestered are deliberately selected, not random; eventual outcome may not be known yet.

Public Comment

Dr. Kouveliotou asked what was the most significant science result that could be obtained from the released data (excluding the sequestered data.) Dr. Borucki said most important objects/phenomena are likely to be those not seen before e.g., structure and ages of unusual stars.

Recommendation on Kepler Data Release

Dr. Huchra asked committee members to choose among the 4 options and explain their choice.

Discussion raised the following points:

- Kepler has done a wonderful job and needs time to validate, but that should be a national effort. Much can be gained by bringing in rest of community.

- Some thought should be given to the amount of time the principle investigator's team put into it.

- Options 1 and 2 represent a fundamental change. Competition is healthy and will bring in other resources. Duplication of efforts should be reduced.

- The process should be more open than it has been. Science is the process of discovery, and bringing the public along is a teaching exercise. The 2-month delay in launch is unfortunate, but full validation will take years.

- Rushing to publish will result in false positives, but option 1 is too restrictive.

- The objects were presented as either a planet or a false-positive. A way around this is to present each as a figure of merit or a probability based on ground-based data, so the conclusion changes as data come in.

- The justification is not sufficient to break with precedent. However, the issue of credibility is very important. Option 3 creates a precedent but does not give the time needed. Option 1 does not give the urgency deserved.

- False positives should be minimized.

- Analysis of infrared spectra illustrates the amount of time needed. Option 4 would do immeasurable damage to NASA and science. If the first few turn out to be false positives, it will take years to recover.

- If a launch is delayed, it is logical to delay reporting of observations. But who is waiting for the data on June 15? If the data release is delayed, it should be reviewed by people experienced in

this field to know whether extending the timeline increases the chance of getting the desired result.

- The data release schedule should be related to the launch; 155,000 objects will be released, which is a lot of data that are not the risky targets.

- The big issue seems to be tied to how to deal with people publishing strange interpretations of whatever data are available.

The final vote was: 7 members for option 3; 4 for option 4; and 1 for option 2. Hence, the group reached consensus between option 3 and 4.

Wrap up, Recommendations, & Actions

Dr. Huchra summed up the Kepler discussion and the recommendation for adopting option 3, stating that the delay in release should be appropriate to delay in the launch. He handed back charge to Dr.Boss, who adjourned the meeting.

Appendix A: Attendees

Subcommittee members
Alan Boss, Carnegie Institute of Washington; *Chair, Astrophysics Subcommittee*
Louis Allamandola, NASA Ames Research Center
Shaul Hanany, University of Minnesota
Hashima Hasan, NASA Headquarters, *Executive Secretary, Astrophysics Subcommittee*
Sara R. Heap, NASA Goddard Space Flight Center
John Huchra, Harvard University
John Hughes, Rutgers University
Mary E. Kaiser, Johns Hopkins University
Vicky Kalogera, Northwestern University
James Kasting, Pennsylvania State University
Ronald Polidan, Northrop Grumman Aerospace Systems
James Rhoads, Arizona State University
Steven Ritz, University of California, Santa Cruz
Leisa Townsley, Pennsylvania State University

NASA Attendees
Michael Bicay, NASA Ames Research Center
William Borucki, NASA Ames Research Center
Padi Boyd, NASA Goddard Space Flight Center
Michael Fanelli, NASA Ames Research Center
Jens Feeley, NASA Headquarters
Thomas Gautier, Jet Propulsion Lab
Richard Griffiths, NASA Headquarters
Mike Haas, NASA Ames Research Center
Ilana Harrus, NASA Headquarters
Paul Hertz, NASA Headquarters
Douglas Hudgins, NASA Headquarters
Cuong Huynh, NASA Headquarters
Chryssa Kouveliotou, NASA Marshall Space Flight Center
Thierry Lanz, NASA Headquarters
Lia LaPiana, NASA Headquarters
David Leisawitz, NASA Headquarters
Jack Lissauer, NASA Ames Research Center
Jon Morse, NASA Science Mission Directorate, Director Astrophysics Division
David Morrison, NASA Ames Research Center
Michael Moore, NASA Headquarters
Mario R. Perez, NASA Headquarters
Moshe Pniel, Jet Propulsion Lab
Michael Salamon, NASA Headquarters
Wilton Sanders, NASA Headquarters
Charles Scott, Jet Propulsion Lab
Martin Sistilli, NASA Headquarters
Marcy Smith, NASA Ames Research Center
Charlie Sobeck, NASA Ames Research Center

Linda Sparke, NASA Headquarters
Stephen Unwin, Jet Propulsion Lab

Other Attendees
Rachel Akeson, NHSI
Linda Andruske, Legislative Affairs
Natalie Batalha, San Jose State University
Kimberly Bridgman, Office of Science and Technology Policy
Jack Burns, University of Colorado
Randall Correll, Ball Aerospace
Edward Dunham, Lowell Observatory
Alan Gould, University of California–Berkeley
Eric Hand, *Nature*
Dan Lester, University of Texas
Micheal Levi, Lawerence Berkley National Labs
Kevin Marvel, American Astronomical Society
Phip Puxley, National Science Foundation
Matthew Scudder, Boeing
Jason Steffen, FermiLab
Winfield Swanson, Harris IT Services Corp., *rapporteur*
Michael Turner, University of Chicago
Jim Ulvestad, National Science Foundation

Appendix B: NAC Astrophysics Subcommittee Membership

Alan Boss, Chairman
Carnegie Institute of Washington

Louis Allamandola
NASA Ames Research Center

Arjun Dey
National Optical Astronomy Observatory

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

Mary E. Kaiser
Johns Hopkins University

Vicky Kalogera
Northwestern University

James F. Kasting
Pennsylvania State University

James G. Manning
Astronomical Society of the Pacific

Chris Martin
California Institute of Technology

Ronald S. Polidan
Northrop Grumman Aerospace Systems

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

Steven Ritz
University of California, Santa Cruz

Leisa Townsley
Pennsylvania State University

Appendix C: Presentations

1. *Astrophysics Division Update*, Jon Morse
2. *Kepler Data Policy*, Douglas Hudgins/William Borucki

Appendix D: Agenda

Agenda		
Astrophysics Subcommittee		
April 12, 2010		
Telecon/Webex		
2:00 p.m.	Introduction and Announcements	Alan Boss
2:05 p.m.	Division Update	Jon Morse
2:35 p.m.	Discussion	Alan Boss/Subcommittee
2:50 p.m.	Kepler Data Policy—HQ	Doug Hudgins
3:05 p.m.	Kepler Data Policy—Project	William Borucki
3:50 p.m.	Discussion	John Huchra/Subcommittee
4:20 p.m.	Public Comment Period	John Huchra/Alan Boss
4:30 p.m.	Recommendation on Kepler	John Huchra
4:35 p.m.	Wrap up, Recommendations, Actions	Alan Boss
4:45 p.m.	Brief to Jon Morse	Alan Boss/John Huchra
5:00 p.m.	Adjourn	