Issues in Physics & Astronomy at the BPA

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Particles, Physics, and Paths Ahead

David B. Lang, NRC Staff

Today, the U.S. particle physics program is at a crossroads. Researchers have worked for decades to uncover the intricacies of the subatomic world to better understand how the universe fits together. These tremendous efforts have yielded a working model of interactions between elementary particles and three of the four forces (known as the Standard Model) that have guided investigations. But as researchers approach the Terascale—a level of energy out of reach of the current world-leading accelerator at Fermilab—the Standard Model becomes incomplete. It is with the exploration of these energies that particle physicists expect to discover exciting new science, new particles, and perhaps reconcile the twin pillars of 20th-century physics—the theory of quantum mechanics and the theory of general relativity.

While innumerable scientific opportunities sit just out of arm's reach, the United States has positioned itself for disinvestment in research at the forefront of humanity's understanding of the cosmos. The Tevatron at Fermilab is scheduled for shutdown by the end of the decade, and facilities at Stanford Linear Accelerator Center (SLAC) and Cornell University will be converted to other uses. And with new facilities soon opening at the European Center for Nuclear Research (CERN) in Europe and the High Energy Accelerator Research Organization (KEK) and the Japanese Proton Accelerator Research Complex (J-PARC) in Japan, the intellectual center of gravity has already begun to move overseas. In addition, the U.S. efforts in this field lack a coherent, strategic direction, slated to continue on an incremental "business-as-usual" path.

It is at these initial conditions that the National Research Council's Elementary Particle Physics in the 21st Century Committee found the U.S. program. Indeed, for a committee to offer a new vantage point for observing the scientific potential for the field (and from that to recommend an actionable and logically organized set of recommendations to construct a 15-year plan), it would need to credibly analyze, and even challenge, the field of particle physics on a tenet it had taken for granted: that particle physics is especially exciting and an important priority for the nation.

To undertake this difficult task, the National Research Council (NRC) formed a committee that was only half-comprised of particle physicists (including one each from Europe and Japan). Chaired by Harold T. Shapiro, president emeritus and professor of economics and public affairs at Princeton University, the committee also included experts from within condensed-matter physics, medicine, science policy, engineering, and astrophysics. Rather than finding new ways to repeat the same analyses of the state of the

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In this issue:

Survey of Condensed-Matter and Materials Physics

Phillip D. Long, NRC Staff

Condensed-matter and materials physics (CMMP) is one of the core branches of physics covered in the Board on Physics and Astronomy's *Physics 2010* series. A new BPA study committee, *CMMP 2010: An Assessment of an Outlook for Condensed-Matter and Materials Physics*, will evaluate the remarkable advances in the CMMP field since the previous decadal survey published in 1999 and identify new opportunities for the upcoming years. The breadth and richness of the CMMP field requires that the committee cast its net far and wide to incorporate many key sub-disciplines. This analysis will investigate exciting areas of research, connections to other fields, and contributions to societal needs.

Framing the study are some of the following issues. CMMP is a fundamental science that has strong intellectual connections with other fields, both within and outside of physics. It is an essential component of the continuum of physics, and concepts that have emerged from theory and experiment in CMMP have had profound influence on the entire spectrum of physics. In collaboration with the applied physics and materials communities, discoveries in CMMP have led to new devices that have changed the world. The global landscape for research in CMMP and its applications has changed dramatically in the past few years, providing additional motivation for a study of CMMP at this time. The great industrial laboratories are no longer major players in CMMP. This change has influenced the CMMP community in numerous ways, not the least of which is the reduction of the overall size of the U.S. effort. The movement of high-tech manufacturing overseas is having a significant impact on the employment prospects for new physicists, especially those specializing in CMMP. At the same time, it is likely that national priorities, such as defense and

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Highlights of the Spring Meeting of the Board on Physics and Astronomy

The Board on Physics and Astronomy met for its annual spring meeting in Washington, D.C., on April 21-22, 2006. Vice Chair Anneila Sargent called the meeting to order with a warm welcome to everyone. A common topic throughout the day's discussions was the President's American Competitiveness Initiative (ACI). Proposed by President Bush in his January 2006 State of the Union Address and supported in his FY2007 budget request, the ACI seeks to double the combined budgets of NSF, NIST, and DOE Office of Science over a period of 10 years. However, at this early stage, it is not clear how individual agencies or programs will be affected. In addition to education and business incentives, the ACI supports funding for innovation-enabling research in high-leverage fields of physical science and engineering.

The Board started the day with presentations on the state of the astronomy and astrophysics budget from representatives of the federal agencies. Wayne Van Citters spoke about the status of the NSF Division of Astronomical Sciences (AST). The site for the National Solar Observatory Advanced Technology Solar Telescope (ATST) has been selected; it will be constructed atop Mt. Haleakala in Maui, Hawaii, and an environmental impact study is now underway. The astronomy division continues to provide funding for the project with the earliest likely entry to the NSF Major Research Equipment and Facilities Construction account in FY2009. NSF continues to feel the impact of changes at NASA with strong increases in proposal pressure. Research grants proposals were up 20 percent in FY2006, following a 15 percent increase in FY2005. To address this issue, NSF continues to interact with NASA colleagues with coordinated reviews and funding recommendations. The astronomy senior review is also nearing completion. The senior review calls for a cross disciplinary, competitive review of existing NSF astronomy facilities, including setting priorities and considering possible closure or privatization. The committee has now met four times and a final report is forthcoming soon. The Committee on Astronomy and Astrophysics will be consulted as the division acts on recommendations. The results of the report will inform FY2008 budget development.

Tom Gergely from the NSF Office of Spectrum Management remarked on NSF's response to the Presidential Initiative on Spectrum Management released in mid-2004. The report emphasized standardizing methods of evaluating spectrum efficiency and effectiveness, and recommends that government bodies work in a more coordinated manner to ensure the nation's priorities, including scientific research, are taken into full consideration. Dr. Gergely pointed out that efficiency is "in the eye of the beholder," noting that radio astronomy receivers operate near the quantum limit in some spectral bands. He also remarked on the difficulty of ambiguities inherent to pricing the spectrum. In response to the presidential initiative, NSF developed itsLong Range Spectrum Plan that covers radio astronomy, atmospheric research, and the polar programs' use of spectrum. In particular, the report anticipates the need for allocations for radio astronomy above 275 GHZ to be able to perform research. Despite the need, spectrum management faces dire straits due to human resource issues, and all spectrum science faces deterioration if this problem is not solved.

Garth Illingworth then made remarks about discussions and activities of the joint NSF, NASA, DOE, and OSTP Astronomy and Astrophysics Advisory Committee (AAAC), which he chairs. The AAAC has convened several subcommittees to investigate the status of certain fields of astrophysics, these are: the Cosmic Microwave Background Task Force, the ExoPlanet Task Force, Dark Matter Science Assessment Group, and the Dark Energy Task Force (DETF). The DETF recently released its report in draft form, citing that the science case for dark energy research is extremely compelling, and that no one technique to investigate dark energy will be successful without

complementary approaches. The remaining subcommittees' reports are not due for some time. Dr. Illingworth then turned to recent discussions within the AAAC about issues facing the field of astronomy and astrophysics, and how the committee responded to those in its recent annual report. The AAAC is particularly concerned about the somewhat dismal budget out-year forecast for NASA science; this budget line is expected to decrease by about $3 billion over the next 5 years. Because of the current portfolio of activities at NASA, this plan risks upsetting the balance of programs the field currently enjoys. AAAC is encouraged, though, by DOE's Office of High Energy Physics (HEP) growing involvement in astrophysics.

Paul Hertz presented an overview of programs at NASA's Science Mission Directorate (SMD). With the scheduled disinvestment of $3.1 billion in SMD over the next five years, Dr. Hertz noted that reductions in previous science planning are necessary, and that an executable program based on strategic NRC priorities is needed to maintain a balanced program. The $3.1 billion difference will go to fund operations to complete the shuttle and International Space Station programs. This downslide puts pressure on existing programs, especially as the Hubble Space Telescope's scheduled servicing mission slips to late 2007, and the James Webb Space Telescope project has met with unforeseen cost increases on the order of $1 billion. The Gamma-ray Large Area Space Telescope faced a cost re-baselining due to technical problems while the Kepler Mission established its baseline. The Wide-field Infrared Survey Explorer is scheduled to enter development this year, and the Space Interferometry Mission's launch readiness date was pushed into 2015-16. A review of the cancelled Stratospheric Observatory for Infrared Astronomy is being conducted to determine the best course of action, and the Beyond Einstein program will engage in a replanning exercise to establish which of LISA, Con-X, and JDEM will be selected to proceed first. Meanwhile, the Research & Analysis budget line has been proposed for a 15 percent reduction in FY07.

Turning the discussion to physics and materials, Lance Haworth described the status and plans of NSF's Division of Materials Research (DMR). He discussed the balance in funding in the division between principal investigator grants, centers, and facilities, noting that the largest increase in funding over the past 10 years has been for facilities and instrumentation followed by principal investigator grants and, lastly, centers. DMR supports two university based synchrotron facilities whose awards will expire in 2008/2009 and 6 instruments at the NIST Neutron Scattering Facility. DMR is considering an internal review of their facilities and instrumentation portfolio. They are interested in evaluating their support for university-based synchrotron facilities, support for "Mid-Scale Instrumentation" including beamlines at national facilities, the role of the Center for High Resolution Neutron Scattering at NIST in context of the Spallation Neutron Source, and NSF support for a future energy-recovery linac. Dr. Haworth also highlighted a new program on biomaterials scheduled for full implementation in FY07. The program will focus on the study of biologically-related materials and phenomena, including biological pathways to new materials.

Joe Dehmer presented remarks on the NSF Division of Physics. The strategic goals for the division focus on the intellectual frontiers, broader impacts, education, and stewardship. Several frontiers were identified, inclduing elementary particle physics, physics of the universe, fundamental mathematical and statistical science, physical sciences at the nanoscale, cyberinfrastructure and the cyberscience it enables, the molecular basis of life processes, and sustainability. Specific examples of physics frontiers were given that fall in these areas. Division priorities for FY06 include strong and flexible core programs, elementary particle physics and physics of the universe, increased diversity, strengthened theory, stewardship of facilities, and addressing future opportunities such as the International Linear Collider.

Pat Dehmer shared her thoughts on the DOE's Office of Basic Energy Sciences (BES). With the ACI driving increased

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Committees of the Board on Physics and Astronomy

Atomic, Molecular, and Optical Physics 2010 (AMO 2010)*
Phillip Bucksbaum, Stanford University, and Robert Eisenstein, *Co-chairs*

Committee on Astronomy and Astrophysics
C. Megan Urry, Yale University, and Roger D. Blandford, Kavli Institute for Particle Astrohysics and Cosmology, *Co-chairs*

Committee on Biomolecular Materials and Processes
Arup Chakraborty, Massachusetts Institute of Technology, *Chair*

Committee on Radio Frequencies
Karen St. Germain, Naval Research Laboratory, *Chair*

Condensed-Matter and Materials Physics 2010 (CMMP 2010)*
Mildred S. Dresselhaus, Massachusetts Institute of Technology, and William J. Spencer, SEMATECH, *Co-chairs*

MRSEC Impact Assessment Committee
Matthew V. Tirrell, University of California at Santa Barbara, *Chair*

NASA Astrophysics Program Assessment Committee
Kenneth H. Keller, University of Minnesota, *Chair,* and Martha P. Haynes, Cornell University, *Vice Chair*

Plasma Science 2010*
Steven Cowley, University of California at Los Angeles, and John Peoples, Fermi National Accelerator Laboratory, *Co-chairs*

Plasma Science Committee
Cary B. Forest, University of Wisconsin at Madison, *Chair*

Rare Isotope Science Assessment Committee
John F. Ahearne, Sigma Xi and Duke University, and Stuart J. Freedman, University of California at Berkeley, *Co-chairs*

Solid State Sciences Committee
Marc A. Kastner, Massachusetts Institute of Technology, *Chair,* and Peter F. Green, University of Michigan, *Vice Chair*

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*Elements of the new survey *Physics 2010*

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science and options for the future, the committee "outsiders" forced the particle physicists to rethink their field's priorities and to take a hard look at the field's science portfolio, not only at home but also abroad.

After one and a half years of study, six full committee meetings, international trips to Japan, Germany, and Switzerland, and countless hours of deliberations, the Elementary Particle Physics in the 21st Century Committee released the product of its toils in the form of the report *Revealing the Hidden Nature of Space and Time: Charting the Course for Elementary Particle Physics* in late April 2006.

The report frames the current position of the U.S. effort in particle physics (one that has steadily decreased over the past decade) as part of a larger global effort, assesses its potential, and recommends a 15-year strategy to reinvigorate and sustain the U.S. program as a leader complementary to worldwide efforts. Historically, the United States has been a leader in particle physics research, with important discoveries coming out of particle accelerators like the Stanford Linear Accelerator Center (SLAC), the Cornell Electron-positron Storage Ring (CESR), Brookhaven National Laboratory and the world's most powerful particle accelerator, the Tevatron at Fermilab in Illinois. But experiments for particle physics at SLAC's accelerator, the Tevatron and CESR are all slated to end over the next decade, leaving researchers with drastically reduced opportunities for research in the United States and potentially leading to a brain drain as promising young physicists move abroad.

Based on a prevailing set of firm strategic principles and scientific priorities, and the many benefits that shared leadership in the field will bring, the committee came to a single overriding recommendation: "The United States should remain globally competitive in elementary particle physics by playing a leading role in the worldwide effort to aggressively study the Terascale. Indeed the committee believes that only a strategy that includes an important accelerator-based component to exploit the Terascale can sustain the distinction of the U.S. program."

To achieve this overall goal, the repoprt states, the DOE and NSF need to work together to achieve the following objectives in priority order:

1. Fully exploit the opportunities afforded by the construction of the Large Hadron Collider at CERN.

2. Plan and initiate a comprehensive program to become the world-leading center for research and development on the science and technology of a linear collider, and do what is necessary to be able to mount a compelling bid to build the proposed International Linear Collider on U.S. soil.

3. Expand the program in particle astrophysics and pursue an internationally coordinated, staged program in neutrino physics.

The report stresses the notion of shared leadership, not dominance. The soon-to-open Large Hadron Collider (LHC) at CERN will cost in the ballpark of $6 billion (not including the pre-existing underground tunnel), and required the collective scientific and financial participation of countries from every populated continent on the planet, in addition to effective and efficient cooperation. Similar, though somewhat less sizeable efforts, are being undertaken at facilities in Japan, and have required the expertise and contributions of multiple nations. Even as the Europeans have been finishing the Large Hadron Collider (LHC), particle physicists worldwide have been designing the next generation of particle accelerator. Known as the International Linear Collider (ILC), this new tool would consist of two accelerators that fire electrons and anti-electrons at each other head-on, re-creating conditions that existed just a fraction of a second after the universe's birth. The ILC would be of such a scale and complexity, similar to the LHC, that only a global, cooperative effort could make it possible. It was the committee's judgment (echoing many others) that the ILC was a necessary tool to fully exploit the scientific opportunities of the Terascale. The committee believed that the potential role of the United States in building, supporting, and perhaps hosting the ILC was key to the continued distinction of the U.S. program.

It is not just the tools that require international partnership, but the science that comes out as well. One nation alone would be incapable of handling and interpreting such vast amounts of data that the machines collect. Teams of visiting and off-site scientists offer invaluable intellectual resources.

At these physical and intellectual scales, no one nation can dominate the particle physics enterprise. It is essential to continue the trend towards planning big science in an international arena if the United State is going to promote cooperative global leadership. The committee felt strongly that because of the increasing cost and complexity of particle-physics experiments, and the need to deploy public funds in the most effective and responsible manner, it is more important than ever for all the major programs in particle physics to leverage their resources by working together internationally.

A critical element of the committee's strategy is maintaining a diverse portfolio of activities in particle physics. Accelerators, space-based experiments, underground laboratories, and precision measurements of various kinds offer a variety of ways to explore the pressing questions of particle physics. Even during periods of budgetary stringency, a healthy program will maintain a diverse and comprehensive portfolio of research activities that encompasses university-based students and faculty, national laboratories, and activities conducted in other countries, the report states. Reflecting the committee's rejection of a "dominance" paradigm, the report argues that the highest scientific priorities should not consume all possible resources; rather, a mixed strategy that prioritizes the most important science but allows room for some other activities is best.

In fact, the committee describes the path they laid out for U.S. particle physics as the best risk-adjusted strategy available within any budget scenario. Continuing on as planned could more deeply entrench the community in scientific isolation and in a competitive run-off with Japan, while more and more U.S. scien-

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Biomolecular Materials and Processes

Phillip D. Long, NRC Staff

The twenty-first century promises a revolution in scientific advancement as the barriers between disciplines erode and wonderful new integrative approaches begin to surface. Although not a new phenomenon, the present pace of such interdisciplinary endeavors has accelerated tremendously in recent years. Among the most exciting areas is at the molecular level of biology. The complexity and elegance of this realm holds bountiful opportunity for those who can decipher the molecular-scale processes and understand the constitution and applications of both natural biomolecular materials and biologically-inspired synthetic versions. This vibrant field is experiencing an infusion of energy and scientific talent from traditionally distinct disciplines such as physics, biology, chemistry, and engineering which all stand to contribute to, and benefit from, the convergence of expertise.

At the behest of federal agencies that sponsor research in this area, the National Research Council (NRC) has agreed to undertake a survey of the field. Acknowledging the inherent interdisciplinary nature of such an investigation, the Board on Physics and Astronomy and the Board on Life Sciences have joined forces to collectively undertake this study. With the support of NSF and DOE, the Committee on Biomolecular Materials and Processes (BMAP) has been appointed to assess current work and future promise at the interfaces between biology and materials research, and to recommend actions to realize the identified opportunities. Including experts from many disciplines, the committee's broad expertise spans such areas as bio-inspired materials, biological processes, theory and computational modeling, single molecule biophysics, biomolecular functional systems, interfaces, soft biomaterials, and biological self-assembly. The BMAP committee will compose a final report addressing the following tasks:: (1) Identify the most compelling questions and the emerging scientific opportunities at the interface between biology and condensed matter and materials research—the biomolecular domain; (2) Suggest strategies to best meet the identified opportunities; and (3) Consider connections to national priorities including healthcare, security, workforce, economic and other societal needs.

In carrying out this study the committee may consider what opportunities biology presents to materials research and what opportunities materials research presents for biology. In its deliberations, the committee may consider previous reports in this field (such as *Biomolecular Self-Assembling Materials: Scientific and Technological Frontiers*, National Academies Press, BPA 1996), current programs and strategies implemented by the federal research support agencies, and a review of international activity.

The BMAP committee met for the first time at the Keck Center in Washington, DC on March 16-17, 2006. After being familiarized with National Academies study process, the committee heard testimony from the chair of the 1996 NRC's Biomolecular Self-Assembling Materials committee and received further explanation of the committee's charge from the former chair of the Solid State Sciences Committee (SSSC). Additionally, the co-chair of the 2004 NSF Workshop entitled "The Role of Theory in Biological Physics and Materials" offered his analysis of the field and how the committee could most effectively explore and respond to its charge. The following day offered an opportunity for DOE and NSF representatives to elucidate the questions they hope the committee will address. Armed with a thorough grasp of their endeavor, the committee divided into working groups to probe different areas of the discipline. The committee also analyzed its composition and determined that additional areas of expertise were needed. Two members with expertise in synthetic organic chemistry and single molecule biophysics were added to the committee.

The second BMAP committee meeting will take place on June 18-19, 2006, at Lawrence Berkeley National Laboratory's Molecular Foundry Building in Berkeley, CA. The aforementioned working groups have been at work since the March meeting to prepare for this next conference and much progress is anticipated by the time they adjourn on June 19, 2006. ■

Committee on Biomolecular Materials and Processes

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homeland security, will require people educated in CMMP. Similarly, nanoscale science and technology have become national priority areas for investment.

With support from DOE and NSF, the National Research Council (NRC) formed a committee with broad expertise in CMMP and closely related disciplines, including members from academia, industry, and national labs, to undertake a broad assessment of the field and to frame an outlook for the future. Experts in chemistry; atomic, molecular, and optical science; and science communication also sit on the committee. The CMMP 2010 committee has been explicitly tasked to address the following points:

1. Review the field of CMMP, emphasize recent accomplishments, and identify new opportunities and compelling scientific questions, connecting to other recent studies where appropriate.
2. Identify the potential future impact of CMMP on other scientific fields and current and emerging technologies.
3. Consider how CMMP has contributed and will likely contribute to meeting national societal needs such as in education, workforce, and healthcare.
4. Identify, discuss, and suggest priorities for construction, purchase, and operation of tools and facilities ranging from instrumentation for the individual investigator to the national user facilities.
5. Make recommendations on how the US research enterprise might realize the full potential of condensed matter and materials physics research.
6. Examine the structure and level of the current research effort in condensed-matter and materials physics. Obtain objective information on current status and trends in the following areas: (1) the performing institutions: government, universities, and industry; (2) different levels of aggregation of researchers ranging from principal investigators through small groups and large teams at centers; (3) the role of the research community and performing institutions in initiating research; (4) the relationship between research opportunities and the current structure of the research effort. Analyze this information, make comparisons internationally, and draw relevant conclusions.

The broad purview of this charge demands that the committee work vigorously and collect input from numerous and diverse stakeholders. The committee, therefore, has met twice since February in formal meetings and communicated often in the intervening periods. The February 12-13, 2006, meeting was held at the Beckman Center of the National Academies in Irvine, CA. At this first meeting, the committee was introduced to the NRC study process and it discussed the substance of the CMMP 2010 charge. The committee also heard perspectives from the Solid State Sciences Committee (SSSC) and thoughts from the study chair of the previous CMMP decadal survey. Other testimony described the current context of CMMP and methods of data gathering. On the second day, the committee heard testimony from each of the key federal agencies supporting CMMP research endeavors and received input from representatives of the Office of Management and Budget and the Office of Science and Technology Policy about how to prepare a useful and compelling report.

The committee convened again on May 25-26, 2006, at the Keck Center of the National Academies in Washington, DC, for its second meeting. Invited speakers addressed DOE user facilities, the role national labs presently play in innovative research and how that effort might be enhanced in the future, and key lessons learned from the AMO 2010 report. While synthesizing this information in closed-session, the working subgroups of the committee presented their respective progress to the rest of the members and solicited feedback. The committee emerged from this discussion with a refined structure for the final report, concrete plans for communicating their message to the various audiences, and action items for moving forward. Most importantly, the committee worked on its draft interim report, reaching consensus on the content. The interim report is scheduled for release in August 2006 and will present some of the committee's initial findings. ■

Committee on Condensed-Matter and Materials Physics 2010

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Outlook for Astronomy and Astrophysics

Brian D. Dewhurst, NRC Staff

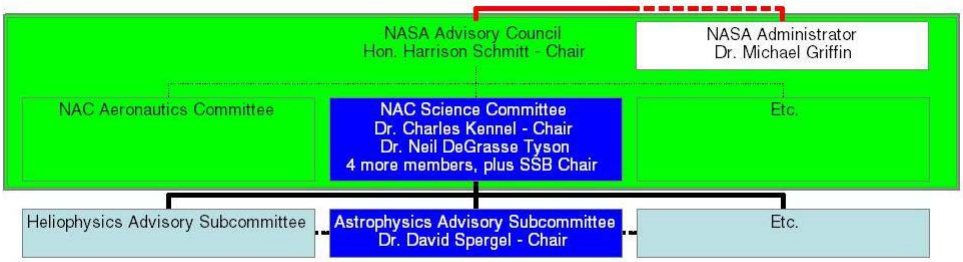
The Committee on Astronomy and Astrophysics (CAA) held its spring meeting on May 19-20, 2006, at the National Academies' Keck Center in Washington, D.C. The spring meeting is traditionally the time each year when the committee converses with agency officials and policymakers in Washington. This year the committee spent much of its time considering the state of the NASA astrophysics program and how the changes at NASA are having an impact in the astronomy and astrophysics community. In addition, the CAA continued its discussion about various options for conducting the next astronomy and astrophysics decadal survey.

On first day, the committee received presentations on the current status of the astronomy program at the NSF, on the new NASA Advisory Council (NAC) structure, the new National Academies' report on elementary particle physics, the activities of the Astronomy and Astrophysics Advisory Committee (AAAC), and the current context for science funding as seen by the Office of Management and Budget (OMB). The bulk of the day on the 20th was spent on the James Webb Space Telescope (JWST) program, followed by committee discussions about the next decadal survey. The public presentations (including those not discussed further in this article) can be found on the CAA page of the BPA web site (see URL http://www.nas.edu/bpa/caa.html).

NASA Advisory Council

The NASA Advisory Council is chartered to provide advice to the NASA Administrator through the Federal Advisory Committee Act (FACA) process. In the past the NAC had a variety of subcommittees that were also FACA-chartered and that reported directly to corresponding NASA officials (such as the Associate Administrator for Space Science, who received advice from the Space Science Advisory Committee). However, Administrator Griffin abolished the old structure and has created a new structure which operates in a different way.

The current NAC is made up of 25 members, plus the chairs of the National Academies' Space Studies Board and Aeronautics and Space Engineering Board who serve as *ex officio* members. In addition to meeting as a full council, the NAC is broken down into several committees, such as the Science Committee or the Aeronautics Committee. Only members of the NAC serve on these committees. In addition to the NAC and its committees, the Science Mission Directorate (SMD) has established a set of discipline-focused subcommittees. These subcommittees report to the Science Committee of the NAC.



Organization chart showing the advisory structure for NASA; as shown, the NASA Advisory Council (NAC) ultimately reports to the NASA Administrator.

The CAA heard presentations from two members of this new structure, Neil DeGrasse Tyson, who is a member of the NAC and its Science Committee, and David Spergel, who is the chair of the Astrophysics Subcommittee.

Dr. Tyson's presentation focused on how NASA influences and is influenced by current political and societal trends. Summarizing current public attitudes about NASA, Dr. Tyson encouraged the astronomy and astrophysics community to support NASA's exploration initiatives, and to work with the agency to make those initiatives scientifically useful in addition to continuing to support a strong science program in the Science Mission Directorate.

Dr. Spergel presented the current membership of the Astrophysics Subcommittee and summarized the results of that committee's first meeting held earlier in the month. The subcommittee concluded that NASA should reverse the proposed cuts to the R&A lines, restore the Explorer line of missions, and provide technology funding for future missions. However, the subcommittee did not identify where the additional funding might come from.

James Webb Space Telescope

After the James Webb Space Telescope presentation at the November 2005 CAA meeting, the committee still had a number of questions about the JWST program and how it might impact future plans for the Astrophysics Division. The committee invited the project team back to address these questions at its spring meeting.

In advance of the meeting, the committee summarized many of the community's concerns into the following two questions:

1) Is it reasonable for the JWST spending profile to follow the current plan allowing a wedge to open up in 2009 or will it be much longer before other projects can start?

2) Is the JWST project now in a situation when there is no feasible large descope and further cost increases, if they happened, would lead to a stark choice for NASA: find the money or cancel?

However, it was recognized that a set of more specific questions would be more likely to address the concerns at the roots of these more general concerns. This additional set of questions (for example: what are the three greatest technical and three greatest programmatic concerns?) was also provided to the project team and formed the basis of the conversation.

The JWST project was represented by Eric Smith from NASA headquarters, and John Mather, Phil Sabelhaus, and Mark Clampin from the Goddard Space Flight

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funding for the physical sciences, the Office of Science was proposed for an increase of 14 percent in the President's FY07 budget request to congress. If Congressional appropriations match the President's budget, BES would see a funding increase of 25 percent for their programs. BES continues to roadmap their science programs with the "Basic Research Needs" workshops. This year there will be four workshops on superconductivity, solid-state lighting, advanced nuclear energy systems, and combustion of alternate fuels. An additional workshop on energy storage is planned for 2007.

Robin Staffin discussed DOE's Office of High Energy Physics (HEP) with the Board. The U.S. high-energy physics program is at a crossroads. With the Large Hadron Collider being built in Europe, the nation requires both a strategic plan and sufficient matching investments to remain a leader in particle physics. Dr. Staffin also described how the International Linear Collider (ILC) and the Large Hadron Collider (LHC) will work in tandem. For many potential discoveries with the LHC, the ILC will bring further understanding to those discoveries. Following from this, the community is looking ahead to the ILC, whether it will be built, and whether the United States will host it. Dr. Staffin also thanked the BPA for its role in originating the EPP2010 study whose report has been warmly received.

Dennis Kovar presented an update from the DOE's Office of Nuclear Physics (NP). Over 90 percent of federal support for nuclear physics research is funded through NP. They support eight centers and four user facilities with nearly half of the facilities users coming from the international community. The major scientific thrusts and opportunities identified by the community are in the quark structure of matter, phases of nuclear matter, nuclear structure and dynamics, nuclear astrophysics, and fundamental symmetries. The research program has been structured to address these thrusts. NP would also see increased funding of 24 percent if the President's FY07 budget is passed by Congress. The Nuclear Science Advisory committee is now developing a new long-range plan for the NP program.

Erol Oktay shared observations on DOE's Office of Fusion Energy Sciences (OFES). With U.S. participation in the multinational ITER program, the U.S. fusion energy sciences program is in transition to a new era. The text of the international ITER agreement has been completed and has been initialed by the contributing parties. The agreement is expected to be signed in the fall of 2006. The U.S. Burning Plasma Organization (USBPO) has been formed to coordinate U.S. research for ITER support and burning plasmas. The USBPO is developing a plan for the U.S. participation in ITER that will address the research agenda, methods for evaluating progress, and benefits to domestic fusion program.

In a related program, Chris Keane discussed the high energy density physics program in DOE's National Nuclear Security Administration. Dr. Keane reported on the National Ignition Facility (NIF) program which has completed 400 experiments to date with eight beams ran at full power. The project is now 85 percent complete. They do not plan for any more experiments until the facility is complete in 2010.

Following the agency talks, the Board heard from Michael Turner, former Assistant Director for Mathematical and Physical Sciences at NSF. Dr. Turner recounted the highlights and accomplishments during his term as assistant director. He noted that the President's ACI has opened the doors for the physical sciences and now it is the community's turn to shape the ACI and convince Congress and the public that this investment is in the nation's best interest. He wrapped up with some examples of the stunning scientific opportunities ahead.

Norman Augustine joined the Board meeting to discuss the impact of the Academies *Rising Above the Gathering Storm* report, which he chaired. The committee that authored the report was composed of a mixture of company presidents, scientists, former presidential appointees, and leaders from the public school system. This combination of the science community and business world sends a stronger message to Congress and the public than any group working individually, he said. In deciding how to approach the report, the committee focused on job creation since that speaks to Congress and the public most directly. While only four percent of the workforce are scientists or engineers, they create a disproportionately large numbers of jobs for the remaining 96 percent of the workforce, he explained. Further, Mr. Augustine described the change in the global economy as the "death of distance" where planes now move people and things around the world and the information technology revolution moves information around the world much more quickly than in the past. To show how the United States could lose its science and engineering leadership in the coming years, the committee compiled a list of worrisome indicators that indicated a growing science and engineering community abroad and a waning community in the United States. Mr. Augustine followed by describing some of the current legislation in the House and Senate based on the recommendations from the report. They have received bipartisan support.

Robert Dimeo, Assistant Director for Physical Sciences and Engineering at the White House Office of Science and Technology Policy, presented views from the Administration. He described the context for the ACI with the national debt at eight trillion dollars and a goal to reduce that by half by 2009. In order to do so, discretionary funds are under stress. He described the ACI as a prioritization of the research investment by the country to maintain its competitive edge. David Trinkle, Amy Kaminski, and Joel Parriott attended from the White House Office of Management and Budget and made several key comments. They noted that the House is taking fiscal responsibility more seriously in this constrained budget year. They reinforced the message that in this first year of the ACI, all three targeted agencies are roughly on the doubling path but that there is no overall plan for physical sciences funding at the various agencies in the ACI.

On the second day of the meeting, the

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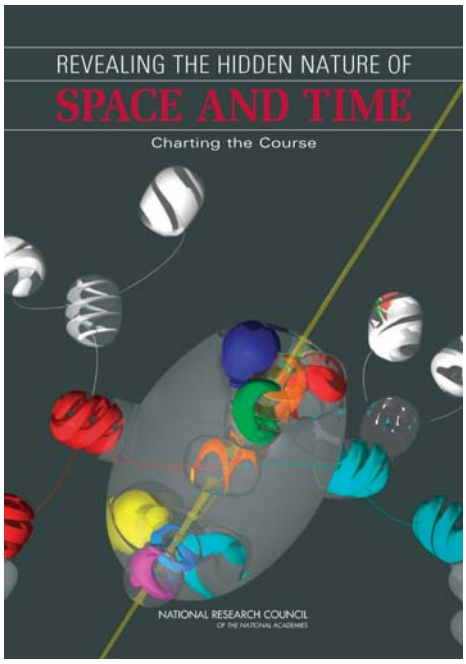
EPP2010 (continued from page 4)

tists move overseas to work at foreign labs.

For such an ambitious strategy to be executed, and for the field to find itself in safer waters, the political planets must align properly. This is no small task. Accurately communicating the report's findings and recommendations to parties in the executive branch (OMB, OSTP, DOE, and NSF), Congress, and the larger science community is of the utmost importance. As committee chair Harold Shapiro pointed out recently while speaking on behalf of the committee, the U.S. program in particle physics will require support from all of the physical sciences in order to move forward on the most compelling scientific opportunities. The committee has assumed this role vigorously.

As part of the report-release activities, Dr. Shapiro and several members of the committee briefed individuals in many of these offices, including the Secretary of Energy and the Associate Director for Natural Resources at OMB. The team also met with Dr. John Marburger, Director of the Office of Science and Technology and Policy. Dr. Shapiro, Dr. Dawson, and several other committee members briefed Dr. Pier Oddone, Director of Fermilab, Dr. Jonathan Dorfan, Director of SLAC, and Dr. Robert Rosner, Director of Argonne National Laboratory. On the Hill, the briefing team met with House of Representatives members Bart Gordon (D-TN), Mike Honda (D-CA), Vern Ehlers (R-MI), Judy Biggert (R-IL), and Rush Holt (D-NJ). They also met with senior staff of the offices of Jeff Bingaman (D-NM), Alan Mollohan (D-WV), David Hobson (R-OH), Dennis Hastert (R-IL) and the House Committee on Science. In response to the visit, the Honorable Bart Gordon wrote a strong letter of support to the committee. The briefing team met with the Universities Research Association (URA) Board of Trustees. (URA and University of Chicago recently announced the formation of a partnership to jointly bid for the DOE contract to manage Fermilab beginning in January 2007. URA currently manages and operates Fermilab.)

The report was released to the public during a briefing at the Keck Center of The National Academies on the afternoon of April 26, 2006, and featured a small subset of the committee to address questions from the audience. The panel consisted of Dr. Shapiro, vice chair Dr. Sally Dawson, Brookhaven National Laboratory, Dr. Jonathan Bagger, Johns Hopkins University, and Dr. Takaaki Kajita, University of Tokyo. After a brief introduction, Dr. Shapiro



presented prepared remarks then addressed several questions from the audience. Nearly 200 people attended the release between guests in the room and on the webcast. Committee member and 2005 Nobel prize winner in physics David Gross also presented the report at the annual meeting of the National Academy of Sciences.

The report has received considerable national media attention with articles in the *New York Times*, *Chicago Tribune*, *Chicago Sun-Times, Christian Science Monitor*, several Chinese science and technology news services, and even *The Economist*. Magazines such as *Nature, Science,* and *Physics Today* all ran stories describing the report and the unusual composition of the committee. Many of these sources later ran editorials that resonated strongly with the report's analysis and emphasized the need for action; *Nature* noted that the committee's "endorsement of the [linear collider] project reflects a consensus within the wider scientific community that particle physics, although expensive and esoteric, is of fundamental importance and worthy of support." On the *New York Times* opinion page, noted author Verlyn Klinkenborg observed in support of particle physics and the report, "The overwhelming risk, the panel concluded, is that without this [linear collider] project, the thrust of high-energy physics in this country will simply die away." Although the committee's strategy reflected a broader view than just one large project, the attention on the issues has been welcome.

Public presentations of the report to the science and policy communities, both nationally and internationally, have been equally important. In a sign of true commitment to the report, many members, including committee chair Harold Shapiro, have accepted engagements around the world to discuss the report. Presentations to standing-room-only crowds have been made at SLAC, Fermilab, Cornell, and Washington, D.C. Other committee members have presented the report in Japan and the United Kingdom, and plans have been confirmed to brief CERN and DESY in Europe within the next few months. Additional efforts are underway to share the report with neighboring scientific communities at regularly scheduled professional conferences over the next year. Perhaps a tribute to the roots of the web, the electronic version of the committee's report was downloaded more than 30,000 timeswithin the first week of its release; as many know, the key protocols underpinning the world-wide-web were developed by particle physicists.

As Dr. Shapiro noted when describing the report recently, only time will tell if this report will have a lasting impact—and whether the National Academies will repeat this experiment with such an unusual committee. ■

Astronomy (continued from page 7)

Center. Over the course of nearly five hours, this group led the CAA through the JWST project (their presentations can be found on the CAA web page). The majority of this discussion was led by Mr. Sabelhaus, the project manager. Mr. Sabelhaus explained the results of the recent project rebaselining, the findings of the Special Review Team that had recently completed its work, and the current status of the project. At the end of the session, many of the CAA members expressed their appreciation for the work that has already been done and their clearer understanding of the project. A number of the committee members commented that some of the confusion in the community stems from the fact that JWST is currently classified by NASA as in Phase B (preliminary design studies), while judging from the traditional flow of NASA projects and the amount of hardware already built, the project should be considered to be in Phase C/D (construction). Understanding the project status and development path in this light resolves many questions, although committee members were still worried that there could be still unforeseen difficulties as the project moves forward which would severely impact the rest of the astrophysics program.

Looking Ahead to the Decadal Survey

Over the past two years the CAA has devoted a portion of each meeting to considering options for enhancing the process for the next decadal survey. The impetus for these discussions was the perception that the science, the community, and the policy context have all evolved significantly over the past ten years, and that the decadal survey process should evolve to match. To this end, the CAA has asked agency officials and policy makers, as well as some community members, for their perspective on the decadal process. The goal of the spring 2006 meeting was to begin to place down on paper the options that the committee has heard for consideration by the broader community. To this end, the CAA has begun to draft an options paper that it intends to present at a Town Meeting at the January 2007 American Astronomical Society meeting in Seattle, Washington. When the paper is ready, it will be placed on the BPA website, and feedback will be solicited from the broad research community. ■

BPA Meeting (continued from page 8)

Board heard an update on several new and emerging projects. EPP2010 committee chair Harold Shapiro also briefed the Board on the findings and recommendations of the report which he chaired (see related article in this newsletter). Carl Wieman addressed the BPA on the recently formed Board on Science Education (BOSE) of the National Academies, which he chairs. BOSE was formed to address science education at all levels, in all settings, and on all issues. Dr. Wieman provided background on science education as a research field, noting that it requires knowledge of science and education research and that it is growing in level and quality of activity for all sciences. In the last 10 to 20 years, the research community has gained a much better understanding of how people learn, how people learn science, what characteristics are needed to "think like scientist," and how to better teach and measure outcomes. Dr. Wieman presented interesting data on the effectiveness of traditional approaches to science teaching such as lectures, homework problems, and exams. Most students learn less than thirty percent of new concepts presented in a traditional lecture course. The lecture quality, class size, and institution did not affect the outcome. Multiple surveys attributed the loss of physical science majors to students "learning" that the subjects are inherently uninteresting and to the style or quality of teaching. Dr. Wieman continued by describing several principles for effective teaching and learning. For example, most people retain only about seven items in short term memory and can process only four ideas at once yet a typical class presents much more than this "cognitive load." A general principle is that people can memorize what they are told, but actual learning of science (thinking like scientist) is a construction process, built on the foundation of previous thinking.

With a round of thanks and appreciation to the members for participating, chair Burton Richter adjourned the spring meeting of the Board. ■

BPA Mission

The Board on Physics and Astronomy (BPA) was created in 1983 as the successor to the National Academy of Sciences Office of Physical Sciences. Several standing committees were assigned at that time to the BPA, including the Committee on Atomic, Molecular, and Optical Sciences, the Solid State Sciences Committee, and the Committee on Radio Frequencies. Later, the Committee on Astronomy and Astrophysics and the Plasma Science Committee were created in response to requests from the scientific community. Since its inception, the BPA has published more than 40 reports, workshops, and collaborative activities, including two surveys of physics and two surveys of astronomy.

The important questions in physics and astronomy change as we learn more about nature, and that rate of change has been increasing. The BPA seeks to inform the government and the public regarding important scientific opportunities and issues as well as the changing nature of science. It builds bridges between the evolving subdisciplines of physics and astronomy and with other areas of science. The BPA is successful if it helps the science community and society understand what is needed to advance physics and astronomy and why doing so is important.

Every activity of the BPA is aimed at accomplishing one or more of the following goals:

- Monitor the health of physics and astronomy.
- Identify trends in research and new developments at the scientific forefronts.
- Foster interactions with other fields and cooperation among academic disciplines.
- Strengthen connections to technology.
- Facilitate effective service to the nation.
- Improve public understanding of science.
- Encourage cooperation among federal agencies, government laboratories, and universities involved in research in physics and astronomy.

Approaches for achieving these objectives include the following:

- Periodic assessments of major fields. By setting priorities, these surveys provide programmatic guidance to agencies.
- Response to particular needs and requests from federal agencies, both those that have programs of research and those that play an administrative role.
- Continuing surveillance of scientific progress and identification of issues and problems in various fields. Several standing committees are focused on this task.
- Cross-disciplinary studies of special areas that lie at the intersection of several disciplines.
- Many scientific assessments address the benefits that accrue to society through technology development that follows from the pursuit of science.

BPA Update: Emerging Projects

• *Assessment of the NASA Astronomy and Astrophysics Portfolio (NAPA).* In collaboration with the Space Studies Board, a committee has been formed to study the alignment of NASA's Astrophysics Division with previous NRC advice - primarily the reports *Astronomy and Astrophysics in the New Millennium* and *Connecting Quarks with the Cosmos*. More specifically, the committee shall address the following: 1) How well NASA's current program addresses the strategies, goals, and priorities outlined in reports from the National Academies; 2) Progress toward realizing these strategies, goals and priorities; and 3) Any actions that could be taken to optimize the science value of the program in the context of current and forecasted resources available to it. The study will not revisit or alter the scientific priorities or mission recommendations provided in the cited reports, but may provide guidance about implementing the recommended mission portfolio leading toward the next decadal survey.

Recent BPA staff photograph. (left-to-right) D. Shapero, D. Lang, N. Melcer, T.I. Meyer, P. Lewis, B. Dewhurst, V. An, and P. Long.

New Title for BPA Newsletter. Some of our more avid fans may have noticed the new title for this edition of the BPA newsletter. The new title, "Issues in Physics & Astronomy at the BPA" was selected as a more accurate description of the content and purpose of the newsletter, especially to those less familiar with the BPA.

BPA Update: Meetings in 2006

May 2006	
05/25-26	CMMP 2010 meeting, Washington, D.C.
June 2006	
6/12-13	MRSEC meeting, Washington, D.C.
6/18-19	BMAP meeting, Berkeley, California
6/19-21	NAPA meeting, Washington, D.C.
July 2006	
7/14-15	RISAC meeting, Vancouver, British Columbia
August 2006	
8/14-16	NAPA meeting, Boulder, Colorado (tentative)
September 2006	
9/30-10/1	PLSC meeting, Irvine, California
October 2006	
10/16-17	CORF meeting, Socorro, New Mexico
10/19-20	SSSC meeting, Irvine, California
10/20-22	NAPA meeting, Washington, D.C.
November 2006	
11/4-5	BPA meeting, Irvine, California
11/28-29	CAA meeting, Irvine, California

THE BPA Web site at **www.national-academies.org/bpa** provides news on recently released reports and other developments as well as a link to this newsletter in PDF format. Reports may be ordered at **www.nap.edu**.

Recent Reports:

Revealing the Hidden Nature of Space and Time: Charting the Course for Elementary Particle Physics

Coming Soon:

Interim Report of the CMMP 2010 Committee

Final Report of the AMO 2010 Committee

Final Report of the Rare Isotope Science Assessment Committee

Board on Physics and Astronomy
The National Academies
Keck Center, 922
500 Fifth Street, N.W.
Washington, DC 20001

BPA Newsletter for: