Issues in Physics & Astronomy

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Understanding the Impact of Selling the Helium Reserve

Michael H. Moloney, BPA Staff

Under the sponsorship of the Bureau of Land Management at the Department of the Interior, the BPA, in cooperation with the National Materials Advisory Board, has initiated a study to understand the impact on the scientific community of the continuing sale of the U.S. helium reserve and recent developments in the helium market.

The element helium has unique properties. Liquefying near absolute zero, it is the only option for many cryogenic applications, such as cooling superconducting magnets for scientific and medical instruments. In fact, cryogenic applications account for nearly 28 percent of annual consumption according to a 2002 survey of helium uses. Being chemically inert, helium is used for pressurizing and purging fuel tanks and in breathing gas mixtures for deep-sea diving. Because it is the smallest monatomic element, it passes easily through tiny orifices and is therefore used for leak detection in many scientific and technical applications. Its density is only 15 percent that of air, making it useful as a lifting gas for aerostats and other devices. Its high heat capacity, along with its inertness, makes it the preferred quenching medium for many applications in materials processing, such as the production of high-quality superalloy powders. It is the preferred carrier gas for gas chromatography, a widely applied technique for chemical separations.

Helium has, however, one other less desirable characteristic—it is a nonrenewable resource. Helium is a byproduct of purifying or liquefying natural gas. Recovering helium from a natural gas mixture containing 0.3 percent helium is considered economically viable. A few gas deposits contain as much as 8 percent helium. By comparison, the atmosphere contains only about 0.0005 percent. Helium from wells that produce uneconomically low concentrations, or from wells that produce higher concentrations but do not flow through an extraction plant, is often vented to the atmosphere when the natural gas is burned. A relatively minor amount of helium also is vented at extraction plants that have no access to a helium storage facility when excess helium production cannot be marketed.

From 1929 until 1998, the Federal government operated helium production

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In this issue:

The Moment of Truth for Inertial Fusion

Riccardo Betti, University of Rochester

While the quest for controlled thermonuclear fusion energy has been ongoing for the last half century (magnetic confinement since 1950's and laser fusion since 1960's), fusion research is about to reach a climax with the construction of the National Ignition Facility (NIF) and International Thermonuclear Experimental Reactor (ITER). Conclusive tests for the physics of the magnetic and inertial confinement concepts will be performed on these ignition machines.

Technically, thermonuclear ignition is a thermal instability, a runaway process in the thermal energy of the thermonuclear fuel—typically a 50-50 mixture of deuterium (D) and tritium (T). In an ignited DT plasma, known as a burning plasma, the fraction of the energy associated with the α-particles (3.5MeV) from the fusion reactions $D + T \rightarrow \alpha + n + 17.6MeV$ is deposited in the plasma itself thus increasing its temperature and, in turn, the fusion reaction rate. The hotter the plasma, the greater the number of fusion reactions that heat the plasma. This runaway process ceases when micro and/or macro instabilities of the plasma or saturation of the fusion rates prevent further growth of the plasma temperature. When properly controlled, the amplification of the fusion reaction rate resulting from the plasma self-heating process can lead to a fusion energy output many times larger than the input energy required for bringing the plasma to ignition conditions. The ratio of the energy output to the input is the energy gain.

Demonstrating thermonuclear ignition and energy gains in the laboratory has been a goal of fusion energy research for decades, and it is widely considered a milestone in the development of fusion energy, as well as a major scientific achievement.

Ignition in the lab does not imply that

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Review of the Plan for U.S. Participation in ITER

David B. Lang, BPA Staff

Ed. Note: This article is largely inspired by the Executive Summary of the report.

The development of a plan for the participation of the U.S. fusion community in the ITER program was mandated by the Energy Policy Act of 2005 (EPAct). The EPAct, in Section 972 (c)(4)(B), also directed that, after completion of the plan, the U.S. Department of Energy (DOE) request an external review of its content. Accordingly, on August 10, 2006, the DOE Under Secretary for Science submitted the completed plan to the National Academy of Sciences for review. In response, the National Research Council (NRC) organized a committee to review the DOE plan with the following charge:

The committee will prepare a short report addressing the following tasks:

I. Review the document "Planning for U.S. Fusion Community Participation in the ITER Program." Determine whether the plan provides a good initial outline for effective participation of U.S. plasma scientists in research at ITER.
II. Evaluate the following required elements of the plan: (1) an agenda for U.S. research at ITER, (2) methodologies to evaluate ITER's contribution to progress toward a power source, (3) description of the anticipated relationship between the U.S. ITER research program and the overall U.S. fusion program.
III. The committee will recommend next steps in the development of the plan, including: (a) appropriate elements and/or goals for the plan; (b) procedures to facilitate further development of the plan; and (c) metrics for measuring progress in establishing robust U.S. participation in the ITER research program.

The committee was appointed on October 1, 2007 and met in Washington, D.C. on December 14-15, 2007. Soon after, the FY2008 Consolidated Appropriations Act became law, under which U.S. contributions for ITER were unexpectedly eliminated. Although this committee was not specifically tasked to assess the implications of the FY2008 budget, it believed that the budget would necessarily affect U.S. researchers' ability to participate fully in the ITER project, and it therefore felt obliged to address this issue.

ITER presents the United States and its international partners with the opportunity to explore new and exciting frontiers of plasma science while bringing the promise of fusion energy closer to reality. The ITER project has garnered the commitment and will draw on the scientific potential of seven international partners, China, the European Union, India, Japan, the Republic of Korea, Russia, and the United States, countries that represent more than half of the world's population. The success of ITER will depend on each partner's ability to fully engage itself in the scientific and technological challenges posed by advancing our understanding of fusion.

The NRC Committee to Review the U.S. ITER Science Participation Planning Process was tasked to assess the current U.S. Department of Energy (DOE) plan for U.S. fusion community participation in ITER, evaluate the plan's elements, and recommend appropriate goals, procedures, and metrics for consideration in the future development of the plan. The committee found that:

• The 2006 DOE plan for U.S. participation in ITER is operating and has proven effective in beginning to coordinate U.S. research activities and the development of the ITER program. U.S. scientists have been well engaged in the planning for ITER, and the United States should endeavor to maintain this level of activity. The plan in its current form is well aligned with DOE Office of Fusion Energy Sciences goals.
• The U.S. ITER research program is at least as organizationally and technically mature as that of the other ITER participants at the time of this writing.
• The U.S. research program for ITER as described in the DOE plan is appropriate and justified, and the committee notes that the domestic program will evolve as the international research program is developed. U.S. involvement in developing the research program for ITER will be crucial to the realization of U.S. fusion research goals.
• The committee underscores as its greatest concern the uncertain U.S. commitment to ITER at the present time. Fluctuations in the U.S. commitment to ITER will undoubtedly have a large negative impact on the ability of the U.S. fusion community to influence the developing ITER research program, to capitalize on research at ITER to help achieve U.S. fusion energy goals, to participate in obtaining important scientific results on burning plasmas from ITER, and to be an effective participant in and beneficiary of future international scientific collaborations.
• Consistent with previous National Research Council and Fusion Energy Sciences Advisory Committee reports, the

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Committee to Review the U.S. ITER Science Participation Planning Process

Patrick L. Colestock, *Chair*
Los Alamos National Laboratory

Roger D. Bengtson
The University of Texas at Austin

James E. Brau
University of Oregon

Cary B. Forest
University of Wisconsin

Stephen Holmes
Fermi National Accelerator Laboratory

George J. Morales
University of California at Los Angeles

Thomas M. O'Neil
University of California at San Diego

Tony S. Taylor
General Atomics

Dennis G. Whyte
Massachusetts Institute of Technology

Michael C. Zarnstorff
Princeton University

NRC Staff

Donald C. Shapero, BPA Director
David B. Lang, Program Officer
Caryn J. Knutsen, Program Associate

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

Jim C. Lancaster, BPA Staff

The Board on Physics and Astronomy met for its spring meeting on April 25-26, 2008, at the Keck Center of the National Academies in Washington, D.C. Chair Anneila Sargent called the meeting to order and thanked everyone for their attendance and participation.

The meeting opened with a presentation by Tony Chan, assistant director of National Science Foundation (NSF)'s Mathematical and Physical Sciences directorate. Dr. Chan began his remarks by discussing recent changes in the staffing and organization of the directorate. He then discussed the implications of the FY08 budget and hopes for the President's FY09 budget request. FY08 funding was flat, compared to FY07, which caused significant tightening of budgets–requiring most activities, including individual investigator programs and MRSEC funding to be held level, and delaying or cancelling outright other programs. Among the issues they are grappling with in times of limited funds are how to balance the emphasis between multidisciplinary versus disciplinary initiatives, and broad-based versus special initiatives.

Denise Caldwell, deputy director of the Physics Division at NSF, spoke next. She discussed the four irreducible strategic goals of the division–to always work at the intellectual frontier, to seek programs that will have broad impacts, to promote education, and finally to maintain stewardship of the core programs in physics supported by the division. Dr. Caldwell sees growing overlap among different fields–quantum fluids with condensed matter, for example, and the emergence of new fields such as cyberscience and quantum information. Another new area in which the physics community is increasingly engaged involves living systems and this area has a priority for growth within the division. Major facilities such as LIGO and DUSEL are progressing according to schedule.

Zakya Kafafi, Director of the Division of Materials Research (DMR) at the NSF, discussed some of the recent changes occurring at DMR. Similar to other NSF Divisions, DMR has been unable to increase research and education support because of budgetary constraints and she does not expect DMR will be able to increase support for centers or enhance their many other programs in the near future. One consequence of these tight budgets is that the success rate for individual investigators is quite low, and will probably remain low for the immediate future. Materials Research Science & Engineering Centers (MRSECs) remain a focus of the division, and she intends to continue to pursue opportunities in that area, including expanding participation in The Materials World Network. Among the major challenges faced by DMR is stewardship of NHMFL, for which DMR provides approximately 95% of the funding, even though that facility is serving an increasingly broad user community and is involved in developing a future light source facility.

The Board next heard from Eileen Friel, executive officer of NSF's Division of Astronomical Sciences (AST). Dr. Friel reported similar budgetary constraints faced by the other Divisions. As a consequence, all facilities have been held flat and they haven't been able to increase grants nor implement new programs. AST recently was reviewed by a Committee of Visitors, which provided generally positive observations and conclusions and saw no need for fundamental changes in direction or use of existing resources. They are also implementing a Senior Review Update that recommends adjustments to the funding of several programs, which they intend to implement. The decadal survey of astronomy and astrophysics is being planned for and they are looking for the recommendations from that study to guide future efforts.

Tom Gergely and Andy Clegg, from NSF's ESM Office, and John Zuzek, from the NASA Spectrum Management and

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BPA (continued from page 3)

Planning Office, spoke to the BPA about spectrum management activities in their offices. Dr. Gergely discussed the outcome of the recent World Radio Conference (WRC-07) and expectations for the conference to be held in 2011. Dr. Clegg discussed some of the consequences, including increased interference, from the analog to digital TV transition. Dr. Zuzek focused on spectrum issues as they affect space operations, and the various protections sought that impact spaced-based radars.

Ed Weiler, Associate Administrator of NASA's Science Mission Directorate (SMD), and Jon Morse, Director of NASA's Astrophysics Division, fielded questions from the BPA and its guests on SMD's activities. They remarked on the budget outlook for astrophysics, the effects of a change in administration, and the next decadal survey in astronomy.

The session after lunch began with Pat Dehmer, Deputy Director for Science Programs at DOE, discussing her division's research activities. In the last two years, they have seen more volatility than historically observed in the amounts appropriated versus presidential requests, which has affected planning. She commented that BES continues to operate a set of state-of-the-art facilities, and that 40% of the BES budget goes to these facilities. She remarked on the usefulness of recent NRC studies, including the Energy Summit and America's Energy Future initiative; stating that NAS can and needs to weigh in on issues such as energy policy.

Harriet Kung, the new Director of the Materials Sciences and Engineering Division of BES, DOE, spoke next. She emphasized the new team structure in that division, with a new focus on Materials Discovery, Design and Synthesis and the combination of Condensed Matter and Materials physics. The Five Nanoscale Science Research Centers (NSRC) are in operation and serving users. They currently are under review and four out of the five are very strong. Like the other divisions, they saw a significant budgetary shortfall which has impacted all aspects of their funding. Dr. Kung ended by reporting on the results of a series of workshops addressing outstanding energy issues.

Dennis Kovar, Acting Associate Director for the DOE's Office of High Energy Physics (HEP), reported on the status of HEP, noting that facilities they are supporting offer high promise. However, recent budget cuts have affected their productivity and workforce, causing the loss of momentum and some credibility issues with collaborators and partners in some of the facilities. The current budget has produced detrimental consequences for Fermilab and SLAC, and for projects in development such as NOvA and the ILC.

The next presentation to the Committee was a joint discussion with representatives of the Office of Management and Budget–Joel Parriott, Amy Kaminski and Michael Holland–and the Office of Science and Technology Policy, represented by John Henry Scott. They touched on general science funding and some of the steps the physics communities need to take to promote a better legislative response to funding requests. These include emphasizing the concrete, measurable benefits society gets out of the funding provided. OMB also discussed a need for science to track the production and careers of its students

Jehanne Simon-Gillo, head of Nuclear Physics (NP) at DOE, discussed the activities of that office. She noted that 90 percent of federal support for nuclear physics comes from NP. While the programs NP supports have made the United States a leader in two major subfields of nuclear physics, they are facing international investments that challenge that leadership in the future. Like many other divisions, they have been subject to significant budgetary constraints in recent years and need sustained funding to fully realize the benefits of past investments and achieve planned goals.

Ray Fonck, head of Office of Fusion Energy Sciences at DOE, spoke next. After first discussing some of the ongoing work in plasma sciences funded by his office, he commented on the status of the ITER project. While there is a significant

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Committees of the Board on Physics and Astronomy

Committee on Radio Frequencies
Jeffrey Piepmeier, NASA Goddard Space Flight Center, *Chair*
Douglas C.-J.Bock, UC-Berkeley/CARMA, *Vice Chair*

Committee to Assess the Impact of Selling the U.S. Helium Reserve[1]
Charles G. Groat, University of Texas at Austin, *Chair*

Materials Synthesis and Crystal Growth Committee
Paul S. Peercy, University of Wisconsin at Madison, *Chair*

Plasma Science Committee
Riccardo Betti, University of Rochester, *Chair*

Research at the Interface of the Physical and Life Sciences Committee[2, 3]
Erik O'Shea, Harvard University, and Peter G. Wolynes, University of California at San Diego, *Co-chairs*

Scientific Assessment of Free-Electron Laser Technology for Naval Applications Committee[4]
Thomas Katsouleas, University of Southern California, *Chair*

Solid State Sciences Committee
Barbara Jones, IBM Almaden Research Center, *Chair*
Monica Olvera de la Cruz, Northwestern University, *Vice Chair*

Spectrum Study Committee
Marshall H. Cohen, California Institute of Technology, and Albin J. Gasiewski, University of Colorado at Boulder, *Co-chairs*

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[1]Joint with National Materials Advisory Board
[2]Joint with Board on Life Sciences
[3]Joint with Board on Chemical Sciences and Technology
[4]In coordination with Naval Studies Board

Planning for Astronomy & Astrophysics 2010 Well Under Way

Michael H. Moloney, BPA Staff

Planning is at an advanced stage for the next astronomy and astrophysics decadal survey—the next in a series of surveys that have been carried out approximately every 10 years. This series has provided priorities for the federal investment and have enabled the remarkable success of the field with facilities such as the Hubble Space Telescope. The decadal survey process is organized by the BPA in cooperation with the Space Studies Board, and the study is being sponsored by NASA, NSF and (for the first time) DOE.

Now that negotiations with the sponsors are complete on the scope of the study, the survey committee is expected to be appointed over the summer months with a first meeting in the fall. At that first meeting, the survey committee will decide on the structure and timeline of the study, including the organization and reporting schedule for the up to nine panels that are envisioned. Each panel will report directly to the survey committee to communicate the results of their respective panel's deliberations. The exact organizational nature of relationship will be determined by the survey committee. Upon receiving each panel's final input, the survey committee will discuss their recommendations and develop a decadal research strategy for the field.

Membership

The process to appoint the chair of the Astro2010 survey committee is well under way. The NRC solicited suggestions for chair from the community by means of several mechanisms. An email announcement was sent to the membership of the American Astronomical Society in early June 2008 requesting suggestions for the chair and membership of the survey committee and panels. Also, in an address to the Astronomy Section of the National Academy of Sciences during the April 2008 NAS meeting, NAS Astronomy Section chair John Huchra and BPA chair Anneila Sargent asked for nominations for the survey chair position. Suggestions were also gathered during Town Hall meetings jointly held at the April 2007 APS Meeting, the January 2007 AAS Meeting, and the January 9, 2008 AAS Meeting.

Over 300 members of the astronomy and astrophysics community suggested a total of 85 candidates for the position of Astro2010 chair. To sift through these suggestions, the BPA and SSB formed a search committee that has considered the suggestions for chair and developed a short list of candidates at its meeting on July 14, 2008. The short list is now being considered by the BPA and SSB and the NRC's Division of Engineering and Physical Sciences, before being presented to the NRC Chair and NAS President, Dr. Ralph Cicerone, who will make the appointment. This process should be complete by late August. As with all NRC panels, Dr. Ralph Cicerone will also appoint the survey committee and panel members.

Suggestions for survey committee and panel members are still welcome, and should be submitted as soon as possible; the cut off dates are as follows:

• Nominations for Survey Committee membership will be taken through August 25, 2008

• Nominations for panel membership will be taken through October 15, 2008

These cut off dates are subject to change as the appointment process progresses. Please check the Astro2010 website for updates. A web-based nominations form can be found at http://www.nationalacademies.org/astro2010.

Throughout the study, the committee and sub-panels will continue to solicit community input. Researchers and other interested parties will be able to submit written contributions to the survey process and a series of town meetings will be held, including at the AAS meeting in Long Beach, CA in January 2009. Details of all these activities can be found on the Astro2010 web page. By the time of the January 2009 AAS meeting, the survey will be well under way and the town meeting there will provide an early opportunity for the community to interact with the chair and committee members.

Scope

The decadal survey will address the future of the U.S. astronomy and astrophysics program by formulating a decadal research strategy with recommendations for initiatives in priority order within different categories (related to the size of projects and their home agencies). In addition to reviewing individual initiatives, aspects of infrastructure, and so on, the committee will take a comprehensive look at the U.S. astronomy and astrophysics program and make a judgment about how well the program addresses the range of scientific opportunities and how it might be optimized. The guiding principle in developing the decadal research strategy and the priorities will be maximizing future scientific progress.

In contrast to previous surveys of the field, in view of the number of previously recommended but unrealized projects, the prioritization process will include those unrealized projects and it will not be assumed that they will go forward. Projects that are sufficiently developed in terms of engineering design and technology development or have been given a formal start by the sponsoring agency would not, in general, be subject to reprioritization. ■

Astro 2010 Statement of Task

• The committee will survey the field of space- and ground-based astronomy and astrophysics, recommending priorities for the most important scientific and technical activities of the decade 2010-2020.

• The principal goals of the study will be to carry out an assessment of activities in astronomy and astrophysics, including both new and previously identified concepts, and to prepare a concise report that will be addressed to the agencies supporting the field, the Congressional committees with jurisdiction over those agencies, and the scientific community.

Growth and Change at the BPA

Caryn Knutsen, BPA Staff

New Board Chair and Vice-Chair

The BPA Chair position, attended to over the past 3 years by Anneila Sargent-Caltech, rotated to Marc Kastner-MIT, previously Vice Chair of the BPA, in June. The BPA would like to sincerely thank Dr. Sargent for her diligent work and expert leadership throughout her term, during which she oversaw the completion of 15 BPA reports and the inception of the next decadal survey of astronomy and astrophysics.

Marc Kastner is the new Chair of the Board on Physics and Astronomy. Dr. Kastner is Donner Professor of Physics and Dean of Science at the Massachusetts Institute of Technology. He is also affiliated with the Quantum-Effects Devices Group at MIT's Research Laboratory for Electronics. He received his Ph.D. at the University of Chicago in 1972, and has been a member of the Department of Physics at MIT since 1973. He served as director of the NSF-sponsored Materials Research Science and Engineering Center at MIT from 1993 to 1998. Dr. Kastner's research involves experimental studies of the behavior of electrons in semiconductors and high-temperature superconductors; many also consider him to be the "father" of the single electron transistor. He is a fellow of the American Physical Society, a fellow of the American Association for the Advancement of Science; in 1988 he received an Outstanding Scientific Accomplishment Award from DOE's Division of Materials Science. In 1995 he received the David Adler Lectureship Award of the American Physical Society. Dr. Kastner has also served on the NRC's Solid State Sciences Committee (SSSC) including two years as SSSC chair and he is a member of the National Academy of Sciences.

Adam Burrows is the new Vice-Chair of the Board on Physics and Astronomy. Dr. Burrows is a Professor of Astrophysical Sciences at Princeton University. Prior to Princeton, he was on faculty at the University of Arizona. He received his B.A. in physics from Princeton University in 1975, and his Ph.D. in physics from Massachusetts Institute of Technology in 1979. His research is focused on supernovae and on the formation of small objects such as brown dwarfs and extrasolar planets. Dr. Burrows was been a member of both the NRC's Committee on Astronomy and Astrophysics and the Committee on Rare Isotope Science Assessment. He was also a member of the theory panel of the 2000 Astronomy and Astrophysics decadal survey, and has recently served as the chair of NASA's road mapping effort for the search for Earth-like planets.

New Faces

James Lancaster joined the BPA as a program officer in March 2008. Dr. Lancaster holds a B.A degree in Economics from Rice University, a J.D. degree from the University of Texas, a B.A. degree in physics from Portland State University, and M.A. and Ph.D. degrees in physics from Rice University. His doctoral thesis involved investigating interactions between slow moving, spin-polarized charged particles and an array of surfaces. Dr. Lancaster subsequently became a staff researcher at Rice University, where he participated in experimentation investigations studying the interactions of highly excited atoms with electromagnetic pulses and surfaces. He also served on faculty at Rice, teaching introductory physics to science and engineering students. During his time at Rice, Dr. Lancaster received both the Wilson Prize for an outstanding doctoral thesis in physics and astronomy and the APS teaching award for his work as an instructor of undergraduates. He is the co-author of over 25 peer-reviewed articles and a member of the American Physical Society.

Allison McFall joined the BPA in June as a Senior Program Assistant. Previously, she spent three years at Meridian International Center as a Program Associate where she administered one of the U.S. Department of State's professional exchange programs. Allison has a B.A. in International Affairs and a minor in political science from Florida State University. While in college, she studied in Valencia, Spain and London, UK. At the BPA, she is responsible for the administrative aspects of multiple committees.

Beth Dolan joined the NRC in June 2008 and serves as the Financial Manager for both the BPA and the BSMA. Previously, Ms Dolan was employed with the International Society for Performance Improvement for three years. Prior to that she worked for the American Association of State Highway & Transportation Officials for four years.

Staff Growth

Donald Shapero has been promoted to Senior Board Director for the Board on Physics and Astronomy. Dr. Shapero received a B.S. from MIT in 1964 and a Ph.D. from MIT in 1970. His thesis addressed the asymptotic behavior of relativistic quantum field theories. After receiving the Ph.D., he became a Thomas J. Watson postdoctoral fellow at IBM. He subsequently became an assistant professor at American University, later moving to Catholic University and then joining the staff of the National Research Council in 1975. Dr. Shapero took a leave of absence from the NRC in 1978 to serve as the first executive director of the Energy Research Advisory Board at DOE. He returned to the NRC in 1979 to serve as special assistant to the president of the National Academy of Sciences. In 1982, he started the NRC's Board on Physics and Astronomy (BPA). As BPA director, he has played a key role in many NRC studies, including the two most recent surveys of physics and the two most recent surveys of astronomy and astrophysics. He is a member of the American Astronomical Society and the International Astronomical Union, and a fellow of both the APS and the AAAS. He has published research articles in refereed journals in high-energy physics, condensed-matter physics, and environmental science.

Michael Moloney has rejoined the BPA staff as Associate Director. Although Michael has spent the last four years as a senior program officer at the National Materials Advisory Board, he remained during this time involved with a number of BPA activities including the AMO2010 and Plasma2010 decadal studies. A physicist, Michael did his graduate PhD work at

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CORF Meeting

David B. Lang, BPA Staff

The Committee on Radio Frequencies (CORF) met for its spring meeting at the Keck Center of the National Academies in Washington, D.C. on May 20-21, 2008. The committee heard presentations from several government representatives. Tom Gergely and Andrew Clegg, National Science Foundation, John Zuzek, NASA, and David McGinnis and David Franc, NOAA, spoke to CORF about their agency's perspectives of the outcomes stemming from the recent World Radiocommunication Conference (WRC) which concluded in November 2007. They also discussed future agenda items of interest to radio astronomy (RAS) and Earth remote sensing (EESS) that will be debated at the next WRC, currently scheduled for 2011. CORF's legal counsel, Paul Feldman, described ongoing FCC proceedings pertaining to RAS and EESS. Ron Repasi, Federal Communications Commission (FCC), presented information on developments at the FCC and how CORF might communicate with the FCC in the future. Representatives of Iridium spoke to CORF about the company's next generation system of satellites, and how it is working with passive scientific users to help mitigate future interference issues. The day concluded with a talk by Tom von Deak, NASA, on the Global Positioning System and its applications to aid science.

The second day of the meeting was devoted to a discussion with CORF's foreign colleagues regarding spectrum management issues and notable radio science developments in their home countries. In addition to the previous day's guests, Alberto Carramiñana, INAOE (Mexico), B. Murray Lewis, NAIC (USA), Harvey Liszt, NRAO (USA), Mónica Rodriguez, Subtel (Chile), and Ken Tapping, Herzberg Institute for Astrophysics (Canada) were in attendance. The discussions were productive, and CORF came away with several tasks to aid in strengthening both international and domestic spectrum management coordination. ■

Highlights of the Spring Meeting of the Solid State Sciences Committee

Jim C. Lancaster, BPA Staff

The Solid State Sciences Committee held its spring meeting at the Keck Center of the National Academies in Washington, D.C. on April 11-12, 2008. As part of its efforts to stay abreast of leading edge research in the solid state sciences communities, the committee heard from several speakers. The first speaker of the day was Dr. Jeanie Lau, from the University of California, Riverside, who discussed recent research involving graphene. Dr. Clare Grey, from SUNY Stonybrook, closed out the first day of the meeting, speaking on challenges facing those engaged in research on lithium ion batteries. Dr. David DiVincenzo, of IBM Yorktown Heights, began the second day's meeting by addressing some of the outstanding solid state issues arising in the quantum computing field. The committee also heard from one of its own members, Dr. George Crabtree, of Argonne National Laboratory, who reported on the status of workshops conducted by the Basic Energy Sciences Advisory Committee (BESAC) for the Department of Energy, on the role science can take in facing the United States' energy challenges.

A significant portion of the meeting also involved hearing from and engaging with representatives of the federal funding agencies that provide support for the solid state sciences communities. All of the agencies reported extremely tight funding, causing them to significantly limit their ability to fund research and pursue new initiatives. Finally, the committee spent time discussing topics for possible future studies. Two areas of particular interest are evaluating what new materials and phenomena will be needed to meet future energy needs and to extend the information technology revolution. ■

SSSC Roster

Barbara Jones, *Chair*
IBM Almaden
Monica Olvera de la Cruz, *Vice-chair*
Northwestern University
Daniel Arovas
University of California, San Diego
Collin L. Broholm
Johns Hopkins University
Paul Chaikin
New York University
George Crabtree
Argonne National Laboratory
Elbio Dagotto
Oak Ridge National Laboratory and University of Tennessee
Duane Dimos
Sandia National Laboratories
Andrea J. Liu
University of Pennsylvania
Joseph Orenstein
University of California at Berkeley
Arthur P. Ramirez
Alcatel-Lucent
Richard A. Register
Princeton University
Mark Stiles
National Institute of Standards and Technology
Dale Van Harlingen
University of Illinois, Urbana-Champaign
Fred Wudl
University of California, Santa Barbara

BPA Staff
Donald C. Shapero, *Director*
James C. Lancaster, *Program Officer*
Allison McFall, *Sr. Program Assistant*

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The Solid State Sciences Committee (SSSC) is a continuing interdisciplinary body with expertise in solid-state physics, solid-state chemistry, electronic materials, metallurgy, polymers, and the basic materials science aspects of ceramics. The committee identifies and makes recommendations on the needs of the materials research, development, and applications community, particularly in connection with research opportunities and support, and it provides guidance to federal agencies regarding their materials science research programs.

Fusion (continued from page 1)

economically attractive fusion energy is just around the corner, however. Daunting engineering challenges still remain even after the demonstration of ignition. In fact, the development of a viable fusion power plant requires large scientific and financial investments. In a magnetic confinement fusion system operating in steady state, truly ignited plasmas are fully self-heated by the α-particles, and, after the initial start up phase, the input energy is negligible and the energy gain is, theoretically, infinite. ITER, to be constructed over the next decade in Cadarache, France, is technically not an ignition experiment but its predicted energy gain is large enough (~10-20) to study many important physics issues of a magnetically confined burning plasma. In inertial confinement fusion (ICF), the hot plasma is only confined for a very short time (hundreds of picoseconds) by its own inertia while the thermonuclear instability (e.g. ignition) develops in the center of a tiny capsule of DT plasma (~1 mg) compressed to ultra-high densities (>100 g/cc) and pressures ($>10^{11}$ atm) by an external driver, typically a laser or other source of intense radiation.

The ignition process in inertial fusion has the same role of the spark plug in a gasoline engine. The spark in the center of the compressed plasma ignites the neighboring DT nuclei thus launching a burn wave that lights up the entire mass of thermonuclear fuel. The hot blob of DT plasma keeps burning until it cools down due to its own hydrodynamic expansion. The ratio between the fusion energy output and the input energy required to compress the DT capsule yields the energy gain. Because of its finite mass and finite burning time, the energy gain of an ICF capsule is always finite, even under idealized conditions. To increase the energy gain requires more fuel mass, a larger driver and/or greater compression. New ICF concepts, such as fast ignition, based on a two-laser system (one for compression and one for heating of DT fuel) may open a viable path to higher gains and smaller drivers. In terms of burning plasma physics, there are only minor qualitative differences between a gain of 10 and 100 in inertial fusion, though to demonstrate the viability of inertial fusion energy, achieving gains in excess of 100 is of fundamental importance.

The National Ignition Facility at Lawrence Livermore National Laboratory, a formidable laser (500-Terawatts, 1.8MJ of UV light on target) set for completion in 2009 is predicted to demonstrate an energy gain of ~20-30—large enough to fully test the physics principles of thermonuclear ignition via inertial confinement. Achieving even higher gains is a possibility under favorable circumstances.

The NIF will first test the indirect drive approach to inertial confinement fusion. In indirect drive, a cryogenic spherical capsule containing a solid DT layer is imploded by the x-rays emitted from a cylindrical enclosure irradiated with the NIF laser. According to complex numerical simulations, the capsule volume shrinks by about 40,000 times, the DT density reaches ~1000 g/cc, and the central plasma is heated to a temperature of about 100 million ^{o}C before the onset of ignition. Achieving such an extreme state of matter can only be accomplished if the compression is uniform. This requires a large number of laser beams (192 for the NIF), careful control of the illumination pattern, and a target with very smooth surfaces.

The direct drive approach can also be tested on the NIF. In direct drive, the laser beams are directed on the target surface and used to accelerate the cryogenic DT shell to implosion velocities up to 400 km/s. Imploding shells are unstable to hydrodynamic instabilities that amplify the initial nonuniformities either imprinted by the laser on the target surfaces or caused by imperfections in the target manufacturing. An excessive growth of such instabilities can lead to the target breakup and failure to reach the ignition condition. While numerical simulations indicate that hydrodynamic instabilities can be controlled within acceptable levels, some uncertainties still remain with regard to the achievement of ignition and energy gains on the National Ignition Facility.

Within the next five years, initial data on the performance of indirect drive ignition targets will provide essential information on the prospects for thermonuclear ignition and the viability of inertial fusion energy. The moment of truth is approaching rapidly for ICF and the fusion community is gearing up for the challenge. ■

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progress to report, several major design issues must be addressed in the near future. Of more critical importance is the funding instability here in the United States. In order to continue participating in ITER, the United States will need to comply with its financial obligations to the project. Funding constraints on other parts of their budget are presenting challenges in terms of prioritizing projects. Finally, Dr. Fonck reported that they are considering reorganizing OFES in response to recommendations in the Plasma 2010 and other NRC reports.

Michael Donovan, from the National Nuclear Security Administration (NNSA), presented the last talk of the day. Dr. Donovan discussed the inertial confinement fusion (ICF) program being funded by his agency. He noted that NNSA's funding has declined by 20% in the last decade, even though research being conducted remains strong. Several other programs are either in process or coming on line, including additions to the Omega laser system and refurbishment of the Z Pulsed Power Generator at Sandia National Laboratories.

The committee adjourned for the day, and reconvened the next morning in public session with a talk from Board Member Michael Turner. Dr. Turner spoke about the large-scale characteristics of the federal budget, noting that, of the $3T budget, $2T is mandatory spending, $0.5T is defense spending, and $0.5T covers everything else. He then discussed the role of R&D funding, noting that funding as a percentage of GDP in the United States has been flat for the past 15 years, and that it can no longer dominate sciences as it once did. While dominance is no longer possible, leadership is, and there is a need to recognize and respond to this.

Lastly, Joe Redish, from the University of Maryland, discussed a growing interest in a decadal study of physics education that he hopes would be undertaken by the NRC. Dr. Redish commented that physics education is growing in complexity and that biology and engineering have already completed such a study.

The meeting adjourned with a thank you from outgoing BPA chair, Anneila Sargent. ■

BPA Changes (continued from page 6)

Trinity College Dublin with John Hegarty (formerly of Bell Labs) and received his undergraduate degree in experimental physics at University College Dublin, where he was awarded the Nevin Medal for Physics. Michael has served as a Study Director on many studies across the NRC, including reports for the BPA, NMAB, the Board on Manufacturing and Engineering Design (BMED), and the Center for Economic, Governance, and International Studies (CEGIS). In addition to his over six years of professional experience at the National Academies, Michael has over seven years experience as a foreign-service officer for the Irish government. Michael re-joins the BPA as it is preparing for the Astronomy 2010 Survey. He will be taking on the role of study director for the survey.

David Lang has been promoted to Program Officer. Mr. Lang received a B.S. in astronomy and astrophysics from the University of Michigan in 2002. Mr. Lang came to the BPA as a research assistant supporting multiple studies . As a program officer he is responsible for the operation of several standing and study committees, including the Committee on Radio Frequencies and the Committee to Review the U.S. ITER Science Participation Planning Process. In January 2006 he received the "Rookie" award of the NRC's Division on Engineering and Physical Sciences. He is currently working on his master of public policy degree at the University of Maryland at College Park.

Caryn Knutsen has been promoted to Program Associate. She came to the BPA in 2006 as a Senior Program Assistant after completing a B.S. in mathematics from the University of Colorado at Colorado Springs in 2006. While attending CU-Colorado Springs, she also earned two Certificates in Industrial Mathematics (levels 1 and 2). At the BPA, she operates in various administrative and supporting roles for multiple committees, and in January 2008 she received the "Rookie" award from the NRC's Division on Engineering and Physicals Sciences. She is a member of the Society of Industrial and Applied Mathematics. ■

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committee emphasizes that a vigorous and strategically balanced domestic program is required to ensure that U.S. participation in ITER is successful and valuable for the U.S. fusion program.

• The DOE plan for U.S. participation in ITER includes well-thought-out metrics for measuring progress toward development of fusion energy as a power source.

• The DOE plan includes well-thought-out metrics to measure the robustness of U.S. participation in the ITER project.

Based on these findings, the committee makes the following recommendations:

• The Department of Energy should take steps to seek greater U.S. funding stability for the international ITER project to ensure that the United States remains able to influence the developing ITER research program, to capitalize on research at ITER to help achieve U.S. fusion energy goals, to participate in obtaining important scientific results on burning plasmas from ITER, and to be an effective participant in and beneficiary of future international scientific collaborations.

• Important considerations that are not reflected in the current DOE plan for U.S. participation in ITER should be addressed during the further development of the DOE plan. These considerations include:

- Existing gaps in planning for a Demonstration Power Plant;
- Dissemination of information on and the results of ITER research activities to the broader scientific community; and
- Planning for the recruitment and training of young scientists and engineers.

• The committee recommends that the following goals be adopted as the foundation of DOE planning activities for U.S. participation in ITER:

- Ensuring broad academic and industrial participation in ITER;
- Enabling the United States to contribute substantially to and reap the rewards from ITER; and
- Recruiting and training young fusion scientists and engineers.

• The committee recommends the following procedures to accomplish the U.S. planning goals recommended above, and to facilitate the further development of the DOE plan:

- DOE should create a long-term strategic plan for the U.S. burning plasma fusion program within the context of global fusion energy development activities.
- The U.S. Burning Plasma Organization should continue to be an essential point of communication, and serve as a home team to encourage broad cooperation and collaboration among all U.S. participants in the ITER project.
- DOE should maintain a vibrant domestic fusion program through strong support for basic research and facilities.
- The DOE plan for U.S. participation in ITER should consider what capabilities exist and need to exist at U.S. plasma science facilities.
- The DOE plan should consider the needed operating availability of domestic tokamaks.

• The committee recommends that the following five metrics be considered for inclusion during the future development of the DOE plan for U.S. fusion community participation in ITER.

- Periodic evaluation by expert and knowledgeable members of the scientific, engineering, and industrial community regarding the U.S. return on its ITER investment.
- Periodic assessments by independent, external bodies of the effectiveness of domestic project management.
- Balance in the fraction of U.S. published research conducted on ITER according to author's institutional affiliation (university, national laboratory, and industry).
- Number of research and technology publications documenting results obtained on ITER that are cited by or produced in collaboration with U.S. researchers, students, and technologists across U.S. plasma science and physics.
- Achievement of predictive capability, to be evaluated by peer review.

The committee's final, unedited, prepublication version of its report is available for free download at the National Academy Press website.■

Helium Committee Roster

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and purification plants and facilities for helium shipping and pipeline transmission. In 1960, the world's first underground helium storage facility was developed. The storage facility in Texas maintains the Federal Helium Reserve (Reserve), which currently consists of about 23 billion cubic feet (Bcf) of government-owned helium. The facility also contains about 2 Bcf of helium stored under contract for private producers. In the United States in 2006, about 3 Bcf of helium were consumed, and an additional 2 Bcf were produced for export.

With the passage of the Helium Privatization Act of 1996, PL 104-273, the government's role in the helium market was redefined, effectively handing responsibility for future conservation efforts to the private sector. In addition, the legislation ordered the Department of the Interior to begin selling off the Reserve by 2005 and required that all but 600 million cubic feet be offered for sale by 2015 in a manner consistent with "minimum market disruption" and at minimum price given by a formula specified in the Act.

The Bureau of Land Management (BLM) conducted its first open-market crude-helium sale in March 2003 and has held four additional open market crude helium sales. Revenue generated from all sources minus operating and environmental cleanup cost has been returned to the U.S. Treasury–$459 million at the end of 2007.

In 2006 the global helium industry experienced a helium demand-supply imbalance. The shortage has been reported to be the result of several factors including scheduled and unscheduled U.S. plant maintenance outages, problems with production from two plants in Algeria and one plant in Qatar, and compressor problems at a key facility on the Federal Helium Conservation Pipeline.

Among its provisions, the 1996 Act called for a National Academy of Sciences study to determine the impact of selling the Reserve using the pricing mechanism described in the Act. The first study was published by the National Academies' Press (NAP) in 2000. Five open-market crude-helium sales have been conducted since and so it is now timely to reevaluate the impact of selling helium under the current pricing mechanism and to determine whether there are adjustments that would optimize future availability of helium for its many scientific and industrial uses.

This new study will determine whether selling off the U.S. Helium Reserve in the manner prescribed by law has had any adverse effect on U.S. scientific, technical, biomedical, and national security users of helium. To provide a meaningful context for this effort, the study will examine the helium market and the helium industry supply chain.

The study committee will address the following tasks:

• Review the report *The Impact of Selling the Federal Helium Reserve* (NAP, 2000) and compare projected expectations with actual outcome. Determine the reasons for the differences.

• Examine the availability and reliability of worldwide supply, technical opportunities to increase that supply—such as through improved recovery—and the relationships among supply, demand, and market price.

• Assess the current and projected U.S. marketplace for refined helium, including worldwide helium demand by industrial and other users. Assess the role of private industry in future conservation efforts.

• Assess the current "flywheel" concept for operating the Reserve. Develop scenarios for how the Reserve might be used to meet future helium demand.

• Assess the role that organizational and financial factors play in meeting the goals of the Federal Helium Program. Identify measures that would enable the Program to respond more effectively to the dynamics of the helium industry.

The first phase of the study is under way with the committee meeting for the first time on June 24th and June 25th in Washington DC. Having heard there from the sponsors, federal science agencies, and the majority of liquid helium suppliers, the committee is now planning the remainder of the study. The committee's report is expected in mid 2009. Further details on the study can be found on the BPA web page. ■

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, 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 about 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

• *Astronomy and Astrophysics 2010.* The BPA, in conjunction with the Space Studies Board, has completed negotiations with the agencies for the next decadal survey of astronomy and astrophysics and the process to appoint the committee is well under way. This survey, named Astronomy and Astrophysics 2010 (Astro2010), will be completed by a survey committee with the support of a series of panels. The survey's charge is given in the article on p.5. The BPA has engaged the community in the committee appointment process by soliciting suggestions for the chair, the survey committee, and the panel. Panel chairs and members will be drawn from the pool of suggested candidates. The appointment of the survey committee will follow after the chair is in place. Once appointed, the survey committee will meet to decide on the panel structure. More information is available at http://www.nationalacademies.org/astro2010.

• *Physics Education 2010.* Future success in physics research depends on the ability of the physics community to continue to recruit, retain, and prepare talented physics students. The BPA is currently working on a proposal for a decadal study on undergraduate physics education. This study would help the physics and science education communities understand both the challenges and opportunities the nation faces at this time and would help ensure that intellectual and financial resources are deployed so as to optimize their impact. The study would also identify the grand challenges facing undergraduate physics education research and examine issues underpinning the field.

• *Committee on Atomic, Molecular, and Optical Science* (CAMOS). The BPA is preparing for the revival of its standing committee on atomic, molecular, and optical sciences, which is expected to begin operating again this coming winter (2008-09). The committee's operating guidelines will be: (1) to provide active stewardship of the agenda laid out by the AMO 2010 report; (2) to provide a means by which federal agencies can request technical information and assistance from the National Academies about AMO science and related fields; (3) to initiate case studies on important and timely topics in AMO science and/or its multidisciplinary connections with other fields of science and technology; and (4) to provide an interface for communication among the subfields of the AMO community as well as with the staff of federal agencies that support research in the field.

BPA Update: Meetings in 2008-9

October 2008	
10/10-11	Plasma Science Committee Meeting, Washington, D.C.
10/23-24	Solid State Sciences Committee Meeting, Irvine, CA
November 2008	
11/1-2	BPA Meeting, Irvine, CA
11/3-4	Helium Committee Meeting, Irvine, CA
11/19	Committee on Radio Frequencies Meeting, Irvine, CA
March 2009	
3/27-28	Plasma Science Committee Meeting, Washington, D.C.
April 2009	
4/11-12	Solid State Sciences Committee Meeting, Washington, D.C.
4/24-25	BPA Meeting, Washington, D.C.

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:

Inspired by Biology: From Molecules to Materials to Machines

A Review of the DOE Plan for U.S. Fusion Community Participation in the ITER Program

Coming Soon:

Final report of the New Materials Synthesis and Crystal Growth Committee

Final report of the Research at the Intersection of the Physical and Life Sciences Committee

Final Report of the Spectrum Study Committee

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BPA Newsletter for: