BPA News

Board on Physics and Astronomy • National Research Council • Washington, DC• 202-334-3520• BPA@NAS.EDU • December 1995

Board on Physics and Astronomy Focuses on New Physics Survey

The BPA met at the Academies' Beckman Center in November. The Board reviewed a number of its activities. This article summarizes some of the highlights.

Physics Survey

The Board is currently carrying out a series of studies leading to a new survey of physics entitled *Physics in a New Era*. The status of the series is as follows:

Completed

Atomic, Molecular, and Optical Science: An Investment in the Future. National Academy Press (1994). Available from NAP (800-624-6242). ISBN 0-309-05032-4

Plasma Science: From Fundamental Research to Technological Applications. National Academy Press (1995). Available from NAP (800-624-6242). ISBN 0-309-05231-9

In Progress

Committee on Elementary-Particle Physics. Chair: Bruce Winstein, University of Chicago.

Under Consideration

- *Condensed-Matter and Materials Physics*
- *Nuclear Physics*
- *Biological Physics*
- *Computational Physics*
- *Overview*. This volume will be the final one in the series, to be published by 1999. It will summarize and update the reports on the branches of physics listed above and address topics that concern physics as a whole. Among these topics are the unity of physics, physics and society, connections with other fields of science and engineering, demographics and career paths, international cooperation and competition, and emerging cross-cutting areas of research.

Other Topics

Charles Shank reported on the work of the Committee on Optical Science and Engineering (COSE), which he chairs. COSE, under the joint sponsorship of the BPA and the National Materials Advisory Board, is in the process of holding a series of workshops on national needs. Details of the workshops may be found on the BPA website at http://www.nas.edu/bpa.

The Chair of the Committee on Elementary-Particle Physics, Bruce Winstein of the University of Chicago, described plans for preparing a volume of the physics survey on elementary-particle physics. The Committee has been formed and plans its first meeting on December 8. The membership of the committee can be found on the BPA website.

The new director of the NRC's Office of Scientific and Engineering Personnel, Dr. Charlotte Kuh, described plans for a study of career paths in the physical sciences. The BPA endorsed the plan and expressed the hope that the results would be available for incorporation in the physics survey overview.

Marc Davis, chair of the Committee on Astronomy and Astrophysics, discussed a request from NASA for a study of the possibilities for new astrophysics missions that would follow the completion of the present priorities identified in the Bahcall report, *The Decade of Discovery in Astronomy and Astrophysics*.

Tom Gaisser, Chair of the Committee on Cosmic-Ray Physics, described the recently completed report *Opportunities in Cosmic-Ray Physics and Astrophysics*, an article on which appears in this issue.

The Board will meet next in Washington, DC on April 27-28, 1996. ■

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Solid State Sciences Committee Plans Forum

Approximately every two years, the Solid State Sciences Committee holds a forum in Washington for discussion and information exchange among researchers and policy makers. Forum participants include leaders from academia, industry, government laboratories, federal agencies, and the Congress. The 1996 forum, to be held February 12–13 at the National Academy of Sciences in Washington, will be entitled *Driving Innovation Through Materials Research*.

A member of Congress has been invited to present the keynote address. Agency leaders such as Martha Krebs, Director of the DOE Office of Energy Research, and Arati Prabhakar, Director of NIST, will discuss the R&D outlook from the federal agencies. A special session on wealth creation through materials R&D will feature presentations from William F. Brinkman (AT&T), Paul Horn (IBM), and others. The forum will also explore the R&D opportunities presented by new photon and neutron facilities and by new scientific directions such as nanomaterials.

For more details, see page 4. If you would like to attend, please return the registration form on pages 5-6 of this newsletter as soon as possible. For the latest on plans for the forum, see the SSSC web page, http://www.nas.edu/bpa/sssc.html. ■

Committee on Cosmic-Ray Physics Issues Recommendations for Agencies

by Tom Gaisser, Chair, CCRP

The Board on Physics and Astronomy of the National Research Council established the Committee on Cosmic-Ray Physics to prepare a review of the field that addresses both experimental and theoretical aspects of the origin of cosmic radiation from outside the heliosphere. This action was initially motivated by a request from the Space Physics Division of the National Aeronautics and Space Administration (NASA) to consider the program of research in this discipline in light of new constraints on the scope of missions at NASA, which made previously planned cosmic-ray missions on a large space station and on the Space Shuttle seem difficult to realize at that time. In the meantime, it has become apparent that exciting new opportunities in cosmic-ray physics are ripe for significant progress with ground-based detectors as well as with observations from spacecraft or balloons. Accordingly, the committee was charged to provide a balanced assessment of the entire field at this point and to consider the experiments needed to take advantage of current scientific opportunities.

Another reason for undertaking a balanced assessment of the field is that cosmic-ray physics is an intrinsically interdisciplinary subject. It is a part both of physics and of astrophysics. Its support, moreover, is drawn from several different sources, including NASA, the National Science Foundation (NSF), and the Department of Energy (DOE). The scientific rationale for the field becomes fully apparent only when all aspects of the subject are seen together. Thus, for example, measurements of positrons and antiprotons are relevant both to models of cosmic-ray propagation (space astrophysics) and to searches for dark matter in the universe (particle physics and cosmology). A direct measurement of the composition of high-energy cosmic rays above the atmosphere (supported by NASA) will not only clear up an important question about the efficiency of supernovas as cosmic accelerators, but also calibrate ground-based experiments (supported by NSF and DOE) that can extend the measurements to still higher energies.

The work of the committee began in late 1993, at which time there was a call for comments from the community by electronic mail and through the Division of Astrophysics of the American Physical Society. An interim report entitled *Cosmic Rays: Physics and Astrophysics, A Research Briefing* (National Academy Press, Washington, D.C.) was issued in mid-1994. The committee met again during the Snowmass Summer Study, "Particle and Nuclear Astrophysics and Cosmology in the Next Millennium." The Committee's report reflects interactions of the individual committee members with many working groups and individual scientists during the summer study and afterward, as well as earlier discussions.

Studies of energetic particles from distant regions of the galaxy and the universe bring us information about the processes in which the particles are accelerated to relativistic energies, about the role of the particles and their accelerators in driving dynamical processes in our galaxy and beyond, and about the distribution of matter and fields in interstellar space. This information is complementary to astronomy with photons in various wavelength bands.

The field of cosmic-ray physics has evolved sufficiently so that the general outlines of a theory of the origin of cosmic rays are visible, but as the field has evolved, important questions have been raised. What is the physical origin of the similarities between galactic cosmic rays and solar flare particles? What is the maximum energy to which supernova blast waves can accelerate particles? Can we find specific point sources of high-energy cosmic rays? Is there a high-energy component of protons or nuclei from distant, extragalactic sources, and

how does it interact with microwave background radiation on cosmological time scales? What new sources may be responsible for the few highest-energy particles observed recently with the largest ground-based detectors? Are there signals among cosmic-ray positrons or antiprotons of the existence of dark matter? Are there cosmic-ray antinuclei?

There is much new activity aimed at answering these questions, including efforts by scientists previously working in other fields who have been attracted by the scientific interest of some of the problems. The committee's recommendations reflect this new activity and interest. Cosmic-ray physics is an interdisciplinary field, both in the nature of the scientific problems it addresses and in the techniques it uses. Thus, this report emphasizes the need for the granting agencies to be aware of and responsive to initiatives that sometimes cross the boundaries of traditional scientific disciplines.

Summary Recommendations

• ***NASA should provide the opportunity to measure cosmic-ray electrons, positrons, ultraheavy nuclei, isotopes, and antiparticles in space.***

These measurements are needed to identify the sources of the material that gets accelerated; to understand the time scales for injection, acceleration, and propagation; and to search for possible exotic sources of cosmic rays. They will also lead to greater understanding of the structure and dynamics of the plasma surrounding the Sun. Small, low-cost missions, such as those carried out in NASA's Explorer program, can address each of these issues. Because of the long lead time needed for space experiments, it is essential that there be strong support for balloon payloads. In some cases, significant scientific results can be achieved with such suborbital exposures; in addition, this activity is of great benefit in the development of future payloads for space and in training students to work in a variety of fields that require advanced technical skills.

• ***NASA, NSF, and DOE should facilitate direct and indirect measurement of the elemental composition to as high an energy as possible. Support of long-duration ballooning and support of hybrid ground arrays will be needed to accomplish this end.***

The goal here is to look for a maximum energy associated with acceleration by supernova-driven shocks, which is expected to occur around 10^{14} eV. Since the cosmic-ray spectrum continues to higher energy, a cutoff in one type of source would imply a transition to a new source capable of accelerating particles to higher energy. Understanding whether and how such a transition occurs is an important objective. There is already an indication for some structure in the energy spectrum near 10^{14} eV. Because of the low intensity of cosmic rays at such high energy, however, present direct measurements with detectors flown above the atmosphere have not accumulated enough data to clarify its significance. Long-duration balloon flights of detectors will extend direct measurements by an order of magnitude in energy. Hybrid ground arrays, overlapping with direct measurements at the low-energy end of their range, will extend the study of composition beyond the "knee" of the spectrum to much higher energy.

• ***NSF and DOE should support the new Fly's Eye and provide for U.S. participation in the big projects on the horizon, which include giant arrays, ground-based γ-ray astronomy, and neutrino telescopes.***

In the energy range above 10^{18} eV there is possible evidence from large air-shower experiments for a transition to a different, high-energy component of the cosmic radiation. This component may originate far outside our galaxy, or at least from its outermost reaches. The high-resolution Fly's Eye will be able to explore this region with unprecedented energy resolution. Giant arrays spread over thousands of square kilometers are needed to accumulate sufficient statistics to study the very highest-energy particles, which probe cosmological distances and may lead to the discovery of new, energetic astrophysical sources.

The main thrust of ground-based γ-ray astronomy is to extend present measurements to lower energy and to greater levels of sensitivity in order to study the variety of galactic and extragalactic sources that are being discovered at lower energy with detectors on the Compton Gamma-Ray Observatory. Objects such as active galactic nuclei may be high-energy particle accelerators producing secondary photons and neutrinos at the source. It is desirable to extend measurements of spectra of γ rays from these and other point sources beyond the energies of present space experiments to understand these sources better. If sufficiently large neutrino telescopes can be built, a comparison between neutrino and photon fluxes from the same objects or classes of objects could be made that will be very helpful in understanding physical processes within the source. Because of their great penetrating power, neutrinos probe activity deep within sources where the corresponding photons would be reabsorbed.

• ***NASA, NSF, and DOE should support a strong program of relevant theoretical investigations.***

Examples of key problems are sources and propagation of the highest-energy particles; how the details of the source and the magnetic field geometry determine the maximum energy of a particular accelerator; and the relation between acceleration of electrons and acceleration of ions.

These recommendations cover a broad range of topics and techniques, yet the underlying astrophysical processes that we seek to understand, taken together, form a coherent whole. One unifying theme is particle acceleration on a variety of scales; another is the role of energetic particles in the dynamics of the universe, again on many scales, from the heliosphere to supernova remnants, to the galactic disk and halo, and beyond to clusters of galaxies and distant active galaxies. Ultimately, cosmic rays are tracers of the processes by which the elements, synthesized in stars, are dispersed and reprocessed by energetic processes such as stellar winds, supernova explosions, and jets driven by accretion onto compact objects. The committee concludes that carrying out the recommendations of this report will lead to significant advances in our understanding of these processes from which important new insights and discoveries are likely. ■

Driving Innovation Through Materials Research

The 1996 Solid State Sciences Committee Forum
Lecture Room
National Academy of Sciences
Washington, DC
February 12–13, 1996

Monday, February 12, 1996

Session I: National Perspectives on R&D

Welcome and Introduction – *Paul A. Fleury, SSSC Chair*
Keynote – *Member of Congress TBD*

Session II: Institutional Perspectives on the R&D Landscape

Reinventing R&D – *Erich Bloch, Distinguished Fellow, Council on Competitiveness*
The Research University in 2000 – *Arden Bement, Purdue University*
Research in the Semiconductor Industry – *Charles Shanley, Motorola*
A View from the DOE National Labs – *Al Narath, Lockheed Martin Corporation*

Session III: Outlook from the Federal Agencies

National Science Foundation – *Neal Lane, Director, NSF (to be confirmed)*
National Institute of Standards and Technology – *Arati Prabhakar, Director, NIST*
Department of Energy – *Martha Krebs, Director, DOE Office of Energy Research*
Department of Defense – *Anita Jones, Director, Defense Research and Engineering, DOD*
Panel Discussion – *Speakers and Staffers with SSSC Moderator*

Tuesday, February 13, 1996

Session IV: Materials R&D – Wealth Creation Through Technology

Photonics Accomplishments and Challenges – *William F. Brinkman, Physical Sciences Research Vice President, AT&T Bell Laboratories*
Materials Aspects of Computer and Storage Science – *Paul Horn, Director, IBM Almaden Research Center*
Materials in the New Auto Age – *Norman Gjostein, Director, Materials Research Laboratory, Ford Motor Company*
R&D in Component Suppliers – *Jeffrey Frey, University of Maryland*

Session V: Opportunities in Techniques and Technology

Photon Facilities for Materials Research – *David Moncton, Director, Advanced Photon Source, Argonne National Laboratory*
Neutron Facilities – *Mike Rowe, Chief, Reactor Radiation Division, NIST*
Nanomaterials – *George Whitesides, Harvard University*
Panel Discussion and Wrap-Up: How to Combine Past Lessons and the Current Climate to Ensure that Materials Continues to Drive Innovation – *Paul Fleury, Moderator*

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1996 Solid State Sciences Committee Forum

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Driving Innovation Through Materials Research

TO REGISTER FOR THE 1996 SSSC FORUM

By *January 15, 1996*, send a filled-out copy of this form to the address below with your early registration fee* of $100 (make your check out to "1996 SSSC Forum") or use the form as a self-mailer, folding it and *sealing it on all three sides* so that your check stays inside.

1996 SSSC Forum
Board on Physics and Astronomy – HA562
National Research Council
2101 Constitution Ave., N.W.
Washington, DC 20418
Telephone: (202) 334-3520
Email: BPA@NAS.EDU

*After January 15, the registration fee is $150.

- ☐ My early registration fee of $100 made out to "1996 SSSC Forum" is enclosed.
- ☐ I plan to attend the reception on February 12, 1996, following the first day of the Forum.
- ☐ I plan to take advantage of the block of rooms that has been reserved at the Wyndham Bristol Hotel. (Contact Travel One at 800-367-2038.)
- ☐ I would like to receive a copy of the *Proceedings of the 1993 Solid State Sciences Committee Forum*.

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1996 Solid State Sciences Committee Forum

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The Editorial Page
Science and the New Congress

by James Jensen

The relationship between the scientific enterprise and the Congress is undergoing some fundamental changes. A great deal of attention has been paid to the recent controversies involving the projected cuts in the federal research and development budget—but that is only part of the story. Much deeper fundamental shifts are occurring that could change the post-World War II relationship that has been so beneficial to the scientific community. The shifts are occurring on two planes.

The first plane is well known, and that is the federal budget deficit. The deficit, which is projected to be about 160 billion dollars for fiscal year 1995, is placing an enormous strain on what are called (in budget parlance) domestic discretionary programs. The budget, in the manner that politicians consider it, is divided into four categories: debt payment, entitlement programs (such as social security), defense spending, and the domestic discretionary program. R&D comprises roughly 20 percent of the domestic discretionary programs. Currently, the domestic discretionary programs are the most pressured. As long as the deficit exists, the debt payments have to be made.

Cutting entitlement programs is politically explosive, and defense spending currently enjoys more political sanctity than domestic programs. This is not simply a matter of Republican vs. Democratic platforms—many Democrats are loath to cut defense programs as they are vast sources of jobs to constituents. This leaves domestic discretionary programs, such as R&D spending, at risk when Congress and the President seek to balance the budget over time. So while the projected cuts are not necessarily a sign that science has suddenly become politically unpopular, they *are* a sign that support for such programs always needs to be justified as compared to other federal missions, whether it be the environment, housing, veterans' benefits or disaster relief. This budgetary pressure will continue, at least in the near term, regardless of the accomplishments or worthiness of federal science programs.

The second plane is more subtle and less noticed, but could certainly affect science funding. Since 1990, the structure and membership of the Congress, and particularly the House of Representatives, have been undergoing what I refer to not so much as a revolution but a convectional turnover.

Since World War II, science has enjoyed an enviable relationship with Congress. Most members of Congress, although not very versed in science or engineering, believed that science and technology were good for the nation's welfare. The goals differed sometimes—in the 1950s Congress supported science because it was perceived to be critical to our national security. By the 1980s, many supported it because they perceived it to be good for the nation's economy. Congress has always believed that biomedical research was beneficial to the nation's health, and especially during the 1980's, science and technology were thought to be the ultimate solution to a host of major energy policy challenges. Whatever the problem or goal, members of Congress often saw science as a solution or means and funded it accordingly.

This support was buttressed by the seniority system in Congress, where most major funding decisions were made by members who had been in Congress for decades and who had developed great familiarity with many science and technology programs. Furthermore, particularly for the appropriations committees, their decisions about funding were often unquestioned and were rarely ever reversed by either the House or Senate as a whole. More junior members hoped to stay in favor with the senior members, so that they might occupy those more senior and powerful committee posts one day.

Since 1990, this established decision making system has been undergoing a transformation. The membership in Congress is changing dramatically. In the last two elections, almost 100 new members have entered the House of Representatives, and more than half of the House has been serving only since 1990. In the post-1933 era, Congress had experienced much lower turnover, with 20–30 members entering Congress after each election. Twelve senators have retired from the Senate this year, the most ever since the popular, direct election of Senators began in 1913. Thus the membership of Congress is changing rapidly, and those members who gained their familiarity with science and technology through years and decades of exposure have, in many cases, retired.

Furthermore, the new class of Congressmen has apparently rejected the earlier system of letting the senior appropriations members make all the essential funding decisions, with ratification by the House and Senate at large a matter of routine. Very recently, the House rejected the Republican leadership's compromise for bill funding the Veterans' Administration, Department of Housing and Urban Development, EPA, NASA and NSF, because the House thought its spending on veterans' programs too small. Only a short time ago, it would have been considered fanciful or even suicidal to challenge the appropriations committee. During this recent Congress, such actions have become almost routine. So it no longer suffices for science funding to be supported by a few powerful chieftains. Broad support will be required if science support is to be maintained at levels comparable to those enjoyed in the past. The scientific community will have to rethink how it tells its story to the public and to the government if it is to realize that broad support. ■

James Jensen directs the National Research Council's Office of Congressional and Government Affairs.

UPCOMING EVENTS:

SOLID STATE SCIENCES COMMITTEE 1996 FORUM

To attend, PLEASE SEND IN ENCLOSED REGISTRATION FORM

Recently Completed Studies:

- *Opportunities in Cosmic-Ray Physics and Astrophysics.* Available from the Board on Physics and Astronomy (202-334-3520)
- *Cosmology: A Research Briefing.* Available from the Board on Physics and Astronomy (202-334-3520)

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