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APS NEWS

JUNE 1997 THE AMERICAN PHYSICAL SOCIETY VOLUME 6, NO 6

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Highlights from Kansas City March Meeting

Approximately 4,400 physicists converged on the Kansas City Convention Center in Kansas City, Missouri, 17-21 March, for the Society's annual March Meeting. Over 4,500 technical papers were presented, mostly on topics in condensed matter and materials physics, as well as related fields. APS units represented at the meeting included the Divisions of Biological Physics, Chemical Physics, Condensed Matter Physics, Fluid Dynamics, High Polymer Physics, and Materials Physics. Recently established Topical Groups on Statistical and Nonlinear Physics and Magnetisim and its Applications as well as the Forum on Industrial and Applied Physics were also represented.

Among the technical highlights were numerous sessions on carbon nanotubes, as well as the measurement of atto-Newton forces using magnetic resonance microscopy, the latest on switchable mirrors, the observance of self-organized criticality in mammalian brain cells, the development of x-ray microprobes, and splitting DNA using optical tweezers. There was also a special session featuring lectures by this year's Nobel Prize winners.

Nontechnical highlights included a session on the challenges of handling nuclear waste, a look at entrepreneurial physics, and a humorous series of lectures exploring the "lighter" side of science, the third such session organized by the APS Topical Group on Instrument and Measurement Science since 1994. The meeting also featured celebrations of the 100th anniversary of the discovery of the electron and the 50th anniversary of the transistor.

Prizes and Awards. The traditional ceremonial session for the bestowal of prizes and awards was held Monday evening, followed by a reception hosted by APS President D. Allan Bromley (Yale University). Ten APS

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Career Task Force Makes Recommendations to APS Council

The APS Task Force on Careers and Professional Development presented its final report and recommendations to the APS Council in April. Chaired by Diandra Leslie-Pelecky (University of Nebraska, Lincoln), the task force was created last year in response to concerns over the changing situation for employment of physicists. "The Task Force was asked to take a long-range approach and think of ways that the APS could stimulate improved preparation and broadened career options for physicists," said Barrett Ripin, APS Associate Executive Officer. "We are pleased that did just that," he said.

The charge to the task force included advising the APS on efficient and effective mechanisms for coordinating and integrating the existing Society career-oriented programs with the AIP Career Services Division; formulating a long-term strategy to address career and professional development issues, incorporating existing elements of the APS as well as new ideas and programs; and identification and assistance in the implementation of new programs to effectively serve the physics community in dealing with career issues.

First and foremost, the task force determined that the APS must be concerned with career and professional development issues at all levels, including not only PhDs, but also Master's degree recipients, bachelor-level physicists, and mid-career physicists faced with career changes, voluntary or otherwise. While acknowledging that the need to increase the exposure of faculty and students to different career options has been recognized by the APS and AIP through numerous programs, the task force found that these programs do not currently reach as many members as they could, and called for a continuation of efforts to obtain outside funding for such activities.

Developing a workshop designed to educate faculty about the changing job market, was another recommendation. Suggested contents for workshops, to be presented at APS meetings, included

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Four Corners Section Established by Council

The Four Corners Section, the first new APS regional section since 1976 was established by unanimous vote of APS Council at its April 19 Meeting, subject to ratification of its bylaws by the APS Constitution and Bylaws Committee. The Four Corners Section encompasses Arizona, Colorado, New Mexico, and Utah. There are over 300 charter members to date. APS members living in the Four Corners area are encouraged to join the new section by writing it in on their APS invoice returns. Note that Section memberships are free to APS members.

Interim Four Corners Section Officers, elected by an organizational group meeting in Albuquerque on March 22nd, are: Chair, Bill Evenson (BYU), Chair-elect, J.D. Garcia (U. Of Arizona), Vice-chair, David Wolfe (UNM), Secretary-Treasurer, Eric Jones (Sandia), plus members-at-large of the Executive Committee: Brenda Dingus (U. Of Utah), Mariet Hofstee (Colorado Sch. Of Mines), Andrea Palounek (LANL), Michael Petras (Motorola-Tempe). Harry Lustig, APS Treasurer emeritus and now living in Santa Fe, played a leading role in the new section's formation.

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Members To Vote on Proposed Amendment to APS Mission Statement

At its April meeting, the APS Council approved a proposed amendment to the APS mission statement. The proposed revision will appear on the election ballot this summer for APS members to vote on its adoption. The amendment — actually a preamble — to the APS objective is motivated by a desire to articulate the organization's concern for science education and public affairs issues, and to expand the objective to include activities in this area. The text of the proposed amendment is below.

Article II - Objective.

In the firm belief that an understanding of the nature of the physical universe will be of benefit to all humanity the objective of the Society shall be the advancement and diffusion of the knowledge of physics.

Council Statements Endorsed

Passage of Nuclear Test Ban Treaty

In April, the APS Council approved a statement endorsing the Comprehensive Test Ban Treaty (CTBT), drafted by the APS Panel on Public Affairs (POPA). The statement was prompted by concern that failure of the U.S. to ratify the treaty would tempt other nations to begin testing nuclear weapons again, and greatly weaken the political restraints on those states that do not currently have nuclear weapons. The JASON Group, an independent group of senior non-government scientists that advises the U.S. Department of Energy on national security issues, has released a report concluding that nuclear testing will not be needed, provided that a viable stockpile stewardship program is in place.

The CTBT has now been signed by the five nuclear weapons states and 132 other nations, and is expected to strengthen the nuclear Non-Proliferation Treaty, signed by more than 175 nations agreeing not to develop or acquire nuclear weapons. According to POPA Chair Robert White, the treaty will also strengthen nuclear nonproliferation by raising the technical and political barriers for non-nuclear weapons states to develop nuclear weapons, and for the three primary nuclear weapons states to develop more powerful fission weapons. In addition, the CTBT will strengthen monitoring down to one kiloton or lower in a growing number of locations.

The full text of the APS Council statement follows.

On September 10, 1996, the United Nations overwhelmingly approved the Comprehensive Test Ban Treaty (CTBT), a treaty ending all nuclear testing, of any yield, at any location, for all time. The United States, all other declared nuclear weapon states, and a growing majority of the world's nations have now signed that treaty. Although the date at which the CTBT will enter into force is not yet certain, the treaty is of extraordinary importance to the United States and to the future of all humankind.

The CTBT, the culmination of over 40 years of effort, ends the qualitative arms race among the nuclear states and is central to future efforts to halt the further spread of nuclear weapons. The promise to negotiate and put into force a CTBT was an essential pre-condition to achieving an indefinite extension of the Non-Proliferation Treaty (NPT) in May 1995. Ratification of the CTBT will mark an important advance in uniting the world in an effort to contain and reduce the nuclear danger.

Having been the first country to develop nuclear weapons, having been a major participant in the nuclear arms race of the Cold War, and having played a leadership role in the NPT extension and the CTBT negotiations, it is appropriate and imperative that the United States ratify the Comprehensive Test Ban Treaty at the earliest possible date. The Council notes that detailed, fully informed technical studies have concluded continued nuclear testing is not required to retain confidence in the safety and reliability of the remaining nuclear weapons in the United States' stockpile, provided science and technology programs necessary for stockpile stewardship are maintained. This conclusion is supported by both the senior civilian and military officials responsible for U.S. national security.

The Council of the American Physical Society, representing 41,000 academic, industrial and laboratory physicists, endorses the CTBT, including its extensive technical and procedural provisions to verify compliance with treaty requirements.

Open Flow of Scientific Information

At its April meeting, the APS Council approved a statement in support of the open exchange of scientific data, in response to recently proposed changes to laws that protect intellectual property, which could translate into overly restrictive policies governing "fair use" exceptions for the contents of databases. Fair use exceptions enable scientists and educators to use copyrighted materials, such as published research papers, for free or at reduced costs, if the information is used for research, teaching or other specific purposes.

Specifically, the proposed laws would enable database vendors to charge scientists and educators at commercial rates for access and even, in some cases, to maintain a monopoly on publicly funded research data. According to R. Stephen Berry, a professor of chemistry at the University of Chicago who chaired a National Research Council committee appointed to report on the issue, it is feared that such restrictions could greatly inhibit collaborative scientific research projects that depend on constantly updated information. Limiting access to data would be especially damaging to sciences concerned with international issues such as global change and the environment, the prevention and treatment of disease, and biodiversity, each of which requires the open exchange of globally compatible data among scientists in both rich and poor nations.

Last year the World Intellectual Property Organization (WIPO), an intergovernmental organization affiliated with the United Nations that promotes the protection of intellectual property, introduced a draft treaty on databases and intellectual property at a diplomatic conference. Although the treaty was rejected, WIPO may propose a new version later this year without "fair use" exceptions for scientists and educators.

If WIPO were to endorse such a treaty, it would establish new international norms that in turn would obligate the U.S. and other signatory countries to amend their own intellectual property laws, the NRC committee reported. The Commission of the European Communities (CEC), which sets economic policies for its member states, adopted an intellectual property directive that fails to provide adequate fair use exceptions in February 1996. U.S. legislators introduced a similarly restrictive bill in the House of Representatives in May 1996.

"Science is a cumulative process, and laws that inhibit the flow of science information by making it unaffordable would force cutbacks in research as well as significantly slow our progress in science and technology," said Berry. "These laws are flawed from an economic point of view because of the possibility that unrestricted monopolies may result, particularly by people who have no direct concern for the public benefits of science."

The full text of the statement follows.

The open flow of scientific data is essential to the progress of science. The American Physical Society is therefore greatly concerned by proposed legislation and treaties which would impose, through copyrighting of data bases, severe restrictions upon the fair use of scientific data, the generation of which was supported by public funds. The Society supports a balanced approach to copyright laws, which maintains the traditional principles of fair use and of expiration of copyright after a reasonable period, while still protecting intellectual property rights of authors and publishers.

Neutron Scattering Facilities

At its April meeting, the APS Council approved a statement calling for the renewal and enhancement of U.S. neutron scattering facilities by the U.S. government. According to Frank S. Bates, president of the Neutron Scattering Society of America, the most pressing challenges facing the neutron scattering community are reactor upgrades at Brookhaven National Laboratory and Oak Ridge National Laboratory (ORNL), and construction of a short pulsed spallation source in the power range of one measurement. These projects would provide neutron scattering scientists and engineers in the U.S. with capabilities approaching those currently available in Europe. The full text of the Council statement follows.

The American Physical Society recognizes the scientific importance of neutron scattering science as a key area of endeavor for physics, chemistry, materials and biomedical research. For many decades, the United States was preeminent in neutron scattering science with state-of-the-art reactor and spallation neutron facilities. Today we have lost that preeminence and could well cease to be a major player in this field — in spite of its centrality to fundamental scientific studies as well as many areas of science important to national needs.

The critical need for modern neutron scattering facilities has been well documented and recommendations have been made to upgrade U.S. capabilities, but the needed developments have not come to fruition. If our neutron scattering facilities are not enhanced soon, this field will suffer damage to its research programs that will take decades to rebuild. As U.S. leadership is lost, important technologies that depend upon the knowledge gained from neutron scattering studies — including the development of new polymers, superconductors and chemical catalysts, and the use of neutron probes to study the stresses and impurities in materials that affect the performance and safety of structures such as bridges and aircraft — are increasingly at risk. In addition, we are no longer able to supply our growing needs for neutron-produced radiopharmaceuticals.

The Council of the American Physical Society stresses the critical important of neutron scattering to a wide spectrum of scientific and technical fields and urges the U.S. government to proceed rapidly with the renewal and development of national reactor and spallation neutron facilities.

APS News

Coden: ANWSEN ISSN: 1058-8132
Series II, Vol. 6, No. 6 June 1997

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Editor: Barrett H. Ripin
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APS News (ISSN: 1058-8132) is published 11X yearly, monthly, except the August/September issue, by The American Physical Society, One Physics Ellipse, College Park, MD 20740-3844, (301) 209-3200. It contains news of the Society and of its Divisions, Topical Groups, Sections and Forums; advance information on meetings of the Society; and reports to the Society by its committees and task forces, as well as opinions.

Letters to the editor are welcomed from the membership. Letters must be signed and should include an address and daytime telephone number. The APS reserves the right to select and to edit for length or clarity. All correspondence regarding *APS News* should be directed to: Editor, *APS News*, One Physics Ellipse, College Park, MD 20749-3844, email: letters@aps.org.

Subscriptions: *APS News* is an on-membership publication delivered by Periodical Mail. Members residing abroad may receive airfreight delivery for a fee of $20. **Nonmembers:** Subscription rates are: domestic $160; Canada, Mexico, Central and South America, and Caribbean $180; Air Freight Europe, Asia, Africa and Oceania $210.

Subscription orders, renewals and address changes should be addressed as follows: **For APS Members**—Membership Department, The American Physical Society, One Physics Ellipse, College Park, MD 20740-3844, membership@aps.org. **For Nonmembers**—Circulation and Fulfillment Division, American Institute of Physics, 500 Sunnyside Blvd., Woodbury, NY 11797. Allow at least 6 weeks advance notice. For address changes, please send both the old and new addresses, and, if possible, include a mailing label from a recent issue. Requests from subscribers for missing issues will be honored without charge only if received within 6 months of the issue's actual date of publication.

Periodical Postage Paid at College Park, MD and at additional mailing offices. Postmaster: Send address changes to *APS News*, Membership Department, The American Physical Society, One Physics Ellipse, College Park, MD 20740-3844.

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NSF Faculty Early Career Development Program

Proposals for FY98 are now being considered for the Faculty Early Career Development (CAREER) program sponsored by the National Science Foundation. CAREER is a Foundation-wide activity that supports junior faculty within the context of their overall career development. It combines in a single program the support of research and education of the highest quality and in the broadest sense. The program emphasizes the importance that the NSF places on the early development of academic careers dedicated to stimulating the discovery process in which the excitement of research is enhanced by inspired teaching and enthusiastic learning.

Furthermore, beginning in 1997, the NSF will select up to 20 nominees from among the most meritorious first-year awardees supported by the CAREER program for the Presidential Early Career Awards for Scientists and Engineers (PECASE). PECASE awards recognize outstanding scientists and engineers show exceptional potential for leadership at the frontiers of knowledge early in their careers. It is the highest honor bestowed by the U.S. Government on scientists and engineers beginning their independent careers.

The application deadline for the CAREER program is July 22, 1997, significantly earlier than last year's deadline. Those interested in applying may find additional information on the NSF home page [http://www.nsf.gov] or the Career Program Announcement [http://www.nsf.gov/pubs/1997/nsf9787/nsf9787.txt].

Physics History on the Web

The AIP Center for History of Physics announces two new science history exhibits on the World Wide Web:

Discovery of the Electron. This year is the centennial of the experiments that led J.J. Thomson to announce the discovery of the first fundamental subatomic particle. The history of this famous advance can be reviewed at the Web site below. A text based on recent historical studies is accompanied by photographs, animated diagrams, quotes, and clips of Thomson's voice. Science teachers and students in particular should profit from viewing the site. [http://www.aip.org/history/electron]

Online Einstein Museum. The Center for History of Physics also offers a large Web site giving a guided tour through the life of Albert Einstein. Numerous pictures along with quotes and voice clips illustrate an authoritative text by historians. The viewer can click on menu items dealing with Einstein's formative years, his revolutionary works such as relativity, his world fame (with period cartoons), the nuclear age, and many other subjects. It is organized with an index of topics and features, a chronology of basic facts, and links to much additional information on the Web about Einstein's life and science. [http://www.aip.org/history/einstein]

Career Task Force *(Continued from page 1)*

discussion of the skills necessary for different careers and how to provide students with opportunities to acquire them; mechanics of helping students find a non-academic job; and information on successful programs at other schools. While AIP currently presents career workshops, the task force noted that these are directed towards students and do not contain materials specific to the needs of the faculty member's role as mentor. Sessions directed toward faculty have instead generally focused mostly on statistics. Strong input from industrial scientists was also deemed critical to ensure the relevance of the workshop material.

In addition, the task force suggested that the APS offer short courses on management skills, communication skills, and other helpful skills which might be of interest to APS members. The APS might also offer a short course on pedagogy for physics faculty and graduate students who are teaching or interested in pursuing a teaching career. The task force also suggested development of two short videotapes, one for undergraduate students and another for graduate students, to be provided to physics departments across the country. Finally, the task force called for continued efforts to compile statistical information tracking postdoctoral fellows. This would hopefully help answer questions about where they eventually find jobs.

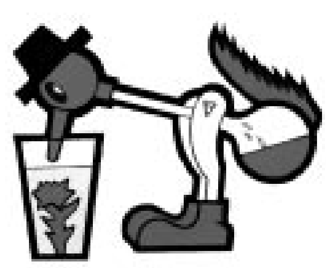
The task force also recommended that an APS committee be given the primary responsibility for career issues and implementing its recommendations, preferably one drawing its members from academia, industry and government to ensure balanced representation. The APS is currently looking into the best way to establish this committee. The task force acknowledged the involvement of several APS forums in this area and emphasized that the committee assignment is not meant to discourage forums from continuing to participate; rather, it will help centralize information for members and provide coordination among interested parties. Over the next year, the Task Force will continue its work, but shift emphasis towards implementing its recommendations.

The members of the task force are: Diandra Leslie-Pelecky, Chair (University of Nebraska), Tony Nero (Lawrence Berkeley National Laboratory), Robert Kwasnick (General Electric), Steven J. Smith (NCAR), Glen Crawford (Stanford Linear Accelerator Center), Robert Bartolo (University of Maryland), Peter Abbamonte (University of Illinois and Argonne National Laboratory), and Peter Wolff (MIT). The senior APS advisor to the task force is Barrett Ripin and Arlene Modeste is staff liason. Also contributing to the discussions were Ed Goldin of AIP's Career Services, Roman Czujko of AIP's Employment and Statistics Division, APS Executive Officer Judy Franz, APS Treasurer Tom McIlrath, AAPT Executive Officer Bernard Khoury, Kevin Aylesworth of the APS Education Division and Sherrie Preische of APS Special Projects.

A full copy of the task force report may be viewed through the APS home page [aps.org] under the Career and Employment button or a hard copy may be obtained by contacting Arlene Modeste, APS, One Physics Ellipse, College Park, MD 20740; phone: (301) 209-3232; email: modeste@aps.org.

IN BRIEF

- Donald H. Weingarten of IBM/Yorktown Heights has been awarded the APS 1997 Aneesur Rahman Prize for Computational Physics. His citation reads, "For his seminal work on lattice quantum chromodynamics, including algorithmic innovations, massively parallel computer software development and hardware implementation that led to calculations of hadron masses and the mass and decay couplings of the scalar glueball." A native of Massachusetts, Weingarten received his PhD from Columbia University in 1970 and subsequently held research positions at Fermilab, the University of Copenhagen, the University of Paris, and the University of Rochester. In 1976 he joined the faculty of Indiana University, leaving in 1983 to join the research division of IBM/Yorktown Heights, where he has worked ever since. The Rahman Prize was established in 1992 with support from IBM and Argonne National Laboratory. It is intended to recognize and encourage outstanding achievement in computational physics research. The Rahman Prize will be presented to Weingarten at the PC'97 Meeting to be held August 25-28, 1997 in Santa Cruz, CA.
- The APS Committee on the Status of Women in Physics and the Forum on History of Physics are co-sponsoring the creation of an historical archive, compiling an electronic collection of citations of women who have made original and important contributions to physics in the 20th century. The project is part of plans for the celebration of the 1999 Centenary of the APS. Nina Byers, UCLA, is directing the project. The APS Council's Executive Board has allocated funds to help pay for the project. UCLA, where the web-site is located, has also provided funds. There turned out to be far more contributions than even the originators of the project realized. So far 167 scientific biographies have been collected and 29 are ready for viewing on the project's Website (http://www.physics.ucla.edu/~cwp). Citations include brief descriptions of the contributions documented with references to published papers, as well as some biographical information.
- The recent energy study conducted by the APS Panel on Public Affairs, which provided the background materials for the APS Council statement on energy ("Energy: the Forgotten Crisis"), is now available on the World Wide Web [http://www.aps.org/public_affairs/popa]. Included are text of background papers written by individual members of the POPA Subcommittee on Energy and Environment. At this point, they reflect the views and perspectives of the authors and not necessarily those of POPA or the APS. Topics include a summary of the current energy situation; a look at kinds of energy supplies, such as fossil energy, nuclear fission energy and renewable energy; an overview of energy use trends, and transportation and energy issues; and other considerations, including climate change, DOE's R&D priorities, pedagogic energy modeling, and energy units. The summary of the energy study is available at the same site.
- The National Science Foundation is instituting new merit review criteria for all grant proposals beginning October 1, 1997. The new criteria were drafted by a special task force formed by the NSF and the National Science Board to suggest changes to the review criteria, which have not been revised since 1981. The task force presented draft criteria to the scientific and engineering community for public comment in November 1996, and the subsequent revised version was approved by the National Science Board in March. Specifically, the task force reduced the number of criteria reviewers must consider from four to two: the intellectual merit of the proposed activity, and its broader impacts. Each of the criteria has a set of related questions to help reviewers evaluate the proposals. Reviewers are asked to provide separate comments for each criterion, a single composite rating of the proposal, and a summary recommendation that addresses both criteria. The task force believes that "adoption of the new criteria will facilitate, clarify, and simplify the proposal evaluation process."
- Two APS fellows were among seven winners of the 1996 E.O. Lawrence Award, established in 1959 to honor the memory of the late Dr. Ernest Orlando Lawrence, who invented the cyclotron and after whom two major DOE laboratories are named. The award is given in seven categories for outstanding contributions in the field of atomic energy. The awards will be presented at a ceremony in Washington, DC, this spring; winners will each receive a god medal and $15,000. APS member Thomas H. Dunning, Jr., a theoretical chemist at Pacific Northwest National Laboratory, is being honored in the Chemistry category for his electronic structure calculations on molecules, which has been applied in laser technology, combustion chemistry and environmental chemistry. Sunil K. Sinha, an engineer at Argonne National Laboratory, will receive the award in the Materials Research category for developing new techniques for using x rays and neutron scattering to learn new details about the structure of many materials.



Prudence

by Robert Garisto

There once was a prof lacking prudence
Who studied a black hole's refusance
To show hide or hair
Of what he'd tossed there,
Including the last of his students!

OPINION

APS VIEWS

What Have You Done for Me Lately?

by Irving Lerch, APS Director of International Scientific Affairs

It may be discomforting, but it's sometimes necessary to take a critical look at our cherished beliefs and venerated relationships and ask, "What have you done for me lately?"

Over the past few years, perhaps in response to the faltering public support for science, a great deal of soul-searching has taken place as various panels have reviewed the status and value of the international scientific unions and the whole panoply of domestic and foreign organizations which comprise the global scientific enterprise. And in these days of budgetary pain and uncertainty, it's easy to sniff waste and inefficiency, and to conclude that our institutions have failed us. So, disintermediation is in and soft-minded accommodation is out. To use the jargon of our era, it's time to hang tough and play a zero-sum game.

Consider the opening paragraph of a report on a meeting on international cooperation on research in science, engineering and medicine, held in Bellagio, Italy in the fall of 1995, which commented, "The institutions designed to serve global science since the end of World War II are not keeping pace with the changes sweeping science and technology." In short, everyone is quite sure that our institutional mechanisms for international science are inadequate, but incremental change and not revolution is preferred.

In a review of the International Union of Pure and Applied Physics (IUPAP) a few years ago, the APS Executive Board concluded that few physicists knew anything about IUPAP, its purpose, or its value. A minority of physicists were aware that IUPAP sponsorship for conferences was essential if they were to use grant funds to attend. Some were aware that ICSU provisions for the free circulation of scientists were important to open conferences to attendees whose political origins would other bar them. And a very tiny group actually participated in the commissions of the Union. One wag suggested that this ignorance might be a good thing, since it was proof that IUPAP was not disruptive and may actually be contributing in some quiet way to the workings of international physics.

But doing no harm is no longer sufficient justification for spending money. The Bellagio panel generated a long list of generic ills broadly applied to many different kinds of international organizations: deficiencies in governance and staffing, narrow participation and focus, lack of resources, institutional rigidity and inefficiency. For example, the panel noted that, "Most institutions ... focus their efforts on university and government scientific capacity. As an economic sector, the private sector has not been recognized as a critical player in global science and rarely has a seat at the collaborative table."

Only in the past few years has the APS itself acknowledged such deficiencies and sought to correct them. But APS is a membership organization whose validity and viability derives from its grass roots. This is not true of the international scientific unions, whose rigid structure and glacial pace of doing business makes it difficult to institute new programs and organizational change. Yet for three generations, when the world was cemented into the post-War political order, this fixity was seen as a virture by many.

What other structures are open to us? The U.S. has increasingly turned to binational foundations to promote scientific collaborations. Establishments such as the U.S.-Korea Science and Technology Forum and the German-American Academic Council Foundation were created at the highest political level and then launched as private initiatives. Because of their lofty origins, they readily promote collaborations across institutional and disciplinary divisions, bringing together a broad collection of government, industrial, policy, technical and administrative experts. Such fora are difficult to organize on a multinational scale, In fact, experience shows that as the international scope broadens, the depth of outcome becomes more shallow.

Both the APS and the Korean Physical Society are sponsors of the U.S.-Korea forum. The membership society is an engine which can revitalize the international physics enterprise. As grass-roots organizations charged with serving the needs of their members, such societies are most sensitive to the prevailing winds which alter the course of science. This sense of change coupled with a firm commitment to science are the essential ingredients for all the organizations in the global physics enterprise.

IUPAP, on the other hand, is insulated from the societies by the national academies and research councils of its members. While the APS has statutory positions on the U.S. Liaison Committee (USLC) for IUPAP, it must act through the National Research Council's Board on Physics and Astronomy in its dealings with the Union. Nonetheless, the APS and other participating societies have moved to invigorate the USLC by taking a more active role in its deliberations. In return, the IUPAP Executive Committee is seeking tighter connections to national and regional societies.

To explore the growing list of critcal issues confronting the international scientific community, APS President Allan Bromley, Past President Robert Schrieffer, and President-Elect Andrew Sessler have called for a small consultative meeting this October of the largest membership societies (Japan, Germany, United Kingdom, China, and the U.S.), as well as the five regional societies (Europe, Latin America, Asia-Pacific, Africa and the Russian Federation). While the focus of the meeting will shift among specific issues — such as electronic publishing, education, science policy, and capacity building — the underlying question will be how the international community can best organize itself to confront these and future concerns.

We will soon confront the issue of whether to work for change from within or to throw over the existing order and start anew. What we eventually decide could resonate for another three generations, and it would be wise for all of us to be heard.

LETTERS

Perspectives on the Job "Crunch"

It was a pleasure to see Peter Abbamonte show the best qualities of a real physicist. I commend him for his analysis and his personal strength ("The Back Page," *APS News*, April 1997). A minor historical note, though: It is not true that the implications of exponential growth of the number of physicists went unrecognised for 80 years. There may also have been earlier instances, but I know that in the job crunch that occurred after the '68-69 downturn in funding, the propensity of systems to change from exponential growth to an "S"-curve as resource limits are approached was noted and discussed in *Physics Today* and elsewhere.

I also recall a brief article (or perhaps letter) wherein a recent Ph.D. presented a sequence of letters ostensibly seeking employment outside of physics. The first indicated his full educational background, followed by a reply rejecting him on the grounds of being overqualified for the job. In the second, third and fourth letters, he limited his resume to M. Sc., B. Sc. and high school diploma, in sequence, and with appropriately declining quality of language, with the same result. The final letter, written in the vernacular, merely indicated that he was qualified to drive a truck, which did produce an employment offer. (I may have the details wrong after a quarter of a century or so, but this catches the tenor.)

So while our younger colleagues may not be standing on the shoulders of giants in this regard, they should at least be aware that they can (and do) benefit from those that have gone before them.

Terry Goldman
Los Alamos, New Mexico

Please congratulate Peter Abbamonte for his delightfully funny Back Page article entitled "The Crunch." At first I was infuriated by his naive attitude of self-importance, but once I realized it was an April Fool's article, it made my afternoon! The very idea that someone could be that whiny and ignorant was hilarious. I especially loved the "garbage can scene" and the idea that physicists breed exponentially like rabbits. What an imaginative gag!

Katherine Rawlins
University. of Wisconsin-Madison

The April 1997 issue of *APS News* contained a well-written "Back Page" article on the employment crunch for young PhDs. Not included was the simple fact that the field of physics as one of productive employment did not exist before World War II. The reason for this is obvious: no product that required those skills for fabrication and/or sales existed. The field is sufficiently difficult — requiring math as its language before a beginning can even be made — that anyone who concentrated on it as a field of learning in college must have been independent of the job market, or not conscious of the facts of life, one of which is a reliable source of money.

Unfortunately the public, from which all new talent comes, was not made aware of the real joy found in creative activities of the technical sort, and many of us neglected to point them out. Things that demand knowledge and the ability to search nature with the tools provided by physics will always be in demand.

Carroll B. Mills
Kenwood, California

We Need an Inclusive Definition for Physicists

After reading them once, and with no reflection, I thought the APS goals outlined by APS President Judy Franz (APS VIEWS, April 1997) all reasonable and worthwhile. I was especially pleased to see phrases like "throughout the world." But Goal # 8 struck me as especially important. I would think it an important goal at any time of the world (from the time of Thales of Miletus to the present). Physics is (or ought to be) a fellowship of those who have the passion for, and a talent sufficient to add to the knowledge of our field. Defining the community of physicists by exclusion, especially in these days, is selfish, and like all selfishness, stupid.

Keran O'Brien
Northern Arizona University

OPINION

Safeguard that Retirement Account!

by Darlene Logan, APS Development Director

APS members attending the Society's March meeting were provided an opportunity to attend a newly offered session on retirement account planning which was led by two skilled and experienced pension benefit and estate planning advisors. The information they provided to the attendees was enlightening to say the least. For example, many APS members did not realize that each year they may be able to use a defined benefit pension plan to shelter up to 100% of self-employment earnings including consulting, royalties from writing a book, fees for editing or reviewing, sales from inventions, income from tutoring, honoraria, and other 1099 earned income. And, almost all APS members did not know that there is a total maximum amount you can save without penalty as assets in your retirement account (TIAA, Supplemental TIAA, IRAs and KEOGHs). With the rise in the stock market, many physicists will easily surpass the limits and will be in the penalty region. Distributions have to be carefully planned around estate tax rules which can claim 75-95% of the accumulations.

Qualified Saving Plan

What are the advantages to using a qualified savings plan to shelter earnings? First of all, the contributions to the plan are tax deductible. Second, the investment earnings on your contributions are not currently taxable. Third, the eventual distributions may be taxed at favorable rates. For example, if you were to contribute $10,000 per year to a qualified savings plan earning 8% per year (net of investment expenses) and if your marginal income tax rate is 40%, then the accumulated savings at retirement age would be as follows:

Tax-free Accumulated Savings at Retirement Age

[from investing $10,000 per year earning 8% net yearly return]

Investment Years	5	10	15	20	25
Outside Plan	$34,607	$78,355	$133,661	$206,578	$291,964
Inside Plan	$38,016	$93,873	$175,946	$296,539	$473,726

As one can see, substantial financial returns are obtained by investing inside the qualified plan. You can also vary your tax deductible contributions to the plan from year to year. Further, even when you reach retirement age, you will not need to pay tax on the full amount of your accumulated savings in your qualified savings plans as you may "roll" your accumulated savings to an IRA. In effect, your savings continue to earn income on a tax deferred basis. When the distributions are eventually taken from the IRA, they will be treated as ordinary income for income tax purposes.

Dangers of Over Accumulation in Retirement Accounts and Options

In planning for distributions from qualified retirement plans and individual retirement accounts, be aware that these distributions may be subject to a number of adverse tax rules. At death, the benefits in such plans may be subject to the federal estate tax which applies to estates exceeding $600,000. Second, the benefits from the plans will also be subject to income tax when received by the beneficiary. Third, excessively large amounts in qualified plans and IRAs, which the IRS deems as excess accumulations, may also be subject to an additional 15% excise tax. The combination of these taxes can be over 75% of the accumulated savings depending upon the size of the account and your age at death. What to do? Naming a spouse as the heir is a choice that makes tax sense as a special rule permits the surviving spouse to defer tax by rolling over the inherited distribution from the account to an IRA.

But what happens to the estate if a child becomes the beneficiary? Acknowledging that the following example uses the maximum estate tax and income tax rates, it still clearly illustrates the point. Assume that there is $1 million in the retirement account which passes directly to a child. If the owner of the account is in the 55% federal estate tax bracket, the federal estate tax consumes $550,000 of the account, leaving $450,000 to the beneficiary, before income taxes. Assuming that the $450,000 would be subject to a maximum income tax rate of 39.6%, this results in federal income taxes of $178,200. This combination of federal estate and income taxes means that the beneficiary will receive $271,800 of what started out as $1 million. This example does not include state income or state estate taxes. Because of this combination of taxes (which can also include a 15% excise tax on certain larger retirement account balances which can be the case for many APS members), qualified plan and retirement assets are particularly useful as sources for potential charitable giving.

If, in this example, the person had named a charitable organization as the beneficiary of the $1 million retirement account, neither estate taxes nor income taxes would have been incurred, and the cost to the family would have been only slightly over 27% of the value of the account. However, perhaps you want to use the retirement account to provide an income interest for a child over his/her lifetime with the charity then benefiting from the assets. If a charitable remainder trust is named as the beneficiary of the retirement account, a charitable deduction for estate tax purposes can be a benefit so that less federal estate tax is paid. Further the payment of the entire retirement account to the charitable remainder trust will not result in immediate income taxation. The effect is that more funds may be available in the charitable remainder trust to be invested for the benefit of the child during his or her lifetime which could actually provide more income than if a bequest of the retirement account had been made directly to them. In addition, a worthy charity benefits from your generosity.

The bottom line is that, in saving for retirement and receiving retirement plan distributions, it is very important to do very careful planning to assure that intended beneficiaries receive the fruits of our labor…not the IRS. Handouts from the March meeting session and information on the speakers, as well as related articles on this subject, are available to APS members at no charge and may be helpful background if you decide to raise this subject with your own financial advisor. Simply e-mail me at (logan@aps.org) with your name and address requesting the "retirement planning packet".

Highlights from Kansas City *(Continued from page 1)*

prizes and awards were presented, and the recipients gave lectures on their respective award-winning topics at various sessions throughout the week. Citations and brief biographical summaries of the recipients appeared in the March 1997 issue of *APS News*.

Technical Sessions.

Room-Temperature Mid-Infrared Lasers. At two Thursday morning sessions, researchers described various new designs for mid-infrared lasers, devices that deliver light with a wavelength of 2-6 microns. Since this light is transparent in the atmosphere, mid-infrared lasers would be ideal for detecting pollutants, and serving as a part of a collision-avoidance system in automobiles. Although it has traditionally been difficult to produce laser light in this part of the spectrum, researchers in the past year have successfully produced room-temperature versions. In addition, they are striving to improve the notorious inefficiency of these devices. Steven Pei of the University of Houston reported details on a brand-new mid-infrared laser design based on antimony.

Chocolate and Shock Absorbers. An electrorheological (ER) fluid is one whose stiffness can be controlled with electric fields. Years of research in this area have yet to result in practical applications, partly through a lack of sufficient control over the ER process. A notable exception is the no-fat ER chocolate bar described to the left on page 4. But this may change soon. At a Friday morning session, Clark Radcliffe of Michigan State University announced the development of a feedback control mechanism using laser light to sense the amount of "chaining" among molecules in the fluid. One byproduct of the precision control of the ER process itself is a 30-fold increase in the ER response time. This should encourage the advent of ER-based components for hydraulic valves, clutches, and shock absorbers. Moreover, one MSU researcher has indeed been studying how ER can be used in the manufacture of low-fat chocolate.

Compact Discs and Blue Lasers. On Monday morning, Shuji Nakamura of Nichia Chemical Industries in Japan announced the development of a room-temperature, continuous-operation, blue-light laser with a much longer lifetime than previous devices. Light-emitting diodes, already in use in display systems, are efficient producers of light (red and blue) and will soon be used in automobile brake lights and traffic lights. For optical storage applications, however, one needs diode lasers. For one thing, the digital versatile discs (DVDs) appearing on the market now would benefit further from the use of blue-light lasers in place of red-light lasers. The data capacity of the new DVD models, now about 4.7 gigabytes (GB)), could be increased to 15 GB with the use of blue lasers. But because of the larger quantum energy gap that must be bridged, blue light is harder to produce than red light in semiconductor lasers. Last year Nichia developed a pulsed blue diode laser, based on gallium-nitride materials, which are thought to possess better commercial prospects than GaAs-based lasers.

Two Types of Superconductivity at the Same Time? Putting a direct current (dc) through a metallic sample, physicists can observe the onset of superconductivity as the resistance drops to zero at the critical temperature. In alternating-current (ac) studies, one looks for peaks in a plot of the impedance (analogous to resistance) versus temperature. Performing ac microwave measurements of YBCO superconductors, Srinivas Sridhar of Northeastern University has observed two peaks, one at a temperature just below 93 K (the recognized critical temperature) and another at 65 K, which he interprets as a hint for the onset of a further kind of electron pairing. Signs of this second type of superconductivity may have been present in previous experiments, Sridhar said, but only now, with the use of new high-purity crystal samples, is direct evidence available.

Single Magnetic Atoms. Single magnetic atoms have been found to disrupt superconductivity on an atomic scale, according to researchers at IBM Almaden. As part of their microscopic study of magnetism, Ali Yazdani and his IBM colleagues deposit single manganese (Mn) and gadolinium (Gd) atoms, each of which exerts magnetic forces, onto a niobium metal, which is a superconductor at low temperatures. By measuring the tunneling current that flows from the surface to the probe of a scanning tunneling microscope, the researchers detected the loss of superconductivity in the vicinity of the isolated magnetic atoms. This represents the first time a local loss of the superconducting state at the atomic scale has been detected. The researchers theorize that the atoms break up nearby electron pairs which constitute supercurrents.

Novel Scanning Probes. When electrons trapped at the interface between two semiconductors are subjected to high magnetic fields and are held at low temperature, they can form into strange configurations, some of which appear to have fractional charges. Physicists naturally want to map this "quantum Hall effect" with as much precision as possible. At a Mon-

Highlights from Kansas City

(Continued from page 1)

day morning session, Ray Ashoori of MIT announced the development of a scanning probe which, sitting outside the semiconductor structure in which the 2-dimensional electron structures are forming, can nevertheless render images of the structures with 40-nm spatial resolution. Answering some questions, the images pose new challenges, in the form of unexplained lateral oscillations of the electron clumps. Ashoori's probe may be useful in electronic chip design and testing since it can measure the local density of electrons even hundreds of angstroms inside a semiconductor.

New Liquid Crystal Phase Discovered With DNA. While many scientists study DNA to unravel the mysteries of life, others take advantage of the fact that DNA is an easily replicated and manipulated version of a polymer—a long, chainlike molecule—to discover new intricacies in materials physics. Helmet Strey and his colleagues at the National Institute of Health have prepared a dense array of DNA molecules in solution to form a liquid crystal, a state of matter in which molecules are arranged to a degree of order that lies between that of crystals (highly ordered) and liquids (less highly ordered). Using x rays to observe their samples, they have discovered a new configuration, or phase, of liquid crystal never before observed in any material. Known as the line hexatic phase, it was originally predicted by John Toner of the University of Oregon in the 1980s. The researchers hope that using DNA will allow them to find and to investigate more types of liquid crystalline arrangements.

Waste is a Terrible Thing to Mind. As the Cold War recedes into history and as weapons containing radioactive warheads are dismantled, a vast amount of chemical and fissionable material must be inventoried and disposed of. The cleanup at U.S. Department of Energy labs alone — 120 sites in 36 states — will require many years and billions of dollars. Speakers at a Tuesday afternoon session revealed the extent to which this tremendous social/technical undertaking has turned an important corner, just in the past year. For example, an emphasis on paper studies and litigation has shifted to actual cleanup activities at specific sites. Chaired by David L. Bodde of the University of Missouri at Kansas City, the session speakers included Alvin L. Alm, DOE Assistant Secretary for Environmental Management; Frank L. Parker of Vanderbilt University; Thomas Winston of the Ohio Environmental Protection Agency; and Charles Powers of the Environmental and Occupational Health Sciences Institute.

Separating Microscopic Particles by Exploiting Brownian Motion. At a Tuesday afternoon session, Martin Bier of the University of Chicago described efforts to build a machine that separates different-sized colloids (tiny, slightly charged particles in fluids) by exposing them to fluctuating electric fields and taking advantage of their Brownian motion, the random movements that they experience when they collide with fluid molecules. Bier's team has demonstrated that it is possible to design a device for separating different-sized colloids because particles of unlike sizes experience different levels of friction in a fluid and thereby undergo differing amounts of Brownian motion. One would be able to add particles for separation continuously to such a device, unlike centrifuges, which must be started and stopped every time new particles are added.

10 Megagauss Fields. For a variety of condensed matter experiments (such as studies of the quantum Hall effect), physicists need strong magnetic fields. The highest steady fields attainable are about 40 Tesla (T), or 40,000 gauss. Operating in a pulsed mode, magnets at Los Alamos have reached 70 T, but only for periods of 20 to 50 msec. With nested pulsed magnets, fields in excess of 100 T will be reached in the near future. By resorting to explosive compression of the magnetic flux in a magnet, even higher fields can be achieved. James Brooks of Florida State University reported on the attempt to carry out condensed matter studies in extremely high magnetic fields, albeit for a period of only a microsecond or so. By using 20 kg of explosives (the skills of weapons engineers came in handy at this stage), a solenoid magnet, made in Russia and consisting of a mesh of thin copper wires was imploded, resulting in fields estimated to have been as high as 1000 T, or 10 megagauss.

SQUIDs for Nondestructive Evaluation of Aircraft. Superconducting Quantum Interference Devices (SQUIDs), the most sensitive magnetic field sensors known to date, are now of sufficient sensitivity and reliability to find practical use in biomagnetism, geomagnetism and nondestructive evaluation of aircraft. The latter is the focus of a recent German research collaboration, led by Rohmann GmbH, which has been in the nondestructive testing business for 20 years. According to Hans-Joachim Krause (Institute of Thin Film and Ion Technology, Juelich), SQUIDs are superior to conventional eddy current testing with coils because their high sensitivity at low frequencies allow for larger penetration depths.

Recently, aircraft wheel testing was successfully demonstrated with a prototype SQUID system in the Lufthansa maintenance facility at Frankfurt's airport. One challenge is to operate the SQUID sensor integrated into a handheld system during movement in the strong ambient fields commonly found in aircraft maintenance facilities. Also, the SQUID must be equipped with mobile cooling with a lightweight nitrogen cryostat. In the near future, an automated wheel testing unit will be development. For fuselage testing, the SQUID will be integrated with an industrial scanning system. The project continues until the summer of 1998, after which Rohmann intends to introduce the new SQUID device into the marketplace.

Hydrogen and Deuterium in Silicon Device Processing. Metal oxide semiconductor (MOS) transistors are the basic building blocks of silicon integrated circuits. Their stability and lifetime depend on the degree of perfection of the interface between the semiconductor, silicon and the oxide. The high quality is achieved by introducing hydrogen atoms into the process to passivate any defects, such as dangling bonds. However, recent surface science experiments using a scanning tunneling microscope have shown that incorporating deuterium instead of hydrogen leads to significant improvement in the lifetime of MOS transistors, because it is even harder to desorb from silicon surfaces. In addition to its impact on current generations of devices, the suppression of defects becomes even more essential for future devices, in which oxide thickness and devise dimensions will shrink still further and the effects of any remaining defects will be magnified.

Advanced Memories and CMR. Information technology is a rapidly evolving industry with a continually changing landscape, but one constant factor is the ongoing need for more information storage for a broad range of applications encompassing small portable digital cameras to huge data warehouses used by global companies. According to James Brug of Hewlett-Packard Laboratories, who spoke at a Wednesday morning session, storing information magnetically has long been the dominant technology, but this becomes more difficult as areal densities increase. However, new understanding of the interaction of electrons with the magnetization in thin films and superlattices is enabling the possiblity of storage architectures other than rotating disks. Some alternatives being considered include new magneto-transport effects, such as colossal magnetoresistance and spin tunneling, which might be utilized in advanced memory applications.

Nontechnical Sessions.

Entrepreneurial Physics. On Tuesday morning, the Forum on Industrial and Applied Physics held a session on entrepreneurial physics organized by Ray O'Neal. W.K. Warburton of X-Ray Instrumentation Associates, a small company that develops specialized electronics to support the detectors used at synchrotron radiation facilities, reviewed the issues a small company must deal with in order to survive in the business world. His company is currently extending its expertise to the development of spectrometry instruments for specialized medical markets. Virgil Elings, president of Digital Instruments, also reviewed the history and development of what is now the world's largest manufacturer of scanning probe microscopes, and offered suggestions for entrepreneurial-minded physicists interested in starting a technology business.

Civic Science. Changing the increasingly negative perception of science by the general public and legislature was the focus of a Tuesday morning session on civic science. Speakers included Robert Greenler of the University of Wisconsin, Milwaukee, founder of a highly popular series of science programs for the public called "The Science Bag," now in its 24th year. Since its inception, the program has drawn a cumulative audience of well over 100,000. In addition, Carl M. Bender described how the physics department of Washington University in St. Louis has established a physics and society course as part of a continuing effort to raise the level of science literacy among bright students who do not intend to take further courses in science or mathematics. The course considers such issues as the availability of energy, nuclear weapons, the greenhouse effect, the ozone hole, risk analysis, the scientific method, and claims of the paranormal.

Centenary of the Electron. Wednesday afternoon's program featured a special symposium commemorating the centennial of the discovery of the electron in 1897. According to William Evenson of Brigham Young University, who chaired the session, the electron's discovery culminated an era of cathode ray physics, during which it was not clear whether cathode rays were particles of electricity or waves. Nor was it suspected that there might be particles of subatomic size until J.J. Thomson's classic experiments on the mass-to-charge ratio for cathode rays. The discovery of the electron led not only into investigations of the subatomic world, but ultimately to nuclear physics and quantum physics as well.

Furthermore, it was the particle that showed the existence of intrinsic spin, and also led the way in the development of our understanding of the properties of large collections of subatomic particles. More recently, the study of systems of strongly interacting electrons has led to the discovery of unexpected new phenomena, such as high temperature superconductivity, intermediate valences, and the fractional quantum Hall effect. Although these are not unique to electron systems, their discovery in those systems "has changed the way we understand quantum mechanics and enriched our understanding of how interactions can change physical systems," said Evenson.

Additional highlights and session summaries from the Kansas City meeting are available for viewing or down loading in the online version of APS News located under the APS News button on the APS home page [www.aps.org].

Special thanks to Philip F. Schewe and Benjamin Stein of the American Institute of Physics' Public Information Office for contributing to the coverage of technical sessions in this issue.

1997 MARCH MEETING PROGRAM COMMITTEE

Chair: David Lang, AT&T Bell Labs
Members: Robert Richardson, Cornell University (Sorters Meeting Organizer); Denis Rousseau, AT&T Bell Laboratories (Division of Biological Physics); James Langer, University of California,Santa Barbara (Division of Condensed Matter Physics); Robert Silbey, MIT (Division of Chemical Physics); Marvin Kalos, Cornell University (Division of Computational Physics); James Riley, University of Wisconsin (Division of Fluid Dynamics); Ken Shull, Northwestern University (Division of High Polymer Physics); G. Slade Cargill III, Columbia University (Division of Materials Physics); Paul Houston, Cornell University (Division of Laser Science); Robert Soulen, Jr., Naval Research Laboratory (Instrument and Measurement Science Topical Group); David Jiles, Iowa State University (Topical Group on Magnetism); Lalit Chhabildas (Shock Compression of Condensed Matter Topical Group); Katepalli Sreenivasan, Yale University (Statistical and Nonlinear Physics Topical Group); L. Craig Davis, Ford Research Laboratory (Forum on Industrial and Applied Physics); John Ahearne, Sigma Xi (Forum on Physics and Society); Rush Holt (Forum on Education); John Rigden, American Institute of Physics (Forum on History of Physics); Roberto Merlin, University of Michigan (Forum on International Physics); Laurie McNeil, University of North Carolina (Committee on Status of Women in Physics); Robert Perry, Ohio State University (Committee on Minorities).

APS Role in the Federation of Materials Societies

The APS joined the Federation of Materials Societies (FMS) in 1995. The FMS is an umbrella organization of societies and affiliates which are involved with materials science, engineering, and technology. Its purpose is to aid the materials community to obtain and exchang information with policies makers.

The APS is officially represented in the FMS by the Divisions of Condensed Matter Physics and Materials Physics. Donald Gubser, Naval Research Laboratory, is an APS liaison to the FMS as well as Sectretary-Treasurer of the Division of Condensed Matter Physics. He reported on APS environmental activities at the last FMS workshop such as APS statements on enviornmental issues (which can be found on the APS home page under the Public Affairs and POPA buttons) and meeting symposia. An example of the latter was the Waste is a Terrible Thing to Mind session at the March Meeting (see page 6)

According to Gubser, the strength of materials research and engineering lies in their interdisciplinarity and in the fact that there is a continuity of activities from fundamental science through engineering, applications, processes and commercial products. The result, however, is that segments of the materials community often find it difficult to discuss common problems, priorities and policies.

The FMS, founded more than 20 years ago, represents 17 member professional societies and three affiliate and two liaison members. These organizations, in turn, have more than 700,000 members. The FMS has been a leader in crystallizing policies in subjects ranging from: materials and resource conservation, materials processing and synthesis, materials and national competitiveness, and delineation of unique features of materials science and engineering.

The FMS sponsors periodic workshops, a biennial meeting on matters of materials policy, and issues reports, white papers, and recommendations for actions. Recently completed reports include "Impact of the new Congress on Materials Policy" (March 1995), "Technology Policy Recommendations from the FMS" (January 1995), and "Materials Agenda for the 21st Century: Policies, Priorities, Payoffs" (June 1996).

Most recently FMS held a workshop to document the current activities underway in FMS member societies and to provide an insight into innovative approaches to the environmental improvement field.

The FMS does several other things for the materials community. FMS members participated in a "Science and Technology Congressional Visits Day" where meetings with decision makers in congress and their staff took place. Similarly, the FMS joined with 45 other scientific societies (including the APS) in calling on the Federal government to reverse the decline in U.S. investment in science.

For more information on the FMS, contact Betsy Houston at betsyhou@ix.netcom.com or Donald Gubser at gubser@anvil.nrl.navy.mil.

DCMP and DMP Celebrate 50 Years

The APS Division of Condensed Matter Physics (DCMP) and the Division of Material Physics (DMP) celebrated their 50th anniversary at the 1997 March APS meeting in Kansas City, Missouri. Almost 50 past and present officers of these divisions, as well as special APS guests, participated in a dinner and reminiscent discussions Sunday evening prior to the beginning of the scientific sessions.

Originally called the Division of Solid State Physics (DSSP), the unit was formed in 1947, the third society division. (The Division of Atomic, Molecular, and Optical Physics was established in 1943, and the Division of High Polymer Physics was formed in 1944.) In 1978 the DSSP was renamed the Division of Condensed Matter Physics to recognize that disciplines covered in the division included liquids (quantum fluids) as well as solids. Today the DCMP is the largest of all APS divisions.

In 1984, the Topical Group on Materials Physics was formed from a subset of DCMP scientists. This topical group grew to become the Division of Materials Physics (DMP) in 1990. The DMP, which is just seven years old, is the fifth largest division today.

The chairpersons of the two divisions, David Lang (DCMP) and Slade Cargill III (DMP), were the official hosts of the celebration. The evening began with cocktails and hors d'oeuvres followed by a dinner at the Kansas City Marriott downtown hotel. A highlight of the after dinner discussions was a conference call with two of the original founders of the DSSP, members of the so-called "group of six": Sidney Siegel and Fred Seitz. These individuals spent over half an hour telling about the early days of solid state physics and the formation of the division.

Although solid state physics was a recognized scientific topic in the 1940's, the society was dominated by research on nuclear physics. Dramatic breakthroughs in solid state physics were only beginning to happen.(The transistor was discovered the same year as the DSSP was formed.) The group of six convinced the APS that a division which specifically focused on solid state physics would highlight the importance of this emerging discipline and better serve the needs of this still small, but growing, community. They never suspected that condensed matter would grow to become almost half of all physics activity

Neil Ashcroft, DCMP chairperson for the 1987 March APS meeting in New York City, spoke of the events leading to the "Woodstock of Physics" meeting, following the discovery of high temperature superconductivity. This meeting clearly fell outside the normal guidelines, with events unfolding long after the final organization and session planning meeting which took place the previous Fall. Other discussions related some of the conflicts between groups of scientists which led to the formation of the DMP in the 1980s. Fortunately, these conflicts are historical events which are not present today and both the DCMP and the DMP are now working amicably together to promote science in their largely overlapping areas of interest.

The 50 celebration was reported on by Donald Gubser, Sectretary-Treasurer of DCMP.

1998 APS Prize and Award Nomination Deadlines

The following are impending deadlines of APS Prizes and Awards. For complete information regarding the description of each prize, previous recipients and the chair of prize selection committees, please see the Prize, Awards and Fellowship Page of the APS home page [http://www.aps.org]; consult the front of the APS Membership Directory, email your request to honors@aps.org, or call (301) 209-3268.

Prize	Nomination Deadline
David Adler Lectureship Award	07/01/97
Will Allis Prize	07/01/97
Apker Award	07/01/97
Hans A. Bethe Prize	07/01/97
Dissertation in Beam Physics	07/01/97
DAMOP Dissertation Award	11/18/97
Biological Physics Prize	07/01/97
Tom W. Bonner Prize	07/01/97
Edward A. Bouchet Award	07/01/97
Oliver E. Buckley Prize	07/01/97
Davisson-Germer Prize	07/01/97
John H. Dillon Medal	07/01/97
Fluid Dynamics Prize	09/02/97
Joseph A. Burton Forum Award	07/01/97
Dannie Heineman Prize	07/01/97
High Polymer Prize	07/01/97
Frank Isakson Prize	07/01/97
Joseph F. Keithley Award	07/01/97
Otto Laporte Award	09/02/97
Lilienfeld Prize	07/01/97
Maria Goeppert-Mayer Award	05/30/97
Dissert. in Nuclear Physics Award	07/01/97
Onsager Prize	07/01/97
George E. Pake Prize	07/01/97
W. K. H. Panofsky Prize	07/01/97
Aneesur Rahman Prize	07/01/97
Prize for Research in an Undergraduate Institute	07/01/97
Earl K. Plyler Prize	07/01/97
J. J. Sakurai	07/01/97
Arthur Schawlow Prize	07/01/97
Leo Szilard Award	07/01/97
Robert R. Wilson Prize	07/01/97

Nominations for 1998 APS Prizes and Awards

The following prizes and awards will be bestowed at meetings of the Society in the coming year. Members are invited to nominate candidates to the respective committees charged with the privilege of recommending the winners. A brief description of each prize and award is given below, along with the addresses of the selection committee chairs to whom nominations should be sent. Please refer to the APS Membership Directory, pages xxiii- xxxix, or the APS home page [http://aps.org] under the Prize and Award button, for complete information regarding rules and eligibility requirements for individual prizes and awards.

1998 FLUID DYNAMICS PRIZE

Sponsored by the AIP Journal, *Physics of Fluids.*

Purpose: To recognize and encourage outstanding achievement in fluid dynamics research.

Nature: The prize consists of $5,000, a certificate citing the contributions made by the recipient, and a travel allowance to the meeting at which the prize is bestowed.

Send name of proposed candidate and supporting information before 2 September 1997 to: James Martin Wallace, Dept of Mechanical Engr, Univ of Maryland, College Park, MD 20742, phone: (301) 405-5271, fax: (301) 314-9477, email: wallace@eng.umd.edu.

1998 OTTO LAPORTE AWARD

Sponsored by the friends of Otto LaPorte and the APS Division of Fluid Dynamics.

Purpose: To recognize outstanding research accomplishments pertaining to the physics of fluids.

Nature: The award consists of $2,000 and a certificate citing the contributions made by the recipient.

Send name of proposed candidate and supporting information before 2 September 1997 to: Frederick K. Browand, Dept of Aerospace Engr, USC, Los Angeles, CA 90089-1191, phone: (213) 740-5359, fax: (213) 740-7774.

1998 THE DAVISSON-GERMER PRIZE

Correction from previous announcements

Sponsored by Lucent Technology.

Purpose: To recognize and encourage outstanding work in atomic physics or surface physics. **The prize for 1998 will be awarded for work in the area of atomic physics.**

Nature: The Prize consists of $5,000 and a certificate citing the contributions made by the recipient or recipients.

Send the name of candidates, biographical information and supporting letters before 1 July, 1997 to: **Andrew C Tam (Chair),** 21463 Continental Cir , Saratoga CA 95070, phone (408) 927-1943, email ACTAM@almaden.ibm.com.

CAUGHT IN THE WEB

Notable additions to the APS Web Server. The APS Web Server can be found at http://www.aps.org

APS News Online latest edition
- Physics News in 1996 (May)
- Campaign for Physics Update (June)

Public Affairs
- Speech by Dr. Mary Good
- Current Energy Situation

Meetings
- PC'97 [DCOMP & FIAP Meeting]
- Conference of Physics Department Chairs

Career/Employment
- Summer Physics Jobs
- NRC Summer Internship Program
- Career & Professional Development Task Force Report

The winner of the March Meeting drawing for *Physical Review, The First Hundred Years* is: Donald Waldo, student member

THE BACK PAGE

Scientists will Build the Bridge to the 21st Century

By Phil Gramm, United States Senator

President Clinton has talked a lot about building a bridge to the 21st Century and, our philosophical differences aside, I want to help him build that bridge…with Bucky Balls.

"Bucky Ball" is the nickname for Buckminsterfullerene, a molecular form of carbon that was discovered by Professors Robert F. Curl and Richard E. Smalley of Rice University in Houston. They won the 1996 Nobel Prize in Chemistry for this discovery.

Bucky Balls were named after R. Buckminster Fuller, the architect famous for his geodesic domes, because this new molecule closely resembles his designs. The silly nickname notwithstanding, their discovery was a breakthrough that will have scientific and practical applications across a wide variety of fields, from electrical conduction to the delivery of medicine into the human body.

Bucky Balls are impervious to radiation and chemical destruction, and can be joined to form tubes 10,000 times smaller than a human hair, yet 100 times stronger than steel. Use of the molecules is expected to establish a whole new class of materials for the construction of many products, from airplane wings and automobile bodies to clothing and packaging material.

This is old news to those of you involved in molecular physics, but think about it this way: Because we encourage the kind of thinking that leads to discoveries like Bucky Balls, the United States stands as the economic, military, and intellectual leader of the world. We achieved this not by accident, but by a common, unswerving conviction that America's future was something to plan for, invest in and celebrate. Using the products of imagination and hard work, from Winchester rifles and steam engines to space shuttles, Americans built a nation. We're still building, but for what we need in the next century, we're going have to turn to people like Curl and Smalley and you to give us materials like Bucky Balls, and the government has a role to play.

Unfortunately, over the past 30 years, American government has set different priorities. In 1965, 5.7 percent of the federal budget was spent on non-defense research and development. Thirty-two years later in 1997, that figure has dropped by two-thirds. We spend a lot more money than we did in 1965, but we spend it on social programs, not science. We invest in the next elections, not the next generation.

The United States is under-investing in basic research. That's right. The author of the landmark deficit reduction legislation known today as Gramm-Rudman supports the idea of the government spending more money on something.

Not only do I support the idea of spending more on science and technology, I have introduced two pieces of legislation which would help achieve that goal. The first bill is the National Research Investment Act, which would double the amount spent by the federal government on basic research in science and medicine over 10 years from $32.5 billion in 1997 to $65 billion in 2007. The second, the National Research and Development Act, would permanently extend the research and development tax credit.

If we as a country do not restore the high priority once afforded science and technology in the federal budget and increase federal investment in research, it will be impossible to maintain the United States' position as the technological leader of the world. Since 1970, Japan and Germany have spent a larger share of their national income on research and development than we have. We can no longer afford to fall behind. Expanding the nation's commitment to research in basic science and medicine is a critically important investment in the future of our nation. It means saying no to many programs with strong political support, but by expanding research we are saying yes to jobs and prosperity in the future.

The R&D tax credit was originally enacted as a part of President Reagan's Economic Recovery and Tax Act of 1981 in order to encourage greater private sector investment in research and development, and its benefits have been enormous. Studies show that each dollar of the credit yields up to two dollars in additional private R&D spending. Furthermore, the rate of return from R&D spending to society as a whole is estimated to be as high as 60 percent. Since its creation in 1981, the credit has been extended seven times, and it is currently set to expire on May 31, 1997.

Given that the ratio of R&D spending to output rose 40% in the 1980s when the R&D credit was in effect for the longest period of time, it is not unreasonable to expect that the benefits of the credit will only be enhanced if it is extended permanently. A permanent extension of the R&D credit would encourage companies to take on additional research and development projects by guaranteeing that the credit will be in effect during these long-term initiatives. In Texas alone, the average high-tech job pays $47,019 a year — almost $20,000 more per year than the average private sector salary of $27,147.

The need to make the credit permanent is only further highlighted by the fact that in 1996, for the first time in its history, the R&D credit was allowed to lapse between July 1, 1995 and July 1, 1996. Haphazard and unpredictable temporary extensions of the credit, combined with this recent lapse, have understandably left the research community in a state of confusion and uncertainty. Do any of us doubt that new home sales would drop if prospective buyers thought the mortgage interest deduction might disappear 5 years into their 20 year mortgage?

Businesses cannot and do not ignore the possibility of future gaps in the R&D credit, and will be forced to scale back new long-term projects if they cannot be certain that the credit will continue. We should permanently extend the R&D tax credit to permanently remove this unnecessary barrier to long-term research and development which has been created by the stop-and-go extension process.

I should also point out that the R&D credit has a long history of bipartisan support. The president has signaled his support for the credit, not only by signing last year's extension as a part of the Small Business Job Protection Act, but also by proposing a further extension as a part of his 1998 Budget. Unfortunately, his proposal follows the ill-advised precedent of merely temporarily extending the credit.

I believe that if we want the 21st century to be a place worth building a bridge to, and if we want to maintain the United States' position as the leader of the free world, then we need to restore the prominence that basic research once had in the federal budget. Our parents' generation fought two world wars, overcame some of the worst economic conditions in the history our nation, and yet still managed to invest in America's future. We have an obligation to do at least an equal amount for our children and grandchildren.

Over the past 30 years, we have not lived up to this obligation, but it isn't too late to change our minds. The discovery of Bucky Balls is a testament to the resilience of the American scientific community. I believe that if we once again give scientists and researchers the support that they deserve, if we make the same commitment to our children's future that our parents made to ours, then the 21st century promises to be one of unlimited potential.

For those of you who want to help, you should contact your Senators and urge them to cosponsor these important bills. The National Research Investment Act is S. 124, and the National Research and Development Act is S. 355. In the weeks since I introduced S. 124, I have received dozens of letters of support from universities and organizations (including, of course, the American Physical Society), representing hundreds of thousands of scientists and researchers from across the country. Let your elected officials know you believe it is vital we reverse the disturbing trend toward shortchanging critical investments in research.

America is a great and powerful country for two reasons. First, we have had more freedom and opportunity than any other people who have ever lived and with that freedom and opportunity people like us have been able to achieve extraordinary things. Secondly, we have invested more in science than any people in history. Science has given us the tools and freedom has allowed us to put them to work. If we preserve freedom and invest in science, there is no limit on the future of the American people.

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The Back Page is intended as a forum to foster discussion on topics of interest to the scientific community. Opinions expressed are not necessarily those of the APS, its elected officers, or staff. APS News *welcomes and encourages letters and submissions from its members responding to these and other issues.*

Researchers Develop World's First Type II Quantum Cascade Laser

A team of researchers from the University of Houston Space Vacuum Epitaxy Center (SVEC) and Sandia National Laboratories has developed the world's first type-II quantum cascade (QC) laser. The laser has the potential to operate at a higher temperature and deliver more power at the 3 to 12 micron wavelength than previous diode laser technology.

The type-II QC laser combines the advantages of a cascade design and the interband transitions of the conventional diode laser. It is based on the type-II heterostructure, in which the conduction-band edge of one layer can be lower in energy than the valence-band edge of the adjacent layer. According to Shin-Shem Steven Pei, associate director for research at SVEC, this unique energy-band alignment allows a staircase arrangement of the laser's active regions, such that every time a carrier jumps down an energy step in the staircase as it crosses an active region, a photon is emitted.

The new QC laser emits mid-infrared light around 4 microns at temperatures up to -150 degrees Fahrenheit, under 100-nanosecond current pulses at a repetition rate of 1,000 per second. Room temperature operation of a 4.2-micron light-emitting diode (LED) has also been demonstrated, with a 50% duty cycle and a repetition rate of 1,000 per second. The average output power is 140 microwatts — over 1,000 times more than that of the first type-II QC LED reported by the same group in 1996 — and is much brighter than the commercially available LEDs at the same wavelength. In another effort, the SVEC team has also demonstrated an 8-micron LED in collaboration with H.C. Liu of the National Research Council in Ottawa.

"Even though the current operating temperature and output power are not as high as other mid-infrared lasers developed recently at SVEC and in other laboratories, the type-II QC design offers clear advantges over these other lasers and may significantly advance the performance of these devices," said Chih-Hsiang Thompson Lin, one of the team members. The SVEC researchers have already developed type-II quantum well lasers that oeprate from 2.7 to 4.5 microns at temperatures up to 170 degrees Fahrenheit. A peak output of 0.27 watts at 3.2 microns has been achieved when the device is pumped with optical pulses at room temperature.

Mid-infrared optical systems operating at 3 to 5 and 8 to 12 microns — two optical transmission windows in the atmosphere — are in great demand for a number of military, space and commercial applications, including infrared counter measures, covert illumination for night vision, free-space communication, collision avoidance and many medical procedues. The laser can also monitor many industrial, pollution, greenhouse, hazardous and toxic gases. In fact, the availability of low-cost light sources at mid-infrared wavelengths may revolutionize remote chemical-sensing technology for pollution monitoring, engine combustion and emission diagnostics, industrial process control, and the detection of explosives and illegal drugs.

Demonstration of the first type-II QC laser is the culmination of recent breakthroughs in narrow bandgap semiconductor material growth and device physics, and is an important milestone in the development of mid-infrared lasers. However, "This is only the first step toward the development of a viable technology for practical applications," said Pei, adding that SVEC is committed to commecializing the technology for both space and terrestrial use.

U-M Scientists Put the Squeeze on Atoms

Using ultra-fast pulses of laser light, University of Michigan physicists have found a way to control the random oscillations of atoms in a crystal lattice: making their study the first experimental modification of one of the most fundamental quantum states of solid matter. Approximately 10 years ago, scientists discovered how to create a "squeezed state" for quantum particles of light energy (photons). However, until the U-M experiment, no one had been able to do the same with phonons, which carry vibrational energy through a solid.

"We can calculate probabilities for an atom's location within a specific area of uncertainty, but we can never know precisely where the atom will be," said Roberto Merlin, U-M professor of physics. "It's like hide-and-seek. With short-pulse, high-power lasers, we can reduce the size of the volume where the atom can hide." He likens the atomic structure of a solid at the quantum level to a cloud whose area is defined by the atom's random motion within the solid, where points of higher density in the cloud represent points where the probability of finding the atom is higher.

The experiment was conducted using a titanium-sapphire laser system at the U-M Center for Ultrafast Optical Science, firing 70-femtosecond laser pulses focused on a tiny spot on a potassium tantalate crystal. The laser beam was then splut into two parts, and one beam is diverted along an alternate path, so the secondary pulse arrived at the target a few picoseconds after the initial pump pulse. The stronger pump pulse hits the atoms in the crystal lattice like a hammer, producing a force which creates pairs of phonons and makes the atomic lattice oscillate. The weaker probe pulse is scattered by these phonos as it passes through the lattice later in time, and researchers then measured the amount of probe pulse energy that makes it through the crystal to determine the behavior of the atoms inside.

"Our goal was to learn how to control matter — to tell the atoms what to do, rather than just watch them do something," said Merlin. While he cautions that it is too early to speculate on potential applications for the squeezed state in matter, the U-M team is planning future experiments to replicate the squeezed state in other types of crystal.

Researchers Explore Applications for Carbon Nanotubes

Buckytubes, nanometer-wide tubes of carbon atoms, are stronger than steel and are now considered to constitute a fourth state of crystalline carbon. The first three known forms of crystalline carbon are graphite, diamond, and solids of C-60 molecules, popularly known as buckyballs. The many sessions devoted to nanotubes at the 1997 APS March Meeting in Kansas City testify to the rapid increase in interest in this research.

Nanotubes, stiffer than steel, only a nanometer wide but many microns long, are essentially rolled-up sheets of carbon hexagons that exist in three varieties: multishell tubes consisting of several nested concentric cynlinders; isolated single-wall tubes; and organized bundles or "ropes" of hundreds of single-wall nanotubes arranged in a two-dimensional triangular lattice. Nanotubes are electrically versatile; doping can make them into metals, insulators, or semiconductors. They have served as the contacts in probe microscopes and have been used as field emitters and single-electron transistors.

According to John Fischer of the University of Pennsylvania, nanotubes were first observed as a minority byproduct from the carbon arc process that yields fullerenes. Then scientists discovered that large amounts of nanotubes were formed in the material deposited on one of the electrodes, while the fullerenes were primarily in the soot which filled the chamber. Single-wall tubes are formed if the graphite target is doped with small amounts of transition metals, which catalyze the growth of single-wall tubes at the expense of fullerene formation. Multi-wall tubes exist in a large range of diameters and concentric shells, making it difficult to determine the intrinsic bulk properties. However, numerous experiments have been performed on isolated multiwall tubes to determine electrical resistance and mechanical behavior, for example.

Richard Smalley of Rice University, winner of the 1996 Nobel Prize in chemistry for his discovery of buckyballs in 1985, reported that his lab currently produces nanotubes at a rate of grams per day, but that within 5 to 10 years this could be increased on a commercial basis to tons per day day. Smalley showed pictures of nanotubes that swallow their own tails, forming closed Bucky toruses, and diagrams of bundles of nanotubes in which one tube stuck out further than its neighbors. Nested stages of such bundles, he said, could be used to fashion pointers — macroscopic at one end but tapering down to a single carbon cell at the other end — with which one could "write" patterns of molecules on a substrate, like an artist dipping a paintbrush into a palette of colors.

Electrically, these versatile nanotubes can be insulators, semiconductors, or conductors, depending on their symmetry, and are expected to exhibit magnetoresistance qualities. "If one could make a perfect joint between different classes of tubes, one would have the world's smallest diode, one of the basic building blocks of electronic devices," said Fischer. In fact, arrays of the pointy nanotubes have already been used as field emitters in flat panel displays. Attaching a semiconducting nanotube to a metallic nanotube one gets a nano-diode. If, furthermore, the joint is angled, the composite tube can actually conduct better in a bent state than straight up; this property makes the structure into a possible nanoswitch or strain gauge.

Fischer reported that nanotubes have excellent mechanical strength along the direction of the tube axis, since the carbon-carbon bond is one of the strongest known. Hence, bundles of long nanotubes embedded in a matrix could be developed as high-strength, light weight, electrically conducting composite materials for structural applications. In addition, their length is much greater than the diamter, making them valuable as flexible probe tips in scanning probe microscopy, since they can explore very deep holes, a useful property for process control in the fabrication of integrated circuits. Finally, nanotubes are hollow inside and in some cases liquids flow into the tubes by capillary action. "One could imagine using nanotubes as tiny hypoderic needles, to deliver chemicals to a single cell," said Fischer.

Steven Louie of Lawrence Berkeley Laboratory studies nanotubes made of boron and nitrogen, or of carbon mixed with boron and nitrogen, which have more consistent semiconducting behavior and hence have greater potential nanodevice applications. In one configuration, a ribbon of conducting carbon hexagons forms a corkscrew pattern up the length of the tube. The current flow through such a tube is therefore helical; in effect this nanotube is the world's smallest solenoid magnet.

Louie's LBL colleague, Alex Zettl, has developed a new random-marex nanotube electron field emission source using arrays of carbon nanotubes, which has demonstrated superior field emission characteristics, simplicity and versatility. According to Zettl, the fabrication method could be easily scaled up, and two methods have been found that allow reliable pixelation of the emission surface for display applications.

The Berkeley group is also pursuing the idea of using a random distribution of carbon nanotubes as an electronic computing machine. "Although in principle, one can make many device elements out of nanotubes, in practice it is not yet possible to syntheize them in a controlled way," said Louie. However, an "as-growth" sample of entangled tubes will contain extremely high density of randomly arranged device elements, possibly orders of magnitude higher than the present state of the art silicon technology. Louie's idea is to attach leads to the sample, and develop algorithms to make use of the functions that already exist in the sample. Such a device is expected to have exception speed and thermal dissipation characteristics.

Cees Dekker of Delft University is able to study the electron transport properties of single nanotubes by draping them across a pair of electrodes; the current-versus-voltage plot is a series of steps, indicative of a "quantum wire." In general one would expect this behavior when the movement of electrons through a conductor is restricted to one dimension.

Scientists Use AFM to Explore DNA Mechanisms

While many people view DNA as a purely chemical creature, defined by the sequence of its base pairs, scientists are now discovering how DNA acts as a mechanical object which performs important functions in the body. Important processes in single DNA molecules have been observed for the first time by using the atomic force microscope (AFM), in which the deflections of a tiny stylus over the contours of a surface can be turned into molecular-scale images. The ability to measure these forces with AFM and other techniques is allowing scientists to understand the physical basis of biochemical mechanisms responsible for life.

Using an AFM, Gil Lee of the Naval Research Laboratory found that a force of about 600 piconewtons was required to tear apart two complementary strands of DNA, namely a 20-base-pair-long strand of polycytosine (a form of single-strand DNA) from single strands of polyinosine averaging 160 base-pairs long. The AFM can image surfaces both in air and under liquids at nanometer resolution. NRL is using this techology to develop ultra-sensitive diagnostics to understand the molecular mechanicsms responsible for biofouling, and to measure the forces necessary for DNA replication.

Living organisms are composed of cells built from macromolecules such as DNA and proteins. According to Lee, these macromolecules make up both the scaffolding that holds the cells together and the motos responsible for motion. Macromolecular function and structure are controlled by the forces between individual units that make up macromolecules and their environment. "Previously, our knowledge of these forces has been gathered from indirect x-ray crystallography and nuclear magnetic resonance measurements," said Lee.

This new ablity to measure inter- and intramolecular forces in macromolecules such as DNA could offer unique insight into how structure produces function in these molecules. For example, the forces responsible for biological adhesion can now be directly studied at the molecular scale. Molecular adhesion controls a diverse array of phenomena such as cell migration in cancer and the adhesion of barnacles to ship surfaces.

Pulling apart a DNA molecule at forces of 60 piconewtons, a University of Oregon-Santa Barbara team has found that DNA undergoes a change in structure in which it exists at 1.7 times its original size. Such studies are important for understanding the process of DNA recombination—for example, when DNA molecules from two parents combine to make the DNA for their child—because proteins that attach to DNA during this process stretch it to 1.5 times its original size.

The technology has also enabled scientists to observe transcription — the first step in a process which converts the genetic information contained in the cell's DNA into proteins — for the first time. Carlos Bustamante of the University of Oregon and his colleagues presented movies showing the first stages of DNA replication, in which a protein is seen to slide on DNA like a bead on a string to find the exact site where it could attach and start the replication process. Binding DNA and RNA polymerase (the protein that mediates the transcription of DNA into RNA) to a mica surface, Neil Thomson of UC-Santa Barbara and his colleagues produced 5-nm-resolution movies of the transcription process, in which RNA polymerase pins down the middle of a single DNA strand and then pulls the strand through as it starts transcribing the DNA into RNA using RNA-building-blocks called NTPs.

Window '97: The Latest on Fast Switchable Mirrors

Certain metal hydrides, such as yttrium-dihydride and hydrides of rare earth films, are shiny and make excellent mirrors. Adding just a bit more hydrogen, however, makes the material into a transparent window. Since Ronald Griessen of Vrije University in Amsterdam first announced this conversion process last year, much progress has been made in terms of improving the process and applying it to solid state devices. First, the switching time (the mirror-to-window conversion can go either way) has decreased from tens of seconds to 40 msec. Second, the contrast between the optically "closed" and "open" states, as measured by the relative amount of light transmitted, is now up to a factor of 1000.

The unexpected discovery of these "switchable mirrors" began in 1990, after the announcement of high-temperature superconductivity, when Griessen's team decided to search for other potential high-temperature superconductors, choosing to focus on metallic hydrogen. However, instead of making hydrogen metallic under very high pressures, they chose to first dissolve hydrogen in a metal to break the molecular bond, then compress the sample under moderately high pressures to increase its metallic character. They chose yttrium as a starting material.

At the end of 1994, a PhD student in Griessen's group observed that thin films of yttrium and lanthanum coated with palladium change from a shiny mirror to a yellow transparent window when absorbing hydrogen, a spectacular and reversible change in optical properties. The transition is simply induced at room temperature by changing the surrounding hydrogen gas pressure or electrolytic cell potential. "These films are unique in the sense that they can continuously, reversibly and rapidly be switched between a low resistivity metallic state and a large gap semiconducting state," said Griessen. Furthermore, the fact that the rare earth hydrides can make the switch at room temperature is critical to developing practical applications.

A theoretical explanation of this dramatic optical switching phenomenon, lacking until now, has been advanced by Fu-Chun Zhang of the University of Cincinnati. The key, he says, appears to be the behavior of the tiny hydrogen atoms inside a lattice of much larger atoms. "We find it is the combination of the ease of the hydrogen motion in the metal and the dramatic change it induces in electronic states that alters the optical properties so quickly in hydrides," he said. Hydrogen can easily diffuse in and out of a rare earth metal lattice with only a small change in the crystal structure. However, once it moves in, a hydrogen atom binds an extra electron to form a negative ion, reducing the number of highly mobile conductive electrons.

According to Zhang, as the number of hydrogen atoms increases in the metal, the material changes from a dihydride to a trihydride, at which point the mobile electrons become stringly bound to hydrogen atoms to form highly localized states, such that no electron can move through the lattice. This leads to a transition of the optical properties from a highly reflecting mirror to those of a transparent window. "Instead of bouncing off the scattered, mobile electrons, light easily passes through the material," he said. Central to Zhang's theory is the strong correlation between the electrons in a negative hydrogen ion: the only way both negatively charged particles can be bound to a single positively charged proton.

Such metal hydrides offer clear advantages compared to other switchable optical systems, such as the transition metal oxides or the electrochromic blue bronzes, according to Griessen, including a faster switching time than any other electrochromic material and a higher contrast between the metallic reflecting state and the transparent state. For example, hydrogen- intercalated metal oxide films, upon the absorption of hydrogen, showed lower electrical resistivity at maximum doping, were only moderately conductive, and while the transparent sample changed to a dark blue color, it remained essentially transparent.

Scientists at Philips Research Lab are working on applying the transition process to solid state devices, in particular metal hydride switches. By selecting appropriate alloys, the Philips team was able to construct an optical device with three different optical states: a color neutral transparent state; a black absorbing non-transparent state; and a metallic reflecting non-transparent state. Each can be used to optimize current applictions of electrochemical devices. For example, large area optical coatings with switchable properties could be used to make transmission variable architectural glass, such that windows in buildings could be changed from transparent to reflective mode.

X-Ray Microprobes Offer New Tool for Materials Science

In what is believed to be the smallest focused point of light at any wavelength, SUNY-Stony Brook researchers have produced an x-ray beam that is just 50 nanometers in diameter. Using this beam, the researchers have mapped the distribution of DNA in bull sperm and are aiming to usher in the field known as "nanotomography," in which 3-D images would be produced of minuscule objects such as cells and subcellular structures like nuclei and chromosomes.

Making such small useful beams requires a combination of very bright x-ray sources and high-quality x-ray optics, such as mirrors, lenses, and pinholes, which can now be fabricated using lithographic patterning techniques developed by the semiconductor industry. And with the advent of state-of-the art synchrotron centers, such as the new Advanced Photon Source at Argonne, researchers can now produce extremely intense versions of x-ray beams only millionths of a meter in diameter. These new sources have enabled the creation of a new tool for material characterization on micron and sub-micron length scales, called an x-ray microprobe (XMP).

According to Eric Isaacs of Lucent Technologies, the XMP combines x-ray sensitivity to crystallographic strain and trace element distributions, with their ability to nondestructively probe deep into a sample, and is beginning to have an impact on a broad range of disciplines, including device engineering, materials science, biology, and environmental science. With these beams, Lucent researchers are now able to perform quality-control studies of the ultrathin quantum wells in state-of-the-art telecommunications lasers.

"In our highly technological society, particularly in communications in biology, complex electronic circuits, solid state lasers, and naturally occurring membranes and other cellular materials are lithographically patterened, or naturally patterend, on length scales of one millionth of a meter and smaller," said Isaacs. "Imaging these patterned structures requires small x-ray beams." The ultimate spatial resolution of a probe is fixed by its wavelength, which is why optical probes using visible light can observe features as small as a fraction of a millionth of a meter.

X-rays can make much smaller measurements, comparable to the spaces between atoms in solid, because their wavelength is 10,000 times smaller than that of visible light. In addition, x-rays are very penetrating and can be used to look deep into bulk objects, making them the dominant probe for determining the three- dimensional atomic structure of large single crystals, including organic compounds such as hemoglobin, insulin and DNA, as well as simple inorganic compounds like silicon and indium phosphide.

Janos Kirz and Chris Jacobsen of SUNY-Stony Brook reported that they had for the first time produced two-dimensional images showing the distribution of DNA and protein in sperm from bulls and other mammals. Kirz reported that producing the images in the temperature range of liquid nitrogen can keep the tissues from showing damage from the x-rays, and predicted that his system will be a stepping stone to developing ways to create three- dimensional images. "Our goal is to image flash-frozen hydrated cells and subcellular structures such as nuclei and chromosomes in three dimensions, without the need for fixation, sectioning, or staining," he said. He also hopes to obtain chemical information with the spatial resolution set by the size of the microprobe, and to visualize labels and markers which biologists may wish to attach to structures of particular interes.

In separate atom-scale investigations employing x-ray beams with 5-10 micron diameters, Columbia and IBM researchers are determining how the flow of electricity through pure

Manufacturing "Electronic Ink" from Modified Bacteriorhodopsin

For the past 25 years, biochemists and biophysicists have studied the mechanisms by which a protein known as bacteriohodopson acts as a "pump" for protons, upon which most biological life processes are heavily dependent for the transport of ions, neurotransmitters, enzymes, wastes and other biomolecules. However, in recent years, bacteriohodopsin has attracted the attention of scientists interested in using biological materials to perform technological functions, such as expoiting the protein's photoelectric properties to manufacture photodetectors, or its optical properties to manufacture "electronic ink" for computer displays.

"Natural materials often perform very complex functions that cannot be easily obtained from manufactured materials such as semiconductors," said Paul Kolodner (Lucent Technologies), who spoke at a Wednesday afternoon session. "They have been optimized for these functions by billions of years of evolution and often perform better than any human-designed material could." And unlike devices such as integrated circuits, which require many time-consuming, high-precision and expensive manufacturing steps, organisms manufacture biological materials all by themselves.

Bacteriohodopsin is an intensely-purple-colored protein molecule found in the cell membrane of halobacterium, which grows in salt marshes. The protein is photosynthetic and can be used by the bacterium to produce matabolic energy. Bacteriohodopsin is produced when the cell senses that chemical nutrients are scarce. Specifically, it functions by "pumping" protons across the cell membrane of the bacterium in response to illumination; these protons are then used to initiate metabolic chemical reactions.

Just as thin films of bacteriohodopsin produce electric fields when illuminated, they can be made to change their optical properties — in particular their color — when acted on by an electric field, a property known as electrochromism. Normal bacteriohodopsin exhibits a weak form of electrochromism. However, certain mutant halobacteria produce bacteriohodopsin which potentially exhibits very strong electrochromism, in which the color changes from blue to pale yellow. "If this property can be enhanced and generalized to other color combinations, this materials couldbe used as an electrically addressable pigment, or 'electronic ink,'" said Kolodner.

The obvious potential use for "electronic ink" is in computer displays. According to Kolodner, a bacteriohodopsin is sandwiched between glass plates that contain arrays of a large number of electrodes. A page of text or a color image is written electrically on the protein film by applying the corresponding array of voltages on the electrodes, similar to the technology used in liquid-crystal displays for laptop computers. The difference is that the electronic ink gets its color bym reflecting ambient light, whereas the laptop displays require an internal light sources which is a drain on the computer batteries. Thus, using computer displays based on bacteriohodopsin "electronic ink" may make an important contribution to the serious problem of battery lifetime in portable computing.

Self-Organized Criticality Observed in Brain Cells

In experiments which may provide new insight into how healthy brain cells successfully communicate over long distances, scientists have found that a system of cultured rat brain cells produces spiral-shaped chemical waves of characteristic sizes which can be described by a mathematical model known as "self-organized criticality."

In the late 1980s, physicist Per Bak of Brookhaven National Laboratory introduced the idea of self-organized criticality, in which certain systems (e.g., a pile of sand grains) can reach a critical state in which the system can exhibit a radical change of behavior such as producing avalanches of all sizes by virtue of its very nature (the internal reorganization of its grains) and not by adjusting an external parameter.

In what is perhaps the first experimental evidence for a biological example of self-organized criticality, Ann Cornell-Bell of Viatech Imaging in Connecticut has found that a system of cultured rat brain cells with the proper level of noise — corresponding to random firings of nerve cells — produces spiral-shaped waves (the propagation of a local chemical imbalance, observed by influxes of calcium ions into the affected cells) of characteristic sizes.

Specifically, the Viatech researchers studied interactions between astrocytes, star-shaped cells that are closely associated with nerve cells, and can help regulate the flow of chemical ions into and out of the cell. When a neurotransmitter known as Kainate binds to an astrocyte, this can cause an influx of soduim atoms into the cell. To compensate for thei imbalance, the cell draws in a flood of calcium atoms which are made to fluoresce and are detected by video camera. This state of imbalance can spread to other cells, thereby causing neighboring cells to draw in calcium ions of their own. The local imbalance propogates as a spiral wave, which are known to exist in many biological systems, such as contraction waves in heart muscles of rabbits and rats, and in growing bacterial colonies.

The waves follow the mathematical patterns which typify self-organized systems, and agrees with a recent theory developed by Peter Jung of Georgia Tech to establish the notion of spatiotemporal stochastic resonance. Originally conceived as a simple model for an excitable medium in contact with a noisy environment, the theory assumes a spatially distributed system with a rest state and an excited state, such that local excitation can spread through the medium, forming excitation waves. The theory's agreement with the Viatech experiments suggests that self-organized criticality might play a role in brain functions, according to Jung. "It is not the firing of a single nerve cell, or the chemical imbalance in an individual cell which is important," he said. "It is the collective properties of the complex system of cells which is important for its proper functioning."

Interestingly, follow-up imaging experiments using cells from excised human epileptic tissue produced waves with significantly different behavior. Epilepsi is a condition where there is a dramatic increase in nerve cell activity and consequently often extremely high levels of neurotransmitter present, according to Cornell-Bell. Films from these experiments show extremely high activity where cells literally flash with calcium spikes.

Scientists Detect Atto-Newton Forces Using MRFM

Force detection with atto-newton precision has been achieved by an IBM-Stanford team of physicists led by Daniel Rugar of IBM. This work, reported during a Monday morning session, was carried out with a magnetic resonance force microscope (MRFM), a device that combines nuclear magnetic resonance technology with probe microscope technology. This new instrument holds the promise of revolutionizig the study of biological processes at the molecular level and adding an entire new dimension to the study of electronic materials at the atomic level.

Magnetic Resonance Force Microscopy (MRFM) brings together probe-microscope (STM, AFM) technology with magnetic resonance (MRI, NMR, ESR) technology. The goal here is nothing less than the ability to make 3-dimensional, non-destructive, in-situ, atomic-resolution images of atoms, molecules, defects in solids, dopants in semiconductors, and binding sites in viruses. According to John Sidles of the University of Washington, who first suggested the device in 1991, the significance of MRFM research derives mainly from the existence of a "gap" in imaging technology capabiities in the size range of 1-100 angstroms, a range that encompasses biological molecules and nanoscale electronic devices.

In the case of bio-medical research, modern techniques can render the molecular sequences for many proteins, but full knowledge of the molecular structure is usually lacking. A prime example is the HIV virus, which is known to contain nine genes which encode at least 14 function proteins that fall withint the 1-100 angstrom size range. The proteins are readily produced in the laboratory, yet after more than decade of stidy, the majority of HIV proteins still have unknown structure, and in many cases, unknown function. "This lack of knowledge reflects the limited capacity of present instruments to image objects in the 1-100 angstrom range," said Sidles. "MRFM technology was conceived specifically to fill this imaging gap."

In the IBM-Stanford setup, a thin silicon cantilever, 230 microns long but only 60 nm thick, is poised above a tiny sample. Under the additional influence of fields from an RF coil, a magnetic particle mounted on the cantilever interacts with tiny volumes of magnetic atoms in the sample. Under just the right circumstances the particle on the cantilever will begin to resonantly oscillate like a diver on a diving board; the cantilever's movement shifts a laser interference pattern viewed through an optical fiber. Using this device, the group was able to measure forces with a resolution of 7 atto-Newtons (7 x 10^-18N), the most sensitive force measurement ever made with a probe microscope. With further refinement the MRFM process will detect single spins, and Rugar hopes to map the spins of electrons in dispersed defect sites in silica.

Key to the achievement was the development of ultra- sensitive cantilevers, 1000 times thinner than a human hair and invisible to the naked eye. The team statrted with an ultra-thin layer of silicon bonded onto a layer of silicon oxide coating a silicon wafer. They then etched cantilever shapes onto the ultra-thin layer and chemically removed the underlying layers of oxide. According to Rugar, silicon was selected to minimize the mechanical damping that occurs when the cantilever vibrates, and because it is compatible with semiconductor processing techniques.

The manufacturing process is so delicate that the researchers could not use normal dying techniques after the final fabrication step. "The surface tension of the water is strong enough so that as it dries, it bends the cantilevers into 'U' shapes, causing them to reattach to the underlying material," said Rugar. The team circumvented the problem by using an exituc biological techniques called critical point drying, which uses liquid carbon dioxide at high pressures.

Sidles emphasizes the possible medical and biological research applications, observing that the structure of some proteins can be worked out with nearly

aluminum wires (highly similar to those in computer chips) can eventually break the wires or cause them to malfunction. Using a 5-micron-diameter x-ray beam at the Brookhaven synchrotron, Slade Cargill at Columbia reported the first real-time measurements of the stresses that occur when electric current traveling through an aluminum wire displaces atoms in the wire, and monitor the gaps and bulges that develop.

The irregularities resulting from this "electromigration" effect are expected to be a problem in the ever-shrinking aluminum-based wires of future-generation computer chips, which are 40 times smaller today than they were 30 years ago. In the past such problems were solved by using new combinations of metals, by limiting the current levels and wire lengths, and by encapsulating the wires in rigid insulating materials. These "solutions can no longer be relied upon, according to Cargill, who maintains that better understanding, better materials and better device designs are needed for the next generation of microelectronic devices.

atomic resolution by crystallizing a sample and then interpreting the pattern of x rays diffracted by the crystal. Other notable proteins, however, do not lend themselves to this process. Moreover, ordinary force microscopes cannot image interesting molecules residing in clefts of biological structures. MRFM, by contrast, will supply 3D images of the hardest-to-get-at molecules, providing information for medical and drug-design research.

A Los Alamos-Caltech group, represented by Chris Hammel of Los Alamos is applying MRFM to the study of multi-layer electronic devices, which could have important implications for magnetic information storage technology. Layers of magnetic material sandwiched with layers of non-magnetic layers such as copper or gold are used as variable resistors. The thickness and roughness of the interface between layers affects the performance of magnetic disks used in computers. MRFM will be able to reveal the irregularities between the layers and the related local magnetism and electrical properties, without having to cut or destroy the samples. Eventually Hammel's probe will be able to map buried structures, such as defects in circuit elements. He uses a stiffer, faster-oscillating tip than the IBM version; this does not necessarily improve the force sensitivity but would greatly speed up data acquisition.

Severl MRFM groups are presently working toward the detection and imaging of individual electron moments which, if successful, will take magnetic resonance imaging to its ultimate limit: one spin in one voxel. However, Sidles emphasized that instrument development is a slow process, and that none of the major biomedical technologies used today were fully developed in less than 25 years. In comparison, scanning probe microscopy at the atomic scale has only been around since 1982. "Based on historical precedent, it will likely be at least another decade before scanning probe technologies like MRFM achieve mainstream status in biomedical research," he said.

Editor's Note: Some MRFM figures are available on the World Wide Web at: http://www.aip.org/physnews/graphics/