APS NEWS

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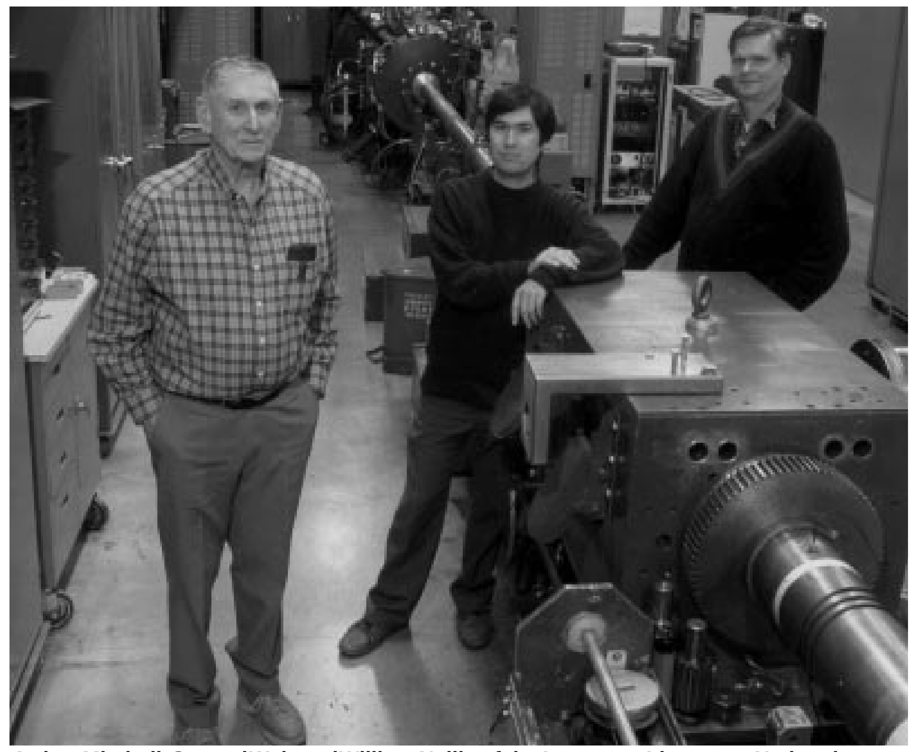
Highlights from St. Louis: Metallic Hydrogen, Magnetic Surgery Mark 1996 March Meeting

More than 4,500 physicists converged on the St. Louis Convention Center in Missouri, 18-22 March, for the Society's annual March Meeting. Approximately 4,200 technical papers were presented, mostly on topics in condensed matter and materials physics, as well as related fields, making it one of the largest physics meetings ever. APS units represented at the meeting included biological physics, chemical physics, condensed matter physics, fluid dynamics, high polymer physics and materials physics.

Among the technical highlights were sessions on the achievement of a metallic state of liquid hydrogen (see story below), magnetic surgery (see page 3), neural encoding of sensory information (see page 3), and stochastic resonance (see page 4). Other technical sessions reported on the latest developments in scanning probe microscopy, single-electron devices, liquid interfaces, nanoparticles, granular flows, optical communications, spatio-temporal dynamics, and cooperativity in biological macromolecules.

Nontechnical highlights included sessions on science policy in an era of political change (see page 2), the future of international science (see page 5), the current status of women and minorities in physics (see page 8), the history of radioactivity (see page 8), and physical methods of waste management (see page 9).

The meeting also featured sessions on physics journals on the Internet and educational issues, as well as numerous career-related talks and activities. For example, volunteers from the APS Forum on Industrial and Applied Physics (FIAP) served as mentors to groups of students and as individual counselors during the meeting in conjunction with the placement center and two career services workshops. Also featured was a talk by Mitchell Fromstein, CEO of Manpower, Inc., on forces driving the current job market and the potential role of a temporary employment agency for physicists in this market.



Arthur Mitchell, Samuel Weir and William Nellis of the Lawrence Livermore National Laboratory metallic hydrogen research group.

The traditional ceremonial session for the bestowal of prizes and awards was held Monday evening, followed by a reception hosted by APS President J. Robert Schrieffer (Florida State University). Ten APS prizes and awards were presented, and the recipients gave

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Journal Embargo Policies Spark Controversy

The APS and the American Institute of Physics (AIP) found themselves at odds in April with editors at *Science* magazine regarding the latter's embargo policy for articles accepted for future publication. The policy is similar to that of *Nature*: acceptance of a scientific paper is conditional upon the nondisclosure of the paper's details to journalists.

The conflict began when Philip F. Schewe, who heads APS meeting publicity for AIP's Public Information Division, noticed an interesting abstract on producing intense laser light for the 1996 APS/AAPT Joint Meeting in Indianapolis, Indiana. He contacted the invited speaker about the possibility of organizing a press conference on the subject. But the speaker had already submitted an article to *Science* on the topic, and the magazine advised him that participation in a press conference might compromise the likelihood of his article being accepted for publication. Unwilling to risk having his article pulled, the speaker declined Shewe's offer.

"In my opinion, the action of the *Science* editor amounts to an act of extortion: forego a press conference or possibly forfeit your paper in *Science*," said Schewe. "It's a shame that things have come to this: a magazine telling a scientist that it's okay to report on an important experiment at a professional meeting, but that he is forbidden to answer a few questions about his talk in an adjoining room immediately afterwards."

The issue of prior restraint is much more far-reaching than the APS/AAPT Joint Meeting. It has long been a source of contention between journal editors and science reporters, who feel their coverage of the hottest topics is often hampered by the refusal of scientists to talk to them out of fear that their accompanying papers will be withdrawn from publication. On April 15, the DC Science Writers Association sponsored a forum on journal embargoes, attended by reporters, editors, public information officers and featuring a panel discussion with *Nature's* North American editor and *Science's* managing editor.

At least one participant suggested alternative policies that might protect the interests of all parties. *Physical Review Letters*, for example, has policy which stipulates that as long as a paper is accepted for publication, it can be mentioned in a newspaper or magazine as an upcoming article in the journal. However, there was no indication following the event that either *Science* or *Nature* would consider changing or improving their existing embargo policies.

IN THIS ISSUE

Livermore Scientists Achieve Metallic Hydrogen

The first confirmed formation of a metallic state of hydrogen was announced at the March Meeting by scientists at Lawrence Livermore National Laboratory. Metalic hydrogen was achieved in a sample of fluid hydrogen, using a two-stage gas gun to create enormous shock pressure on a target containing liquid hydrogen cooled to 20K. Future experiments will be aimed at learning more about the dependence of metallization pressure on temperatures achieved in liquid hydrogen, which is vital for laboratory applications.

"Metallization of hydrogen has been the elusive Holy Grail in high-pressure physics for many years," said William Nellis, one of three Livermore researchers involved in the project, of the achievement. "This is a significant contribution to condensed matter physics, because a pressure and temperature that actually produce metallization have finally been discovered."

Hydrogen atoms constitute the bulk of the universe's ordinary matter, so scientists have long sought to understand the properties and phases of this simplest of elements. Squeezing hydrogen atoms until they surrender their electrons has been tried ever since Eugene Wigner and Hillard Huntington predicted in 1935 that hydrogen would metallize at sufficiently

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U.S. Science Policy Shifting in Era of Political Change

The end of the Cold War and the accelerated globalization of the American economy are shifting long-held rationales for policies on scientific research and education, according to speakers at the March Meeting Monday morning session on science policy. In addition, growing public dissatisfaction with its government and science is further weakening support for federal research funding.

"While certainly not the end of national security issues requiring substantial science and technology involvement, the end of the Cold War resulted in a weaker engine for the freight train that has pulled federal support for science and technology, including substantial civilian research and development activities," said Tom Weimer, staff director on the House Basic Research Subcommittee. "From my personal observation, I have seen no replacement emerging with the equivalent political support that the national security engine once enjoyed in engendering support."

Vannevar Bush's paradigm for research and development, considered sacrosanct for almost half a century, has been declared by some analysts to be irrelevant for America in the 1990s. In addition, the demands for change expressed by voters in the 1992 and 1994 elections, create a new political context within which science policies must be placed. Downsizing of the federal government, begun by the Clinton administration, has accelerated dramatically with the 104th Congress. "The Congressional members I deal with feel they've heard a clarion call to balance the budget and downsize government, and their goal is to put in place the framework to achieve this, resulting in expanded opportunity and economic growth," said Weimer.

Further complicating matters is the relative youth of the 104th Congress, both in terms of age and legislative experience. Weimer estimates that 62 percent of his committee has served for three years or less, a fact which is relevant because it generally takes one to three terms for a new member to become familiar enough with issues to engage in science policy debates. There is also "a young bull versus old bull herd dynamic" present in Congress that cuts across party lines, and has complicated the leadership's ability to implement their agenda.

In terms of the federal budget, the debate appears to be less over direction, than the pace and the ratio of research versus development dollars, and military versus civilian spending. Weimer believes that science isn't faring any worse than other federal discretionary programs under the FY1996 budget, but cautioned that as the appropriations pie gets smaller, some science and technology programs will be competing directly with other discretionary programs, many of which have strong advocacy groups with considerable lobbying experience.

The most complicating and controversial factor is the desire to link changes in science policy with a seven-year balanced budget plan. "There is no such thing as a seven-year plan in Washington," said Robert Park, APS director of public affairs, of Congressional efforts in this area, pointing out that any one Congress can overturn the work of its predecessors in a matter of minutes.

Nonetheless, some general trends are emerging. All the panelists agreed that big expensive projects, whether domestic or international in scope, will have difficulty acquiring federal funding, although Weimer believes the Large Hadron Collider might be funded as an international collaborative effort if the scientific community can agree to make it a priority. Also, while there has been some discussion of consolidating the various agencies, all of whose budgets fall under different committees, the process is most likely to continue as it has in the past, according to Pat Windham, who serves Democratic members as Senior Staff Member of the U.S. Senate Committee on Commerce, Science, and Transportation.

Park believes that the biggest impact of the move to downsize government is likely to be on the culture of science, rather than on research support levels. For example, the APS has learned to lobby in the last 13 years. "There are a lot of people who are concerned about that change, and feel we are trading our credibility for short-term security," said Park. "That may be, but I don't think there's any turning back at this point."

The role of the Office of Science and Technology Policy (OSTP) has come under scrutiny, particularly with the demise of the Office of Technology Assessment. "The job in OSTP is not to represent the scientific community within the executive office," said Ernest Moniz, the OSTP's associate director for science. "The job is to provide advice and policy guidance to the President and his administration, although part of it is to seek out and welcome input from the scientific community."

The industrial workplace has also undergone dramatic change. Most central research laboratories no longer exist, and the industrial commitment to basic research is much less than it was two to three decades ago. Industry demands better educated and more highly skilled workers, even as the nature of science education and the role of the federal government in providing that education is being altered.

However, while Congress is aware of these trends, it is sharply divided along party lines in terms of how to respond. According to Windham, Democrats are concerned about the gap between universities and other laboratories, and believe it is a legitimate government role to foster partnerships between industry and government. Many Republicans, in contrast, don't believe government should have any involvement in funding industrial research, labelling it "corporate welfare."

All the panelists agreed on the need for a continuing program of education for new Congressional members on why federally funded support is an investment. "Most of the members are going to be instinctively against government investment in almost anything unless they see it as having some practical value," said Windham. "The educational function therefore will become all the more important as we get into the continuing budget crunch over the next couple of years."

Weimer identified three ways of educating Congress: through discussions with staff with experience in science policy debates; through a permanent Washington presence, such as professional associations; and through their constituents, which Weimer believes is the most effective route, particularly if young researchers are involved. "Their enthusiasm for research and their goals really comes through and leaves a very positive impression on Congressional members," he said.

There is also a need for more vocal input from the scientific community, the panelists concurred. It is equally important to avoid the appearance of entitlement, and to link research to concrete objectives that could benefit society. "I think the scientific community must take the posture of assuming its responsibilities to society and to members of Congress," Moniz concluded. "It has a responsibility not simply for lobbying, but for education, and the process only becomes education when it is run in a continuing mode."

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TV Series Documents Changing Face of Science in America

In April, Maryland Public Television aired a six-part documentary series profiling 20 contemporary African-American, Latino and Native American scientists and engineers who are making advances in biology, astronomy, physics, mathematics and many other scientific disciplines. Major funding was provided by the Alfred P. Sloan Foundation and the NSF, with additional contributions from a variety of scientific organizations, including the APS.

Intended to counter the prevailing cultural stereotypes of who scientists are and what they do, the series reached an estimated 60,000 viewers in the Washington, DC and Baltimore areas with programs covering ground-breaking research in genetics, environmental studies, new materials, engineering, mathematics and computer science. Among the many respected scientists profiled was James Gates, a professor of physics at the University of Maryland and president of the National Association of Black Physicists, which also sponsored the series.

The series was accompanied by an extensive outreach effort, designed to alert students, teachers and parents to existing science education services and resources, as well as increase the awareness of the daily contribution minorities make to the sciences, and encourage students of color to pursue careers in science, mathematics and engineering. For example, activity guides were available to teachers, containing program summaries, discussion questions and a bibliography. A directory of several hundred accomplished scientists and engineers of color was published and distributed to major media outlets, encouraging producers and editors to consider them as subjects and as experts for science-related stories. And in selected areas, those who called an automated toll-free number (1-800-BIG BREAK) received information on informal science opportunities, such as mentoring associations, scholarships, and science career organizations in 30 regions across the country.

On the electronic front, the APS contributed to the production of a database and resource guide accessible via the World Wide Web to hundreds of teachers and students who access "www.blackside.com". On-line visitors have access to spot-lighted, science-related events and activities in their city, conversations with scientists in the series, event calendars, and links to science activities and educational resources on the Web. The broadcast was followed by a CD-ROM Career Navigator, a comprehensive reference tool that includes such items as career and financial aid information, college profiles, and a basic dictionary of science terms.

Magnetic System Promises To Improve Brain Surgery

An interdisciplinary team of scientists from institutions throughout the U.S. reported development of a computer-controlled magnetic system for delivering therapeutic agents to the brain in an IMSTG session at the March APS Meeting. Known as the Magnetic Stereotaxis System (MSS), it is intended improve treatments for brain tumors, Parkinson's disease, and other neurological disorders. The technology is currently being tested in gel models of the brain and should be ready for human trials by the end of the year.

"The technology will be a minimally invasive, more efficient and safer way of doing brain surgery for certain indications," said Ralph G. Dacey, Jr., of Washington University School of Medicine in St. Louis. The research team includes collaborators from the University of Iowa, the Medical College of Virginia, and the University of Washington, as well as Stereotaxis, Inc., which contracted the first full-scale prototype for human use.

According to Dacey, when neurosurgeons perform conventional stereotactic surgery, they use a computer and MRI or CT scans to locate the diseased part of the brain in three-dimensional space and to determine the best straight line path to that target. Reaching the target could possibly damage structures en route.

The primary advantage of the magnetic system is that it will allow neurosurgeons to move precisely through the brain in any direction, avoiding sensitive areas that may lie between the surface and the area to be treated. Nonlinear movement is possible because magnetic fields guide a magnet the size of a grain of rice, which in turn pulls a small implant containing drugs or sources of radiation.

The system can also reposition an implant over time, permitting surgeons to perform multiple treatments without successive surgeries. "The MSS represent the optimal fulfillment of a minimally invasive concept that will cause the least amount of tissue damage in accessing targets to the brain and other parts of the body," said Matthew Howard III, University of Iowa, who co-invented the system.

After creating a small opening in the skull, the neurosurgeon places the magnet on the surface of the brain and places the patient's head in a "helmet." Superconducting magnets in the helmet generate gradients that direct the tiny magnet through the brain with great accuracy and minimal tissue disruption. The neurosurgeon monitors the movement of the magnet by watching fluoroscopic images superimposed on an anatomical, pre-operative MRI image. Over the next few days or weeks, the therapeutic agent interacts with the surrounding brain tissue.

The research will focus initially on improving treatments for malignant brain tumors, which are typically excised by placing the patient under general anesthesia, shaving the head, temporarily removing a portion of the skull to expose a large part of the brain, and the manually cutting out the tumor under direct visualization. In contrast, magnetic tumor surgery could allow a flexible radioactive catheter to be coiled into the tumor so that gamma rays can kill the tumor cells. The insertion may only take one or two hours, and could possibly be performed on an outpatient basis.

Despite the recent development of an imaging navigational system, which was a key element in refining the MSS technique, it remains difficult to navigate in a live brain with the necessary high precision. The researchers are working on refining the technique and demonstrating the safety and effectiveness of the MSS machine allowing commercialization of the system and development of other applications.

Magnetic drug delivery, to treat disabling neurologic conditions, will be tested during the second phase of the research. By placing drugs directly into the affected part of the brain, the magnetic surgery will bypass the blood brain barrier, which normally prevents many compounds from reaching their destination. Direct delivery will also avoid the side effects that occur when drugs targeted to one part of the brain interact with receptors in other parts of the brain or body.

For example, the system could improve treatment for Parkinson's Disease by delivering implants of dopamine — a neurotransmitter that is depleted in this disorder — or substances that boost dopamine production to an area deep in the brain called the striatum. Applications for other parts of the body will follow the neurological treatments.

Information Theory Provides Unified Framework for Neuroscience

Scientists have long sought to develop a workable model to help them understand the complexities of the neural encoding of sensory information in living organisms. Now, a new framework is emerging for neuronal systems, based on information theory. Known as stimulus reconstruction, or reverse reconstruction, this theoretical model underlies most of the latest experimental studies taking place in this area.

"Our understanding of how the activities of neural systems lead to adaptive and intelligent behavior is still in a primitive state," said John W. Clark of Washington University, who chaired a Division of Biological Physics Tuesday morning session on the subject at the APS March Meeting in St. Louis. "However, it appears that a unified framework for neural computation is emerging, grounded in fundamental principles of stochastic systems and analysis, information theory, and statistical inference." Information theory derives the mathematical laws that govern information-manipulating devices such as audio equipment and telecommunications systems.

According to Clark, traditional approaches to the problem of neural coding have emphasized determination of the transformation leading from a known stimulus to average neural responses. However, organisms face nearly the opposite task: they must extract information about an unknown time-dependent stimulus from a short sequence of action-potential pulses sent by a receptor neuron.

To help explain such a nonlinear system, Charles Anderson, of Washington University, has developed a unified approach to issues of neural coding, computation, and systems integration, based on the hypothesis that ensembles of neurons collectively encode and process probability density functions of analog quantities. "It's like taking an audio signal and turning it into a series of samples that are stored on a compact disc," said Anderson of his theoretical model. "The CD player then turns those samples back into a time-dependent signal that goes into your amplifier and out of your speaker. In a similar way, the nervous system also encodes and decodes information that passes from one neuron to another."

The explicit encoding of uncertainty at a very low level in neuronal systems contrasts strongly with standard electronic computers, where extreme measures are taken to ensure precise computation at all levels of processing. "The application of information theory clears up a lot of the ambiguities and questions that people have about the differences between digital computers and neuronal systems," said Anderson.

Anderson's theoretical models are being tested by Washington University neurophysiologist David van Essen, who is using macaque monkeys to study aspects of visual processing.

Studying single neurons in the fly visual system, researchers at Stanford University applied stochastic systems analysis to devise algorithms for real-time stimulus estimation. The algorithm models real-time analog signal processing by spiking neurons. The basic idea of reconstructing a stimulus from a spike train was subsequently extended from a single neuron to an ensemble of neurons with broadly tuned responses.

To determine characteristics of encoded spike trains, Fred Rieke, a postdoctoral fellow at Stanford University, conducted a series of experiments involving the bullfrog auditory system, which is similar to that of humans in that it uses a system of internal codes to translate sounds into a form the brain can understand.

Rieke's group monitored the electrical activity in bullfrog auditory neurons while the frogs listened to two kinds of sounds: white noise and frog calls. The sequences of spikes encode information about the sounds, and the spike pattern creates a characteristic "fingerprint" for each sound. The group found that the representation of frog calls in these spike trains was much more accurate than the representation of white noise.

Rieke said of the results: "Researchers have known that organisms have a way of filtering out unimportant information, but it was thought that most of this selectivity takes place in the brain. It now looks as though this filtering may take place earlier, in the sensory nerves that carry the information to the brain."

The reverse reconstruction strategy in its ensemble version has also been applied by researchers at the University of California at Berkeley to study sensory coding in the cricket cercal system.

Berkeley collaborator, John P. Miller, identified a subset of four neurons that is capable of determining the direction of low-velocity wind pulses with great accuracy and reliability. To do this, they presented a set of air current stimuli to a cricket within a miniature wind tunnel, and recorded the spiking activity of the neurons elicited in response to those stimuli. Using the analytical tools of information theory, they were able to characterize aspects of the information-carrying capability of the nerve cells in terms of bits and baud rates — the same measures used for performance specifications of modems and other electronic signal transmission devices.

The team determined that the transfer rates for information about air current velocity and the rates by the rate at which the neurons were firing spikes, obtain a measurement of information in terms of one and three bits per spike, remarkably high rates that indicate a high level of encoding efficiency.

"These studies are of general interest, not only because of the importance of understanding the nature of the neural code itself, but also because of the very important constraints a knowledge of the code can place on the derivation and testing of physiological models for the mechanism's underlying neural function," said Miller.

Jacob Levin, also at Berkeley, modified the cricket experiments slightly by introducing varying amplitudes of broadband random background noise air currents to the process. While in general systems noise is considered to be detrimental to performance, there are systems in which a certain amount of externally applied noise can actually improve performance, attributable to a phenomenon known as stochastic resonance, in which the addition of random noise to a small output signal can increase the transmission quality of the signal (see related story, page 4).

Levin found that with a single frequency tone, the output signal-to-noise ratio increased with added input noise to a maximum level, and then fell as the input noise amplitude was increased beyond that level. Further experiments using broadband signals — as opposed to a single frequency — revealed that these improvements were observable over the entire frequency operating range of the neurons, and for almost an entire order of magnitude of near-threshold signal amplitudes. "For the first time, an enhancement of signal encoding was observed over a biologically relevant range of signal frequencies and amplitudes, and we have quantified it in a mathematically rigorous way, through the tools of information theory," he said.

Stochastic Resonance Can Help Improve Signal Detection

Physicists are discovering evidence that adding random noise in the right way to certain electronic devices and biological systems can counter-intuitively increase the detectability of signals and the transmission efficiency of information. Because of its generic nature, this phenomenon, known as "stochastic resonance," holds universal applications extending from classical and quantum physics to biomedicine.

The term "stochastic resonance" was first coined in 1981 by physicists to describe the annoying hiss in modern communication devices that can hinder the detection of weak signals. However, under certain conditions, it has been shown to actually aid detection. This effect is rooted in three basic ingredients: a source of background noise, a generally weak coherent input, and a characteristic sensory barrier or threshold that the system typically has to overcome in order to perform its usual task.

As reported in a Monday Division of Biological Physics session of the March Meeting, scientists have begun to question whether stochastic resonance manifests itself on a quantum scale as well. Peter Hänggi of the University of Augsburg in Germany has theorized that because quantum noise persists even at absolute zero temperature, the transport of quantum information should be aided by quantum fluctuations as well. In fact, the phenomenon of quantum tunneling — in which a particle "tunnels" through a barrier without going over it — provides the nonlinear system with an additional channel to overcome a threshold. For strongly damped systems, these quantum corrections can enhance the classical SR effect up to two orders of magnitude.

In addition, a series of novel nonlinear quantum stochastic resonance phenomena occur in the deep quantum cold regime, where tunneling in the presence of dissipation and periodic time-dependent perturbations mutually influence each other. Of particular interest to scientists is the effect of driving-induced quantum coherences in damped quantum systems, as well as the phenomenon of a characteristic suppression of nonlinear higher harmonic responses. The latter can be used to "clean" the quantum output distortion that is caused in nonlinearly processed information.

According to Hänggi, these novel effects have now been confirmed experimentally using a superconducting quantum-interference device (SQUID), which constitutes a macroscopic quantum system where quantum tunneling transitions begin to modify and blur the classical stochastic resonance response with decreasing temperature. "The combined application of both time-dependent perturbations and quantum dissipation yields novel possibilities to influence quantum processes," he said. These include strong laser light induced manipulation of electron transfer processes, which can be used to control reactant-product yields in chemical reactions, or to regulate tunneling of atoms or molecules that are deposited on surfaces.

Stochastic resonance has also been demonstrated in complex systems of biological transducers and neural signal pathways. For example, it has been experimentally observed to improve broadband encoding in the cricket cercal system (see related story, page 3). However, the principles of biological amplications are far from understood. "It is only clear that biological amplifiers are unique in their ability to detect small signals in a noisy environment," said Igor Vodyanov (National Institute of Health). However, the possibility that the phenomenon could occur at the sub-cellular level remains open, and Vodyanov reported on the recent observation of noise-enhanced electrical signal transfer in a simple system of voltage- dependent ion channels formed by the peptide alamethicin in a lipid bylayer.

In most experiments with stochastic resonance, the weak and noisy signals were first recorded with electronic instruments, and the resulting data were analyzed by computer. Italian physicist Enrico Simonotto of the University of Genoa began to question whether the human brain was designed well enough to extract small amounts of information from quite noisy stimuli. To find out, he has been conducting experiments with human subjects by presenting them with subthreshold images with added noise.

According to Simonotto, for a fixed, subthreshold image, the addition of fast noise dramatically enhances the quality of the image as reported by the subjects, until an optimal level is reached. Thereafter, the addition of more noise only degrades the image quality. "The experiment indicates that dynamical noise — noise that is constantly fluctuating with time, as all noise in the real world does — is more effective than static noise, and the faster it fluctuates, the better," he said. "This may prove useful in enhancing the accuracy and speed of visual perception of information in rapidly changing situations, such as those encountered by the pilots of high-performance aircraft."

Scientists Seek Further Improvements to Quantum Measurements and Standards

A joint symposium on Quantum Measurement and Standards, chaired by R. Erdman of Kiethley Instruments, organized by the Instrument and Measurement Science Topical Group and the Precision Measurement and Fundamental Constants Topical Group, focused on increasingly precise measurement techniques. Scientists continue to find ways to improve measurement techniques and devices, in such areas of better atomic clocks, measuring the mass of the kilogram, and redefining the Coulomb — the basic unit of electric charge — in terms of quantum mechanical measurements rather than classical electrical measurements.

Robert Drullinger of the National Institute of Standards and Technology (NIST) reported on ongoing attempts to improve the accuracy of NIST-7, the world's best atomic clock, which already operates with an uncertainty of less than one part in 10^{14} — a rate that is equivalent to gaining or losing less than a second in over 3 million years. Since the first ammonia-based atomic clock was built in 1948, NIST has improved the performance of their standards by a factor of 10 million. NIST is now working on advanced prototypes that have the potential for an additional factor of improvement of at least 10,000.

According to Drullinger, the highest demands on time and frequency precision measurements are made by users involved with secure communications systems, deep-space navigation systems, and scientific tests of basic concepts in nature. At a lower level, precision measurements are needed for general telecommunications systems, electronic navigation systems for ships, aircraft and land vehicles, and electric power companies that share power across international power grids.

To stay ahead of the demands of industry and science for ever more accurate time and frequency standards, NIST has an active research program aimed at developing the next generation of standards. For example, an atomic fountain standard is currently under development, which operates by launching laser-cooled cesium atoms straight up through a cavity and letting them fall back by gravity. The low velocity of the atoms is expected to reduce the uncertainty in assessing their frequency to a level five to ten times better than the current standard.

Theoretically, the ultimate atomic clock would depend on the behavior of a single stationary, isolated atom, since the fewer the components and their interactions in a timepiece, the greater the accuracy. To this end, a group at NIST's Boulder, Colorado, laboratory has developed a linear ion trap for mercury atoms that have been stripped of one electron. The ions are held in an electromagnetic field and irradiated with laser light in such a way that their motion and temperature are reduced to nearly zero. This eliminates major sources of uncertainty about the resonance frequency, and also allows scientists to observe a given collection of ions for a much longer time. The fundamental uncertainties of this system are thought to be no more than a few parts in 10^{18}.

According to Aaron Gillespie, NIST is also working on a new experiment aiming to re-define the kilogram, the international unit of mass, in terms of fundamental constants in nature. The kilogram is the only international scientific unit still defined in terms of a physical object — a platinum-iridium cylinder stored in Sevres, France.

Using a specially designed balance-wheel apparatus, the NIST experiment yields a value of the kilogram by comparing measurements of mechanical power to measurements of electrical power. It takes advantage of the fact than an electrical watt can be expressed precisely in terms of quantum-mechanical measurements. The apparatus could also be used to monitor possible long-term drift of the kilogram artifact.

Finally, recent advances using quantum dots and single electron transfer suggest that exciting new approaches are on the horizon for developing new quantum current measuring techniques, according to Wiley Kirk of the NanoFAB Center at Texas A&M University.

Biosensors Provide Near-Single-Molecule Sensitivity

In a Division of Chemical Physics session at the March Meeting, scientists at the Naval Research Laboratory reported developments of a novel, high-sensitivity biosensor for potential applications including environmental monitoring of airborne or waterborne contaminants, and clinical tests where ultra-sensitive detection is needed. Employed in a working device, an array of such biosensors would be able to perform immunoassays — the process by which the presence of antigens is detected — in about 10 minutes, much faster that other methods at these small concentrations.

Atomic force microscopes (AFMs) can directly measure the forces at the nanoscopic level, and the NRL researchers have used them to measure the force between two complementary strands of DNA. According to team member Gil Lee, they now hope to use a device based on AFM technology to detect biomolecules. They have developed a "force amplified biological sensor" (FABS), which uses the ultra-sensitive force transducers originally developed for AFMs to detect molecular recognition forces between DNA molecules, metal ions-chelators, antibodies-antigens, or other ligand-receptor molecules. This gives FABS near-single-molecule sensitivity, an improvement of six to eight orders of magnitude over competitive techniques.

According to Lee, the device will soon be capable of detecting atto-molar amounts of various biological species such as cells, proteins, viruses and bacteria. The increased sensitivity of the device greatly reduces sampling requirements, requires no washing or amplification steps, and can be fully automated. The transducers are also micromachined, so FABS devices could eventually be miniaturized into portable units with low power requirements.

Currently, the prototype device works with an immunobead assay, consisting of an antibody attached to a sensitive cantilever beam. Next, an antigen in solution binds to the antibody. A second antibody, mounted on a micron-sized magnetic bead, also binds to the antigen, forming an antibody-antigen-antibody-bead sandwich. After washing away excess particles, a magnetic field is applied, which pulls out the particles, causing the cantilever to bend. The deflection of the cantilever is then measured, and by counting the beads one arrives at the antigen concentration in the solution.

Women in Physics Make Modest Gains, While Minorities Remain Level

Over the last 30 years, the percentage of physics Ph.D.s awarded to women annually has risen from three percent to 12 percent, but the percentages of African-Americans and Hispanics receiving Ph.D.s has remained essentially level at 1 percent each, according to recent data collected by the American Institute of Physics (AIP). Speakers at a Wednesday afternoon session, at the March Meeting, on women and minorities in physics discussed possible reasons why the percentage for minorities in physics has remained stagnant, considered some factors for the improvement in the numbers of women, and discussed how changes in affirmative action policies might affect the numbers of women and minorities in physics.

According to Roman Czujko, director of AIP's Employment and Education Statistics Division, 42 percent of high school students taking physics are women, a dramatic increase from a decade ago. Unfortunately, this percentage drops significantly at the university level: only 28 percent of students taking introductory physics courses are women. Sixteen percent of bachelor's degrees in physics are currently earned by women, with an equal number earning degrees in engineering. In contrast, slightly more than half of all life science degrees, and about 48 percent of mathematics degrees, are earned by women.

At the graduate level, 12 percent of all Ph.Ds in physics are earned by women, with engineering again showing a similar growth rate and life sciences degrees earned by women increasing by about 40 percent. While the percentage of women physics Ph.D.s has shown only a gradual increase, the number of Ph.D.s awarded annually has grown by more than 60 percent. Still, half of those are foreign citizens; thus, while the number of resident women with Ph.D.s has doubled, the number of foreign women earning Ph.D.s has nearly quadrupled over the last 12 years.

Czujko finds the data comparing women in physics to women in other fields particularly significant. "One of the reasons that's often given for why there are so few women in physics is that they don't have the requisite math skills," he said, pointing to the percentage of mathematics degrees held by women as a clear refutation of that theory. Another common misconception is that women don't go into physics because they lack the mechanical skills necessary to build experimental equipment. But nearly four times as many women have Ph.D.s in engineering as in physics.

Still another explanation is that women lack the single-minded ambition and will to succeed. Yet more than 5,000 women endure the stress of pre-med studies to become M.D.s each year, with over 16,000 women earning law degrees. "In short, there are plenty of women who are showing ambition and will to succeed, as well as math ability, and yet physics continues to draw very few, although there have been some improvements," said Czujko.

More encouraging is the data collected with regard to the percentage of women physics faculty at Ph.D.-granting institutions, which has risen to six percent in the last decade, compared to three percent in 1986 and 2.7 percent 20 years ago. The proportion of faculties with no women on staff was 55 percent ten years ago. Now the proportion is down to 35 percent.

Also showing marked improvement are the kinds of positions now being held by women faculty. "At the assistant professor rank, women are being hired at about their availability, which is 12 percent," said Czujko of the results. "In other ranks women are being hired at below their availability. A decade ago, that trend was reversed, with much higher employment for women in short-term, temporary kinds of positions."

In contrast to the modest improvements in the number of women in physics, traditionally under-represented minorities have made only minimal gains. Approximately 4.5 percent of bachelor's degrees in physics were earned by African-Americans in 1994, compared to three percent in 1984. Hispanics fared only slightly better, earning roughly 2.5 percent of all bachelor's degrees in physics in 1994, compared to less than one percent ten years ago.

The percentage of minorities with bachelor's degrees in other fields isn't significantly higher. For example, in 1992, African-Americans earned nine percent of bachelor's degrees in computer science, seven percent of those in business, six percent in mathematics, and 5 percent each in engineering, education, and other physical sciences. Hispanics earned four percent of bachelor's degrees in computer science, two percent in other physical sciences, and three percent each in business, mathematics, engineering and education.

Minorities fare even worse at the Ph.D. level, with such low percentages that Czujko opted to represent the data in terms of raw numbers. African-Americans earned a mere 11 Ph.D.s in physics in 1994, the same as in 1984, and 11 Ph.D.s in mathematics, up from four Ph.D.s ten years ago. However, they showed marked improvement in other fields, earning 34 chemistry Ph.D.s and 54 engineering Ph.D.s, compared with 23 and 15 Ph.D.s, respectively, in 1984. Hispanics earned 31 Ph.D.s in physics in 1994, up significantly from 14 in 1984, and also showed modest gains in chemistry and engineering, earning 59 and 66 Ph.D.s in 1994, respectively. However, Hispanics earned only 13 Ph.Ds. in mathematics in 1994, about the same as a decade earlier.

Interestingly, where a minority student chooses to study seems to have a tremendous impact on his or her likelihood of becoming a physicist. Of the 152 Ph.D.s in physics granted to African-Americans in the last 20 years, 20 were from Stanford University, with Howard University and MIT ranking a close second with 14 Ph.D.s each (see related "factoid," page 6). MIT also granted 9 of the 250 physics Ph.D.s earned by Hispanics in the last 20 years, with Penn State University, University of California-Los Angeles, and the University of Texas at Austin accounting for 8 physics Ph.D.s each.

According to James Gates, a professor of physics at the University of Maryland who earned his Ph.D. from MIT in 1977, it is no accident that so many minority physicists came out of those institutions. Achieving a certain critical mass in the department and the presence of role models and mentors to help both women and minority students through the pipeline are two things that he believes contributed to their success in attracting them to the field of physics.

The commitment to diversity at these institutions is, in fact, what enables minority students to flourish there. "In the biological world, it's very simple to see why diversity is important; that is what allows a group of organisms to survive in a new environment," said Gates. "Since science is about freeing ourselves from unconscious assumptions in order to find the answers to questions, we in fact impede the progress of science by restricting it to certain groups of people."

Most of the speakers also commented on the growing backlash against affirmative action policies in the U.S., made more critical by the current funding climate and tight job market for physicists. Joe Martinez, a physicist with Basic Energy Sciences, distinguished between "Affirmative Action" with a capital "A" and "affirmative action" with a lowercase "a". He feels that hiring is often based on social reasons, such as personal contacts, rather than merit, and cited a case where a former professor in one department made a phone call to the department manager on behalf of a former student and close acquaintance. The student was subsequently hired.

"I don't really criticize this informal method of hiring, but why isn't it applied universally?" said Martinez, classifying the incident as lowercase affirmative action. "Hiring and promotion based solely on personal contacts must no longer be accepted. This, combined with granting equal opportunities to minorities and women, will not let one side of the field pull down another, but rather to pull one side of the field up to the same level as the other."

Metallic Hydrogen *(continued from page 1)*

high pressure. Virtually all predictions have been made for solid hydrogen at low temperatures near absolute zero. The Livermore results were surprising because they looked at liquid hydrogen at relatively high temperatures, for which no predictions had been made.

It was long thought that the road to metallic hydrogen lay with crystalline hydrogen rather than with the disordered fluid phase. According to Neil Ashcroft of Cornell University, dynamic shock techniques to achieve high pressures were first introduced in 1942. Optical evidence of a new phase of hydrogen has been previously reported by scientists at the Carnegie Institute of Washington's Geophysics Laboratory, using an experimental approach that involves crushing microscopic-sized samples of crystalline hydrogen between diamond anvils, achieving pressures up to 2.5 Mbar, but without establishing metallic character. Metallic character is most directly established by electrical conductivity measurements, which are not yet possible in diamond anvil cells at such high pressures.

Thus, Nellis was somewhat surprised when he succeeded at lesser pressures with fluid hydrogen. His team used a two-stage gas gun to compress samples of liquid H_2 and D_2. In the first stage, gunpowder was used to drive a piston down the pump tube, compressing hydrogen gas ahead of it. At sufficient pressure, the hydrogen breaks through a rupture valve and accelerates a projectile down the second-stage barrel, generating a strong shock wave on impact with an aluminum sample container. Upon impact with the cooled liquid hydrogen, the shock pressure first drops, then reverberates many times between parallel sapphire anvils until the final pressure, density and temperature are reached. The temperatures achieved keep hydrogen in the form of molecules, rather than allowing them to break into atoms.

The Livermore team was able to make direct electrical measurements on a 1-inch-wide sample. A trigger pin in the target produces an electrical signal when struck by the initial shock wave. This is used to turn on the shock electronic conductivity data recording system, to determine if metallization has occurred. They observed that the sample's resistivity fell with increasing pressure, leveling off at a low value at pressures above 1.4 Mbar, about a million times Earth's atmospheric pressure.

In studying the span from insulator to conductor, physicists look at the energy gap, the difference between the highest filled electron energy level and the next available energy level, a level at which the electron is free to flow as part of an electrical current. In hydrogen at ambient pressures, the gap is 15 eV, big enough to qualify hydrogen as an insulator. In his shock-compression experiment, Nellis lowers the gap to only 0.3 eV, which is comparable to the thermal energy of the fluid.

Some of the theorists who predicted metallic hydrogen also believed the substance would remain metallic after the enormous pressures required to produce it were removed, and Ashcroft theorized as early as 1968 that it might be a superconductor. But the metallization events at Livermore occurred too brief a period of time to detect these effects if they occurred.

Properties of metallic hydrogen is of interest to astronomers who model the interiors of gas giants like Jupiter and Saturn, which are expected to harbor vast reservoirs of metallic fluid hydrogen. For example, the results suggest that the boundary between the core and mantle of Jupiter is continuous, rather than the discrete barrier predicted in the past. In addition, the Earth-based measurements indicate that the conductivity of Jovian hydrogen is 100 times smaller than that predicted by other models, but that the extent of the magnetic core is much larger. The results might account for the relatively large magnetic field of Jupiter.

Metallic hydrogen's light weight might also have interesting implications for materials science. "The potential uses of metallic hydrogen are fascinating to contemplate, but they are far down the road, and we've only reached the first mile post on that road," said Nellis.

OPINION

APS VIEWS

Minority Scholars Program is a Good Investment in Young Minds

by Arlene Modeste, APS Liaison to the Committee on Minorities in Physics

In 1980, only 2.1 percent of all physics and astronomy doctorates were conferred on minorities, including Blacks at 0.5 percent, Hispanics at 1.6 percent, and no Native American. The APS paid attention to those staggering statistics and believed that something had to be done to swing the pendulum in the opposite direction and get more minority students in the pipeline toward graduate studies. The response to this underrepresentation of minority students in physics was to establish the APS Corporate Sponsored Scholarships for Minority Undergraduate Students who Major in Physics, with financial support from the American Institute of Physics Corporate Associates and other companies.

The purpose of the program is to encourage minority students with an interest and aptitude for science and mathematics to major in physics early in their undergraduate years. Too often these bright students, who could be excellent physics majors, are lured into majors that are less challenging but more lucrative, such as medicine, law or business. Therefore, only high school seniors, college freshmen and college sophomores are eligible to apply. The APS Committee on Minorities, which administers the program, believes that it is important to address the issue of minority underrepresentation in physics at the point where students make the initial critical decision about their careers: the transition from high school to college.

Today, the percentage of minority Ph.D. degrees in physics has gone up slightly, but it is still seriously disproportional to other populations. As one of the five programs supported by the APS/AAPT Campaign for Physics, the Corporate Sponsored Scholarships for Minority Undergraduate Students who Major in Physics is still working to alleviate this problem. The program has three support and follow-up components.

The first is the monetary grant to the students, which is given only if the students commit to majoring in physics. This support encourages them to remain physics majors either by permitting them to devote more time to their studies by eliminating the need to work, or by enabling them to purchase books, equipment, etc. needed to pursue their physics degrees.

The second component is mentorship. The mentor provides advice on career choices, course selections, research experiences and general information on physics. Past studies have shown that the mentorship component is of great importance to the students. Mentors act as role models and the mentor/scholarship combination shows the students that the physics community really cares about them as young physics colleagues.

The third component is the small monetary grant to the student's host physics department, which is often used to promote minority speakers at colloquia, seminars or minority functions. It can also be used to provide additional funds for the department to send the student to a scientific conference or promote the retention of minorities in the department through other activities. More importantly, however, this grant helps to develop a relationship between the physics department and the student, who through his or her hard work has brought money into the department.

From the program's inception in 1980 to the academic year 1996-1997, 359 new and renewal scholarships have been awarded and a total of 200 students have received the scholarship. Of those students, 52 percent are African-American, 38.5 percent are Hispanic-American, 9.5 percent are Native American; 56.5 percent are male and 43.5 percent are female.

One student whose scholarship has just been renewed is a Native American woman from Hawaii who has had an excellent freshman year at Brigham Young University. Her advisor and physics professor at Brigham Young touts her as being one of the most impressive freshman students that he has had the privilege to know. She has begun attending research meetings in the physics department and has also allocated time to learn about the research that her advisor's group is doing on optical characterization of thin films. Her advisor has applied for support for undergraduate research so that she can stay after the semester ends to do research with his group.

This student serves as just one example of the talent, energy and ambition of the current crop of scholars. If the quality of the recent scholarship winners is any indication, the scholarship program is accomplishing its goal of encouraging bright young students to continue with the study of physics. The mentor-student relationship is often the catalyst to the continuation of their studies in physics. Surveys of past scholars also show that roughly 20 percent of the scholarship winners have earned a Ph.D. in physics, 47 percent have earned a bachelor's degree in physics, and 18 percent get degrees in related science or math fields.

Nonetheless, the overall statistics are not where we would like them to be. There is still much more work to be done and we are constantly rethinking our program to accommodate the needs of these students and steer them down a sometimes difficult path of study that can take them to any career they desire.

LETTERS

CareerPlus, Pro and Con

The *APS News* supplement, *CareerPlus*, is great. APS needs to become much more proactive on professional concerns, and this is a good start. I have two suggestions. First, you may wish to discuss interview preparation in a future issue. Second, the resume recommendations on page two center on format more than content.

Specifically, I would have included in the resume column the importance of emphasizing the contributions made and skills learned in each position. Too often, resumes look like a series of pro forma job descriptions. Stating why, in terms of career advancement, the applicant moved on to a new position also is a good idea. In the cover letter column, I would have stated strongly that the letter must convey that the applicant knows something about the company, and that he or she has something to contribute. Mentioning the name of a respected employee of the organization who would speak well of the applicant also is useful.

Brendan Godfrey
Brooks Air Force Base, Texas

Once again, I find myself compelled to write regarding your careers for physicists literature. Over and over in the *APS News* and *Physics Today* you refer to career opportunities for Ph.D.'s. In fact, in the career supplement section of the April *APS News*, you even go so far as to define a physicist as someone holding a Ph.D. in physics! In addition, back when I was job hunting a few years ago, I subscribed to the AIP Career Placement service. I could not help but notice that every single one of the listings in the monthly newsletter required a Ph.D. Does all this mean to imply that if one only has a lower degree in physics, then (s)he is not really a physicist?

Well, I have news for you. There are many people doing physics without the doctorate. In fact, for the past 15 years I have been doing physics related R&D with a mere master's degree (in applied physics, no less). However, if the APS does not consider me to really be a physicist, then perhaps I should resign my membership.

Michael Bleiweiss
Galactic Industries Corporation Salem, New Hampshire

The Editor Responds....

Mr. Bleiweiss' point is well taken. The analysis of the employment situation in the *CareerPlus* section did indeed emphasize the problems currently being experienced by Ph.D. physicists. This is primarily because more data is available and the critical nature of the problem is clearest for this group. Obviously, this leaves a lot of people out of the sample. It is in the nature of a careful statistical analyst to clearly define and limit the subset of the data being presented. Roman Czujko's statistics group is currently collecting and analyzing an extensive set of data from a survey of former Sigma Pi Sigma Members on their employment patterns; these include many non-Ph.D.s and B.S. physics majors who are putting their physics degrees to work in diverse areas. We plan to follow up *CareerPlus* periodically to update, augment, and expand the materials presented in the first edition.

The APS is working alongside AIP's Career Services Division to greatly expand position listings to which physicists at all degree levels might apply. This includes those in nontraditional areas. AIP is planning a comprehensive survey of job opportunities for physicists at all levels in the near future. One problem we noted is that employers rarely advertise for B.S. or M.S. level physicists explicitly, so they don't think to post listings with the AIP. Obviously we have lots of work to do in terms of breaking down stereotypical views of what Ph.D. physicists can do by employers and faculty alike.

If there is a central theme in the *CareerPlus* issue, it is to broaden your horizons and be open to how you can use your physics training, whether it be doing basic or applied physics, developing products, or whatever. This is pretty good advise that, I think, applies at any degree level.

FACTOID

Ph.D. Departments Accounting for Half of All Black U.S. Citizens Earning Ph.D.s in Physics from 1973-1993

Stanford University	20
Howard University	14
MIT	14
University of California--Berkeley	6
Kent State University	5
UCLA	5
American University	3
Brown University	3
Catholic University	3
CUNY	3
New York University	3
Princeton University	3
All Physics Ph.D. Granting Departments	152

Courtesy AIP Education and Employment Statistics Division *Source: NSF*

OPINION

Questioning Affirmative Action

by Elizabeth Baranger

In the past year, there have been several very well publicized events that indicate an increasingly open criticism of affirmative action. The most dramatic scaling back of affirmative action in American higher education occurred when the University of California Board of Regents voted to end racial preferences for hiring by January 1996, and in admissions by the following year. More recently the Arizona Board of Regents ordered the state's three public universities to determine if affirmative action was still necessary. Last May, the Supreme Court let stand an Appeals Court ruling that the University of Maryland's minority scholarship was unconstitutional.

This continued questioning of affirmative action ranges from whether it is truly effective, to the ethics of giving preferential treatment on the basis of race and sex, and to the morality of merging minorities into fields with a grim job market. I believe that most of the people who have criticized affirmative action are not directing their objections to those programs aimed at making the playing field level.

There are people who believe that African Americans can never be successful in a subject as complex and sophisticated as physics, and that they should stick to subjects such as music and drama. Likewise, there are people who believe that women should not enter physics, but should stay home and take care of their children. But they constitute a minority. The vast majority of people agree that playing fields should be level and do not object to affirmative action efforts for achieving this.

There are some affirmative action efforts which are viewed as leveling the playing field by one group of people, and as being unfairly discriminatory by others. For example, if there are no women on the faculty at a university, many would say that they are needed to provide role models for women students, and that one should give preference to women candidates. Similarly, if a university has only a handful of African-American on its arts and sciences faculty, special efforts, such as cognitive opportunity appointments, should be advocated, based on the belief that an African American student is educationally disadvantaged if he never has an African American professor. However, there are others who would say that this constitutes discrimination based on race and sex.

It is often stated that affirmative action means hiring unqualified people simply because they are a minority. One sets a quota and hires people to fill that quota, even if unqualified. I believe that reasonable people who support affirmative action do not support putting unqualified people in any position. However, there may be differences of opinion about what determines qualifications for a position. For example, when appointing a teacher for an inner city classroom, ability to interact with the children would mean that a minority teacher would be preferable. But under no circumstance would it benefit the children to be taught physics by someone who does not understand the subject, even if he or she were a minority.

The claim is also made that affirmative action produces a feeling of inferiority in minority men and in women of all races, and creates a negative stereotype in the minds of white males. For instance, some claim that affirmative action does nothing to alleviate the worst problems of black America, such as the state of the poor in ghettos. Their argument is that it benefits those blacks who are economically advantaged, who, by being put above their academic or career level by affirmative action, are set up for failure in a way that damages their self-confidence and reinforces white prejudices about black inferiority.

These statements are repeated so often that people start believing that there is a semblance of truth in them, although no hard evidence exists for the claim. Other groups — for instance, children of alumnae who are given preference at many private institutions — don't feel any stigma about having been admitted as children of alumnae. Furthermore, the assertion that affirmative action creates negative stereotypes implies that none of these stereotypes existed before affirmative action. I think that all of us know this is not true.

The claim is made that when race and/or sex is included as one of the criteria used to determine the outcome of a decision — such as university admissions, minority scholarships, or faculty appointments — it is, in essence, discrimination based on sex and/or race. In a recent article, Dinesh D'Souza, commenting on the action of the California Board of Regents, states, "It is simply untruthful for institutions to assert in their catalogs and other literature

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Going Against the Flow: A Sabbatical in Russia

by Wallace Manheimer

From February through September 1995, I was on a sabbatical in Russia as a visiting professor of physics at Moscow State University in the group on microwave electronics and space power systems, under Professor Vladimir Vanke. Naturally, it was an amazing experience for me and my wife who joined me; an experience of a lifetime.

The people I met there were tremendously friendly and hospitable. In preparation for the trip, I read quite a few books on Russia and studied Russian language. Also I studied the language rather intensively when I was there. Scientific conversations were about half in Russian and half in English. Other conversations I had with people there were almost entirely in Russian. However the conversations in Russian were not normal speed conversations; almost without exception, the Russian people I spoke to were willing to speak down to my level and tolerate lots of mistakes on my part. Russian is a difficult language with complicated grammar and long words, however trying to communicate in it is a tremendous amount of fun.

For scientists in Russia, to get by today is a tremendous struggle. Salaries of full professors at Moscow State are typically less than $100 per month. By contrast, receptionists and typists in western businesses there typically earn two or three times that. For a scientist to survive, he has to find other ways to supplement his salary. Sometimes these other ways involve science (i.e. tutoring or contract research), sometimes they do not. There are many scientists there who economically are really kiosk operators, taxi drivers, factory workers, window washers, etc.

Naturally it is easy to have a great respect for these people who do their scientific work despite tremendous obstacles. The Russian scientific establishment during Cold War times was too big and unsustainable. However, they are going from one extreme to another. The threat to Russian science is also a threat to world science, I believe. If Vanke is only worth a few hundred dollars per month, we are not worth any more, and most of us cannot live in the United States on that. Somehow Russian science has to, and I believe will, get its act together. Russia has had a strong, independent scientific tradition since the time of Peter the Great.

Even in communist times, the scientific establishment was more independent of party control than other elements of Russian society. However this does not mean that the scientific establishment was in any sense independent. As innumerable people pointed out to me when I was there, it was the scientist party members, or those favored by the party, who got easy publication of their work, trips to the west, etc. Also in internal power struggles in labs and universities, the winner was frequently determined by who had the better party credentials.

Often leading scientists joined the party just to enhance their scientific stature. Roald Sagdeev points this out in his book *The Making of a Soviet Scientist.* However it is important to realize that there were many Russian scientists, some just as capable as he, who did not join the party even though they had the opportunity to do so. They always suffered professionally because of their decision. It was interesting that when we spoke to these people, invariably they found a way to work it into the conversation that they were not party members. They seemed to take a great deal of pride in it, and justifiably so, I think. As we broaden our contacts with Russian scientists, it is important to realize that the best ones may well have been ones we heard very little of during Cold War times.

One interesting thing about Russian science, as told to me by a lab director there, is that in communist times, there was more freedom in physics, at least professionally, than there was in the society at large. Therefore physics had a relatively easy time attracting the brightest people, since often these people were the ones who also valued freedom. However now that Russia is a democracy, and freedom of speech, press and religion are respected (this was obvious to me as a visitor there), physics does not have the same appeal. Bright people can have more freedom than they used to in any profession.

Several people told us how science is funded there. For instance at the Institute for Applied Physics at Nizhny Novgorod there are four levels. First of all there is everyone's basic pay, which is so little as to be almost meaningless. Second there is internal competition for funds for science projects, which can add some to the salaries of the winners. Third there is the Soros foundation which supports some work there. This money is distributed to the winners of competitive proposals. Finally there is what the lab can sell commercially to the rest of the world. For instance this lab, in collaboration with Russian industry sells gyrotrons to various worldwide magnetic fusion projects. They are also working now on such commercial projects as millimeter wave ceramic sintering and very short pulse radars. There are close relations between the university and the major auto manufacturers there. These industries add support to the university, probably to get first crack at hiring the best graduates and also to involve the university in its problems. The major contacts between the industries and universities are done at high level. It seemed to me that this could be a reasonable model for supporting American universities also.

Finally, there has been much talk in the west about doing what we can to help Russian science. I would like to suggest one additional thing which would not only help Russia, but help ourselves also. There are many large international scientific projects world wide. One possibility would be to locate some future ones in Russia. The project would gain from the relatively low price of the Russian scientific and technological infrastructure, and Russian science and technology would be much more integrated into that of the rest of the world.

Thus, my sabbatical was a tremendous experience, and I strongly recommend it to other scientists who might be interested.

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Questioning Affirmative Action

(continued from page 7)

that their policies are anything but... biased based on race, sex or national origin. They are practicing discrimination against individuals for the purpose of admitting members of minority groups who do not represent the same levels of academic credentials as white or Asian Americans."

D'Souza continued, "One can hardly maintain that preferential policies strictly serve the goals of social justice. Take the case of Asian Americans. Members of this minority group have experienced both de facto and de jure discrimination, and they have played no part in the historical crimes that affirmative action was designed to remedy. In fairness, why should the burden of preferential policy be placed on historically innocent parties?" Further, D'Souza argues that SAT scores aren't biased, that grades are relevant, and that therefore, his argument is that affirmative action discriminates on the basis of race, and discriminates against an individual in order to produce products from the group.

There are many arguments one could make against this. For instance, traditionally, we have given preference to other groups, such as athletes. Preference is given to in-state students at a state institution. But this strikes me a little bit as saying that two rights make a wrong. I think a stronger argument is that we don't discriminate, that many factors are taken into account when making admissions. The purpose is to admit students who will succeed, based on a variety of criteria, and race or gender may be taken into account to offset possible discrimination in educational opportunities, or possible cultural or gender bias in the SATs and GREs.

In hiring faculty, the point can be made that we are discriminating against a white male when we give preference to a woman, or when we establish a targeted opportunity position for a minority. Here I think the argument against affirmative action is less strong than in the admission of students. We hire faculty to create a group that meets the needs of students, or who can conduct research at the top of their fields. We hire faculty to further the mission of the college and university, and we all discriminate against people trained in certain fields. We may decide we're only going to hire experimentalists, or go after the next Nobel Prize winner. Similarly, if we are educating a large number of women, we should try to hire a woman the next time we do a search, or try to have targeted opportunities for African Americans to attract them to our department. It doesn't seem to me that this is very different from our usual hiring procedures.

There is one type of preference I find more troubling. The University of Maryland created a fellowship program only for African Americans to attract undergraduates with exceptional academic qualifications. The students admitted to the program came from upper middle class families whose parents could have paid their tuition, and if they didn't go to Maryland, they would have been eagerly accepted someplace else. What is the rationale? It does not best address the needs of minority students who lived in the most disadvantaged areas. It does not educate students who would not otherwise obtain an education.

I think we do it because we are committed to diversity. Universities are the principle institutions where citizens, professionals and leaders are and will be educated and shaped. Each university believes it must have on its campus minority students who will be the future leaders and the future faculty, and who will also be perceived by all students as smart and educated. This is the way to right past discrimination beyond the individual level: by changing the climate on the campus and thus educating all students as to the benefits of diversity.

Finally, it is very difficult to find a job in physics these days, and the situation will probably not improve. Why, then, are we encouraging more people to go into physics, and seeking to recruit women and minorities into a field where they may not be able to get a job? I do think we should cut down on our production of Ph.D. s, and probably on the numbers of international students. But we should also broaden the education of our students so that they will be more employable. I believe we should continue to encourage women and minorities to enter a field which has been closed to them in the past.

In short, affirmative action is under attack. I believe that universities must be the leaders in affirmative action in order to create a diverse environment at their institutions. This will help ensure that the next generation will produce a society in which there is true equal opportunity for all.

Elizabeth Baranger is Associate Provost and Professor at the University of Pittsburgh.

Session Marks Centenary of Discovery of Radioactivity

February 24th marked the 100th anniversary of the first scientific presentation by French physicist Henri Becquerel that led to the discovery of radioactivity. Human use of radioactivity not only led to such obvious results as nuclear energy, nuclear weapons, medical X rays and cancer therapy; it also provided tools that helped launch studies of the subatomic world and making it possible to determine the three-dimensional structure of important biomolecules.

According to Erwin Hiebert, a science historian at Harvard University who spoke at the March APS Meeting, the discovery of radioactivity was one of the first milestones in terms of toppling the inertia of causality in physics. Until the end of the 19th century, chance and probability were taken by most scientists and philosophers as expressions of ignorance, and not as basic components in the structure of the world. With the discovery of radioactivity in 1896, such views began to be questioned. "Here was an event, obeying an exponential decay law, in which chemical elements were known to disintegrate and transmute into other elements in a process that could not be made to alter its course by external changes; fluctuations in the radioactive decay process were real and acausal," he said.

Radioactivity was also the first event in the development of nuclear physics. Although the neutron, positron, deuterium atom, and so forth weren't discovered until 1932 and beyond, radioactivity was the first reaction in which a nuclear phenomenon was taking place at a subatomic level. And to some extent, Hiebert believes, the discovery of radioactivity as a nuclear fluctuating phenomenon was the first example of a quantum phenomenon, in which quantum notions were put to the test. It wasn't until 1928 that Werner Heisenberg put forth his uncertainty principle, which implies that one cannot simultaneously precisely determined the position and the momentum of a particle, implying that there is some indeterminancy in the way that nature behaves.

Scientists were soon using radioactive materials as projectiles to bombard atoms, resulting in the first scattering experiments. On the basis of those, it was recognized in 1913 that the atom had to be extraordinarily compact, and that the nucleus was very much smaller than the atom itself. This early use of projectiles has become modern particle physics. "Before this, it was believed that elements were the basic building blocks of nature," said Helena Pycior (University of Wisconsin, Milwaukee). "Now we understand that they are not; they're all made up of the same particles. Our whole view of the universe was transformed by this."

In addition, radioactive materials were used as early as the 1930's to destroy cancer cells, and diseases, again as a source of subatomic projectiles. Some of the most important applications of radioactivity have been in nuclear medicine, as well as nuclear reactors, power and nuclear weapons, carbon dating, and other radioactive dating, such as potassium argon dating of geologic specimens.

The Curies: The Very Model of Modern Spousal Collaboration

Radioactivity may have given us our prime example of a woman scientist in Marie Curie, but it also gave many women scientists an example of successful spousal collaboration, according to Helena Pycior, a historian at the University of Wisconsin, Milwaukee. She has analyzed the Curies specifically as a research team, whose strengths and limits in the study of radioactivity were due to a complex complementarily, involving differing modes of thought, personalities, scientific styles and levels of commitment to physics and chemistry.

Whereas Pierre was a slow thinker who framed his scientific conclusions soberly and cared little for priority and fame, Marie moved quickly from experiments to bold published hypotheses, Pycior found. Pierre was non-competitive, which may have inhibited his rise to scientific eminence, but at the same time freed him to collaborate with Marie on equal terms, sharing both work and credit. Pierre was intellectually restless; Marie was intellectually broad, but persistent and capable of immersing herself in the study of radioactivity from 1897 through her death. "I think that without Marie, Pierre would not have been a great scientist," said Pycior. "Similarly, without Pierre, Marie would not have been a great scientist. It was their complementarity that enabled them to do so much in the field of radioactivity."

Of greater interest to Pycior was how the pair ensured that Marie received credit for her work, a major problem historically for women who are part of scientific couples. She discovered that the Curies had a unique publication policy, involving having Marie publish independent papers as well as joint ones, as well as recognizing her independent contributions in their joint work. "This made it very hard for the French and even English scientists to miss the fact that Marie was a significant entity in the research team," said Pycior.

The Curies' unique characteristics, both singly and as a couple, may also have influenced their choice of scientific research, according to Susan Quinn, author of a new biography of Marie Curie. In contrast to Henri Becquerel, who was very much part of the French establishment, the Curies were outsiders. Marie was Polish and a woman, while Pierre was largely educated at home by his politically radical father, and thus didn't have access to many privileges of French society. Thus, Quinn finds it unsurprising that the couple would choose to focus on investigating uranium rays, at a time when most of the French scientific establishment was focusing on X rays.

UNESCO Meeting Outlines Current and Future Priorities

On March 14, representatives from the APS, the National Academy of Sciences (NAS) and various other scientific organizations met at NAS headquarters in Washington, DC, for an informal meeting to discuss UNESCO's science activities, current priorities and future plans. The meeting was hosted by NAS Foreign Secretary Sherry Rowland.

The U.S. withdrew from UNESCO participation in 1984 amid charges of corruption on the part of its then-Director General, Amadou-Mahtar M'Bow. A GAO report released last year concluded that subsequent reforms at UNESCO had met U.S. requirements for re-entry, with an equally favorable response from President Clinton. Federico Mayor, UNESCO's current director general under whom many of the reforms have taken place, said that reform initiatives would continue.

Mayor first reviewed the global-scale science programs currently supported by UNESCO, including the development of a new global program to examine the integration of the social sciences into major science initiatives. However, he admitted that there remains a need for new initiatives in support of basic science, although there are partnerships and other collaborations in place where intergovernmental mechanisms in the basic sciences do not yet exist, such as the Microbial Resources Centers Network (MIRCENS) and the International Center for Theoretical Physics in Trieste, Italy.

(continued on page 10)

Physics of High and Low Level Waste Management Explored

Public policy issues and concern over the management of disposal of high and low level radioactive waste were the featured topics at a Monday afternoon session on physical methods of waste management, sponsored by the APS Forum on Industrial and Applied Physics. Related physics and chemistry issues under discussion included criticality, plutonium loading in glass, leach rates, and diffusion, while public policy issues center on non-proliferation, states' rights, stakeholder participation, and nuclear power.

John Ahearne, a lecturer at Duke University and adjunct scholar for Resources for the Future, defines high level waste as used fuel from nuclear reactors and the most hazardous wastes from manufacturing nuclear weapons. Low level wastes include items such as contaminated rags, clothing, and tools from nuclear plants, hypodermic needles, and other medical wastes.

Most of these low level wastes cannot be safely incinerated without producing harmful toxins, and thus are sent to storage sites throughout the country. However, existing sites are rapidly reaching capacity, and no new waste site has been developed because of public opposition. Compaction can further reduce waste volume by as much as 75 percent, and Ahearne favors an omnibus regulation that would allow material below a certain level to be disposed of as regular waste.

A much bigger challenge is what to do about the growing stockpile of high level nuclear waste, according to Ahearne. Currently, such waste is stored on-site in pools of water, in which the water absorbs the radiation from the fuel and also cools it. The preferred option is dry storage, in which the fuel is placed in large casks, which are then placed upon concrete pads. However, state regulatory commissions are reluctant to approve expanded cask storage until there is some solution other than leaving the waste on the utility site for the indefinite future. Consequently, some plants are in danger of being shut down well before the end of their useful life.

Some alternatives include transmuting the fission products into other elements, which is technically possible but not economically feasible, and still may not eliminate the need for a repository. Attempts to liquefy high level waste and store it in glass rods face similar obstacles. Another option being explored for weapons plutonium is storing the waste in holes several miles deep, or in deep seabeds, which would require substantial changes in existing international law.

The problems of cleaning up the former defense facilities are even more complex. To that end, the DOE has recently issued a request for proposals to the research community for long-term research programs aimed at site remediation and decontamination. "First, we lack complete knowledge about what and where the wastes are," said Ahearne of the issue's complexity. "Also, the science and technology does not yet exist for handling many of the DOE's waste problems. Defense wastes are a problem for only a few countries. The difficulties are many, the solutions few, and the costs large."

In the same session, William Edelstein of General Electric's Corporate R&D Center in Schenectady, New York, and Tadeus W. Patzek (University of California, Berkeley) described a new method for destroying soil contaminants without removing or concentrating them first. The process uses the application of heat through thermal blankets or wells to vaporize contaminants, then draws them towards the surface with a vacuum. Temperatures continue to rise as contaminants draw nearer to the surface and the heat source itself, and the molecules are destroyed as they approach 600-700 degrees C. The process works well on any waste that can be volatized at 1,000 degrees C, including mercury, arsenic, lead compounds, and all hydrocarbon compounds.

Robert Frosch of Harvard University's John F. Kennedy School of Government closed the session with a description of Industrial Ecology, a systems view of material and energy flows in the industrial system, and between the industrial system and the environment. "Using fundamental physical and chemical principles, and some business experiences, industrial ecologists suggest that that the reuse of wastes, products, parts, components, and materials is likely to be an environmental and economically beneficial strategy," said Frosch, offering the waste management practices of U.S. steel mills as an example of efficient employment of the method. Although it presents some problems for industry, consumers, and public policymakers, he believes the strategy could be further improved with some technological and business developments.

Scientists Simulate Vortices Flowing Through Superconductors

A new computer simulation developed by physicists at the University of Michigan is enabling scientists to "see" what is happening inside superconductors, which could help solve fundamental mysteries about how vortices and the electrical currents that whirl around them pass through superconducting materials.

"When vortices move they dissipate energy and destroy the material's superconductivity — the unique ability to transmit electrical currents without resistance," said Franco M. Nori, an associate professor of physics at University of Michigan, who presented his findings at a Wednesday afternoon session at the 1996 APS March Meeting. "Understanding how vortices alternately become trapped and break free as they move through superconductors is crucial to minimizing energy loss and can help us develop improved practical applications for superconducting technology — especially more powerful magnets for use in medical imaging systems and particle accelerators."

The University of Michigan simulations were developed in collaboration with experimentalists, and were based on laboratory measurements of voltage pulses and magnetic fields generated by lines of magnetic flux passing through superconducting materials. The advantage of computer simulations, according to Nori, is that they allow scientists to systematically vary the many factors that affect vortex transport phenomena — such as temperature, magnetic field strength, or the number and position of defects or pinning sites in the material — and observe how the vortices react.

According to the simulations, the magnetic field lines known as vortices flow through superconductors in streams that pool and eddy behind obstacles and merge into broad channels in open areas. If these obstacles, or "pits," are deep or strong, the vortex cannot escape and the pit remains filled. If the pits are shallow or "weak," vortices can be pushed out by the pressure of other vortices piling up behind them, producing sudden bursts of energy and a branching network of narrow meandering trails as the vortices alternately dam up and break through the pit barriers.

The forces producing these avalanches or sudden bursts of energy are the subject of intense study, not only in superconductors, but also in sand lies, water droplets, magnetic bubble arrays, earthquakes and other complex systems. "All these apparently dissimilar systems have interacting moveable objects that repel each other and are pushed toward instability by an external driving force," said Nori. "During the unstable state, particle transport occurs in the form of avalances or cascades which release accumulated strain in the system."

Nori and his colleagues are currently studying superconductors with periodic arrays of pinning sites that produce very stable vortex configurations which are unaffected by increasing currents or magnetic fields. They are using vortex transport simulations to explore basic questions about what happens when an elastic lattice is forced onto a rigid substrate, which could lead to applications in many other fields of physics.

STM Key to Positioning Individual Molecules at Room Temperature

Scientists at IBM's Zurich Research Laboratory in Switzerland have used a scanning tunneling microscope (STM) to move and precisely position specially designed individual molecules on a copper surface at room temperatures for the first time. In addition to developing software that moves and positions the STM tip with extreme precision, the team was able to switch the same STM to the imaging mode by slightly increasing the distance between the tip and the surface.

The achievement is an important step towards developing the ability to perform a wide range of nanometer-scale engineering, according to Thomas Jung, who headed the Zurich effort. "Eventually, we hope to learn how to build molecules with specific properties and functions, construct computers of very small size, and even build minute molecular machines capable of cleaning or repairing nano-scale electronic circuits, for example," he said.

The STM, which earned its inventors at IBM/Zurich the 1986 Nobel Prize in physics, can image surfaces with atomic resolution and has been used to position individual atoms since late 1989, when scientists at IBM's Almaden Research Center wrote the letters "IBM" with 35 xenon atoms. However, most atoms and molecules tend to stick strongly to the surface, making it difficult to pick them up and release them in a precisely controlled way. Those that are less "sticky," on the other hand, tend to jitter too easily at room temperatures to make sustainable structures.

The Almaden team overcame the jitter problem by cooling the sample to nearly absolute zero. However, room temperature positioning is required for broad practical uses, such as creating chemical reactions that build functional units from individual atoms and molecules. The first successful room-temperature manipulation of atoms was performed in 1991 by researchers at IBM's T.J. Watson Research Center, using electrical pulses to pick up and release individual silicon atoms. Most molecules would be torn apart by the pulses used in this technique, however.

To solve this problem, the Zurich scientists evaluated a wide range of molecules as possible candidates for the experiments, performing elaborate molecular mechanical simulations. "The molecules have to stick tightly enough to remain at their position, but not so tightly that they cannot be moved," said Jung of the role of the molecule's nature and its interaction with the surface. "On the other hand, the chemical bonds within the molecule must resist being changed or broken when the molecule is pushed by the STM tip."

In an invited paper at the March Meeting, Jung described how they manipulated an organic molecule consisting of 173 atoms, with a stable ring of atoms at its core known as porphyrins. Widely found in nature — they are the basis of red blood cells, for example — the position and structure of porphyrins are easily identified by STM imaging. The molecule also has four strongly but flexibly bonded hydrocarbon groups attached vertically to the ring, which act as "legs" that lift the "body" of the molecule from the atomically flat copper surface.

According to Jung, the porphyrin-based molecule has a number of potential technological uses. For example, the single copper atom at its center can be replaced by another metal atom with different electronic properties, which could be exploited to construct data storage devices with densities 100,000 times higher than today's most advanced disk drives. Another technological possibility involves wires only one molecule wide that could be used to build ultrasmall electronic components.

Highlights from St. Louis: (continued from page 1)

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 1996 issue of *APS News*.

TECHNICAL SESSIONS

Chemical Sensitivity in Scanning Probe Microscopy. On Monday morning, scientists reported on some of the latest advances in using state-of-the-art microscopes to identify chemical bonds in atoms and molecules, and even to tailor the strength of the bonds. IBM's Phaedon Avouris discussed how the electric field in an STM can be used to tune the strength of a chemical bond, resulting in Stark-shifts of the excitation energies which can suppress lateral energy transfer processes to allow very localized bond breaking.

Furthermore, chemical modification of the force microscope probes and sample surfaces with self-assembled monolayers provides a reducible system for quantifying adhesive and frictional forces between distinct functional groups in liquid media, according to Harvard University's Dmitri Vezenov. This technique is called chemical force microscopy (CFM).

Single-Electron Devices. During the past year, a spectacular breakthrough in the fabrication of nanometer-scale single-electron transistors was achieved by several research groups, and these devices exhibit correlated single-electron tunneling with much higher electron addition energies at room-temperature. For example, LSI Laboratories in Japan fabricated a silicon single-electron transistor, and the University of Minnesota is producing single-hole quantum dot transistors. These ultrasmall structures will allow systematic studies of previously inaccessible features of correlated tunneling, and may eventually find their way into mainstream ULSI technology.

Liquid Interfaces. Michael Wilson of the University of California, San Francisco, described the latest ideas on the chemical mechanisms for anesthesia. For almost a century, it was believed that the site of anesthetics action was located in the oily interiors of neuronal membranes. Recently, however, numerous compounds have been discovered — such as lipophilic compounds and water-soluble compounds like ethanol or butanol — for which this basic hypothesis doesn't apply, leading to the conclusion that anesthetic compounds act at water-membrane, or possibly water-protein, interfaces. Using molecular dynamics computer simulations, Wilson and his colleagues have been examining how various solute molecules interact with the water-oil and water- membrane interfaces at a microscopic level of detail not yet available experimentally.

Critical Behavior of Magnetic Films. Many materials become magnetic at low temperatures, and there are existing models to determine the critical temperatures at which this transition occurs for two- and three-dimensional bulk materials. However, to date there has been no general method for calculating critical temperatures for magnetic films of arbitrary thickness, and it is difficult to describe magnetic properties in terms of atomic behavior. D.L. Lin of SUNY-Buffalo has developed a theoretical model that will help scientists understand how the critical temperature changes when film thickness increases from one single atomic layer to many layers. The theory may also be extended to investigate various properties of magnetic films from an atomic viewpoint, particularly by looking at the cooperative behavior of magnetic atoms in ultrathin films. Thin magnetic films are very useful in electronic devices, especially for information storage.

All-Optical Communications Networks. Transistors and other electronic devices could someday be replaced by optical switches in the telecommunications industry, according to speakers at a Friday morning session, who addressed efforts to produce truly transparent optical communication networks, in which the optical signals are never converted to electrical signals and back again. Such transparent, multiwavelength networks could prove to be high capacity, flexible, reconfigurable and cost-effective, as well as compatible with existing systems and easily upgraded — all qualities needed to meet the demand for broadband multimedia services.

Dynamics of Granular Flows. Paul Umbanhowar of the University of Texas at Austin described the discovery of a new type of pattern that occurs in the flow of granular materials, such as corn, pebbles and wheat grain. Such knowledge is important for the mixing, processing and manufacturing of such materials in industrial and agricultural settings. The effects of air between the grains and the interaction between the grains and the walls were minimized by using a wide, shallow container. When the grain sample is vibrated, numerous patterns form: stripes, hexagons, and baseball stitches.

Metallic Nanocrystals. Uzi Landman of Georgia Tech described the first formulation of large-scale crystals, measuring about one micron on a side, out of metallic "nanocrystals" measuring just billionths of a meter on a side. Materials structures of nanometer-scale dimensions often exhibit properties and behavior different from those in the bulk, and Landman is currently investigating the energetics, crystalline structure and morphology, electronic and transport properties, stability, and mechanical response characteristics of several forms of these gold nanostructures. In addition to the crystals, other forms include nanowires formed as junctions between materials bodies, and dots supported on a substrate.

Self-Assembly of Nanostructures. Samuel Stupp of the University of Illinois reported on the discovery of molecules that assemble themselves into 1-micron-thick films of "nanomushrooms" of about 100 molecules each that have potentially useful properties. For example, the film can double the frequency of light by converting infrared radiation to green light. It also sticks tenaciously to glass, while its top surface remains non-sticky, so that it resembles a piece of tape. Furthermore, the sticky surface ends up on the top instead of the bottom of the film by drying the precursor solution on a non-sticky surface like teflon. The discovery is helping scientists to understand the principles that rule self-assembly of nanostructrures, such as the proteins produced in nature.

Constant Materials. According to Rick Moore of the Georgia Institute of Technology, percolating materials — special materials composed of conducting and non-conducting elements — surprisingly conduct better as bulk materials rather than thin layers. These materials have potential applications as antennas and as devices to protect against electromagnetic interference. He found that the structures underwent a transition from two-dimensional to three-dimensional systems as thickness increased.

Ultrafast Scanned Probe Microscopes. Geffrey Nunes of Dartmouth College reported on the status of his efforts to make a "movie" of the charge cloud at single defect sites in semiconductors by building up a time sequence with picosecond resolution of STM measurements. He described two approaches to achieve such resolution. One exploits the intrinsic nonlinearity of the current-voltage characteristic in the STM to mix a fast signal with a short electrical "probe" pulse, similar to ultrafast optical cross-correlation techniques. The other performs boxcar measurements of time-dependent STM signals by varying the tunneling impedance, using a magnetorestrictive tip to control the tunneling distance on nanosecond time scales.

Quantum Biology. Advances in theory and computational power have allowed scientists to make models of biological systems at the atomic and molecular scales, where the quantum energy levels of electrons and other quantum-mechanical effects come into play. Duke University's Weitao Yang reported on the development of a linear scaling electronic structure method suitable for biological macromolecules. The method has been used to calculate the electrostatic potential of proteins and nucleic acids, and studies of thermodynamic properties are underway. At SUNY-Buffalo, a hybrid quantum mechanical and molecular mechanical method has been developed for the simulation of molecules in solution, and scientists at Columbia University have developed applicable novel algorithms and electron correlation methods.

Frontiers in Research. The APS Forum on Education sponsored a session featuring topics on the frontiers of physics research aimed at educators and general audiences. Speakers explored physicists' latest insights into the mysteries of how ice and water drops form; new knowledge on the pretty and intricate patterns formed by groups of living cells; the miniaturization of single magnets to nanometer scales and potential applications; and recent studies allowing physicists to stretch a single DNA molecule to test its mechanical strength and other properties.

NONTECHNICAL SESSIONS

Physics Journals on the Internet. The advent of electronic publishing is having a profound affect on scientific journals. On Tuesday morning, representatives from the American Institute of Physics (AIP) and the American Astronomical Society (AAS) described their efforts to produce on-line versions of their journals. AIP's *Applied Physics Letters* became available online in January 1995, and the APS journal *Physical Review Letters* became available online soon thereafter. Other journals are coming online monthly.

Human Rights in China. The APS Committee on the International Freedom of Scientists (CIFS) sponsored a special session in honor of Henry Wu, a former political prisoner in China who captured world headlines last year when the Chinese government first sentenced him to a harsh prison sentence, but then expelled him from China shortly before Beijing hosted the United Nations' Fourth World Conference on Women. Wu, who emigrated to the U.S. in 1985 and has a degree in geology, spoke informally at the reception, addressing the past and present condition of intellectuals in China. Also making informal comments were Chinese astrophysicist Fang Lizhi (University of Arizona) and physicist Betty Tsang (Michigan State University), both past chairs of CIFS.

Biological Effects of EMFs. The debate continues as to whether the low-frequency electric and magnetic fields from power lines and household appliances affect the cells of living organisms. Some physicists say that ongoing laboratory studies show possible evidence for subtle, though not necessarily damaging, effect of the fields on biological systems. Speakers at a Thursday morning session reviewed recent results from such studies, including work on the ELF charge-to-mass signature, and on the effects of ELF magnetic fields on immune cells.

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

1996 MARCH MEETING PROGRAM COMMITTEE

Chair: Robert C. Richardson, Cornell University. **Members:** G. Slade Cargill III, Columbia University *(DMP)*; Patricia Dehmer, Argonne National Laboratory *(DLS)*; Fred Dylla, CEBAF *(FIAP)*; Robert J. Erdman, Keithley Instruments, Inc. *(IMSTG)*; Charles Falco, University of Arizona *(FIP)*; Joan M. Frye, Howard University *(COM)*; Katharine B. Gebbie, National Institute of Standards & Technology *(CSWP)*; Edward Gerjuoy, University of Pittsburgh *(FPS)*; Chih-Ming Ho, University of California-Los Angeles *(DFD)*; Ruth Howes *(FED)*; Ivar Giaever, Rensselaer Polytechnic Institute *(DBP)*; Barry Klein, University of California-Davis *(DCMP)*; David V. Lang, AT&T Bell Laboratories *(DCMP)*; John S. Rigden, American Institute of Physics *(FHP)*; Joon Roe, University of Cincinnati *(DHPP)*; Steve Sibener, University of Chicago *(DCP)*.

UNESCO Meeting

(continued from page 8)

In terms of regional programs, UNESCO has specifically targeted Africa for development, which is experiencing considerable brain drain: some 30,000 Ph.D.s from sub-Saharan Africa have fled to developed countries, according to Mayor. A development fund has been established, seeded with $1 million and bolstered with contributions from other countries, and Mayor has been working to convince governments in that region to invest some 3 percent of their GDP in education, science and technology combined. In Latin America, there is an increasing need to involve the private sector in science, technology and educational efforts, said Mayor, while Asia is in need of a network of eco-technology centers.

Afternoon discussion at the meeting focused on such issues as telecommunications and renewable energy sources, as well as electronic publishing. It was agreed that there is a need to prevent growing disparities between communities, especially between developed and developing countries.

ANNOUNCEMENTS

NOMINATIONS FOR 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 recipient. 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://www.aps.org] under the Prize, Award and Fellowship button, for complete information regarding rules and eligibility requirements for individual prizes and awards.

1997 FLUID DYNAMICS PRIZE

Endorsed by friends of the Division of Fluid Dynamics and 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 3 September 1996 to: Stanley A. Berger, UC, Berkeley, Dept. of Mechanical Engineering, Berkeley, CA 94720, (510) 642-5950, fax: (510) 642-6163, email: saberger@me.berkeley.edu.

1997 OTTO LAPORTE AWARD

Endorsed by the friends of Otto LaPorte and the Division of Fluid Dynamics.

Purpose: To recognize outstanding accomplishments in research in fluid dynamics.

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 3 September 1996 to: Sung Piau Lin, Box 5725, Clarkson University, Potsdam, NY 13699, (315) 268-6584, fax: (315) 268-6438, email: gw02@splin2.mie.clarkson.edu.

1997 SHOCK COMPRESSION SCIENCE AWARD

Purpose: To recognize contributions to understanding condensed matter and non-linear physics through shock compression.

Nature: This Award is to be presented biennially in odd-numbered years and consists of a cash award of $2,000, a plaque citing the accomplishments of the recipient, and an allowance for travel to the meeting at which the award is presented.

Send name of proposed candidate and supporting information before 3 September 1996 to: James Russell Asay, Solid Dynamics Department, Sandia Natl Lab, MS 0458, PO Box 5800, Albuquerque NM, 87185-0458, fax: 505 844 4543, email: jrasay@sandia.gov

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Impending APS Prize & Awards 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.

1997 Prize	Deadlines		
David Adler Lectureship Award	06/14/96	Aneesur Rahman Prize	06/14/96
Apker Award	06/14/96	I.I. Rabi Prize	06/14/96
Dissertation in Beam Physics	06/14/96	Prize for Research in an Undergrad Inst.	06/14/96
Bouchet Award	06/14/96	Earl K. Plyler Prize	06/14/96
Herbert P. Broida Prize	06/14/96	J.J. Sakurai Prize	06/14/96
Oliver E. Buckley Prize	06/14/96	Arthur Schawlow Prize	06/14/96
Davisson-Germer Prize	06/14/96	Leo Szilard Award	06/14/96
John H. Dillon Medal	06/14/96	John Wheatley Award	06/14/96
Forum Award	06/14/96	Robert R. Wilson Prize	06/14/96
Dannie Heineman Prize	06/14/96	Tom W. Bonner Prize	07/01/96
High Polymer Prize	06/14/96	Fluid Dynamics Prize	09/01/96
Irving Langmuir Prize	06/14/96	Otto Laporte Award	09/01/96
Lilienfeld Prize	06/14/96	Shock Compression Science Award	09/01/96
Maria Goeppert-Mayer Award	06/14/96	Dissertation in DAMOP	11/18/96
Onsager Prize	06/14/96	Will Allis Prize	06/20/97
George E. Pake Prize	06/14/96	Biological Physics Prize	06/20/97
W.K.H. Panofsky Prize	06/14/96	Frank Isakson Prize	06/20/97
		Dissert. in Nuclear Physics Award	06/20/97

CAUGHT IN THE WEB

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

New/Updated Links:

Membership
- New APS Member Directory Search
- Application for member services can be done online now using our SECURE SERVER.

APS News Online (latest edition)

Careers
- New Job listing sites
- CareerPlus Supplement (free for non-members)

Meetings
- Joint Meeting News Conference Schedule

Units
- Updated DMP Homepage
- New DFD Homepage

IN BRIEF

- The 1996 Aneesur Rahman Prize has been awarded to Steven Gwon Sheng Louie, a professor of physics at the University of California, Berkeley. His citation reads, "For innovative applications of quantum theory and computational physics to predict the properties of condensed matter systems, especially the excitation spectra of semiconductors and insulators." Louie received his Ph.D. in physics from UC-Berkeley in 1976. He was a research scientist with IBM's T.J. Watson Research Center and AT&T Bell Laboratories, before accepting a faculty appointment at the University of Pennsylvania. He joined the Berkeley faculty in 1980. Louie's research interests include the electronic and structural properties of crystals, surfaces, interfaces, clusters, and materials under pressure, and on quasiparticle excitations in solids, and electron correlation effects in bulk and reduced dimensional systems. The Aneesur Rahman Prize was established in 1992 to recognize and encourage outstanding achievement in computational physics research. It is sponsored by the IBM Corporation.

- Dr. Javier Solana, a solid state physicist, has been appointed Secretary-General of NATO. Solana received his Ph.D. in physics at the Autonomous University of Madrid, Spain, and is a former Fulbright Scholar. A professor of solid state physics at Madrid Complutense University, he is the author of over 30 publications in his field, and is a member of the Spanish Chapter of the Club of Rome.

- In November 1995, the U.S. Civilian Research & Development Foundation (CRDF) for the Independent States of the Former Soviet Union (FSU) announced a cooperative grants program intended to address the issue of dramatically reduced resources for scientific and engineering research in that region. It is also intended to address defense-conversion issues in scientific and technical expertise to improve economic conditions, and promote effective cooperation between scientists of different countries. The CRDF has received 3,100 proposals to date in all aspects of science and engineering, about 28 percent of which are in physics. APS Vice President Andrew Sessler chaired the physics review panel, which reviewed some 800 proposals, twice the number anticipated. Finalists were forwarded to the full review panel in May.

- The National Research Council's Board on Physics and Astronomy is undertaking a series of reassessments of all the branches of physics as the foundation for a new physics survey. The survey will provide a broad picture of physics as a whole, identify issues that are common to its various subfields, and show the relationships among the different fields of physics and between physics and other areas of science. As part of this effort, the Board's Solid State Sciences Committee (SSSC) is planning a study of condensed matter and materials physics to assess scientific progress in that field and the impact of recent advances and developments. To give the community a means to exchange ideas and provide input to the SSSC and the Committee on Condensed-Matter and Materials Physics (CCMMP), an open forum for electronic discussion has been set up on the World Wide Web. It can be accessed through the CCMMPs website at http://www.nas.edu/bpa/cmmp.html.

  Chaired by Venkatesh Narayanamurti (UC, Santa Barbara), the study will include the following: an illustrative recounting of the major research accomplishments of the field over the last decade; an analysis of the impact of this research on technology; an evaluation of the infrastructure and research modes of the field today, including both large facilities and principal-investigator research, with recommendations for increased effectiveness; an examination of demographics and career issues; an analysis of the implications of the above on student training and employment, with an emphasis on the university/industry interface; and an assessment of the standing of the U.S. effort relative to that of other countries.

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THE FUTURE OF THE NATIONAL LABS

by Congressman Steven H. Schiff (R-NM), Chairman, House Subcommittee on Basic Research

In recent years, the debate over science and technology policy, like the debate over many other public policy issues, has become increasingly partisan. I personally find this to be a very discouraging trend. Shaping science and technology policy should be a bipartisan effort where both houses of Congress, the Administration, and the private sector work together. It is in this latter mode that I would like to discuss the future of the Department of Energy's national laboratories as multi-mission research and development entities and the critical role that emerging partnerships with universities and the industrial sector will play in their future.

The national laboratories were created near the end of World War II, at a time when the United States and the rest of the free world were faced with one of the greatest threats to freedom and liberty ever imagined. The United States responded to this threat in part by allocating enormous resources to atomic weapons development. Because the President and the Congress were concerned about military control of such a physically and psychologically powerful weapon, an independent agency was created to manage the weapons program. That agency and its current successor, the DOE, have successfully managed this effort for better than five decades.

Now, in the aftermath of the Cold War, the national security threat has not gone away, but just changes. We face new challenges in the form of rogue dictators who wish to acquire their own nuclear weapons; global hot spots of civil and religious strife; the responsibility to dismantle aging nuclear weapons; and environmental clean-up, the legacy of 50 years of weapons production. The scientists, engineers, and technicians at the DOE's weapons laboratories helped enable us to win World War II and the Cold War. The physical and intellectual infrastructure created to achieve these goals is now uniquely poised to help meet the new challenges.

The future of the national laboratories depends in part on what happens to their parent agency, the Department of Energy, but these futures are somewhat separable. I believe that the way to most effectively utilize the national laboratories is to continue to house them at DOE. There are those in Congress who, in striving to balance the federal budget, eliminate the deficit and debt and downsize government, would dismantle DOE and subject the national laboratories to the whims of a commission modeled after the Defense Departments Base Closure and Realignment Commission that was established to close military bases. I would like to explain why I think that this is a misguided effort.

First, I too am strongly supportive of efforts to balance the budget. And, I am under no illusions that DOE and its laboratories should be exempt from this effort. However, there are several compelling reasons why eliminating the DOE and subjecting the labs to a closure commission is ill-advised. Perhaps the most important reason is national security. As previously noted, nuclear weapons have been managed by a civilian agency since 1946. In closing DOE, Congress would have to find a sponsor for the management of the nuclear activities as well as all other functions of the agency deemed necessary to the nation. The most frequently discussed sponsor for the nuclear and other defense activities is the Department of Defense. Yet it is widely believed that housing these programs at DOD will erode public confidence and undermine support for the nuclear weapons programs among those who believe that such activities must be under civilian control. In addition, DOD no longer seeks to re-acquire this program.

Further, over the years the DOE has built a world-class system of scientific and engineering laboratories to support its nuclear weapons research and development mission which is integrated with its civilian missions of energy supply, environmental, and basic science research. Moving the nuclear weapons program to DOD, thereby separating national security research from other basic science, energy, and environmental research would destroy a synergism that has benefited all the research performed by DOE. Non-defense research has proved advantageous to nuclear weapons researchers when these activities are performed simultaneously at the laboratories and when labs collaborate with industry and universities. Much of the non-defense research is very basic in nature, and, through dual purpose technology transfer, helps to leverage the weapons research. The multi-disciplinary nature of the laboratories and the research performed there also enables DOE to attract scientists who might otherwise be deterred by the recent trend of decreasing defense budgets from pursuing careers at the laboratories.

Second, I believe that separating the national laboratories from a terminated DOE will leave these entities vulnerable and underutilized. These laboratories make relevant and important contributions in national and energy security, environmental integrity, and economic vitality. There are many problems facing America and the world that the private sector is unable to solve on its own, and for which the basic research capabilities at the laboratories have a unique niche.

The nation's scientific and technical base depends very much on the future of the DOE laboratories. The DOE is the fourth largest federal research and development agency. The research performed at the laboratories is a vital part of the infrastructure that will educate our future generations of scientists and engineers, without which neither national nor economic security can be guaranteed.

In an effort to ensure that DOE and its national laboratories survive to continue to provide our society with all the aforementioned benefits, let me explain my prescription for a leaner, meaner, and more efficient DOE laboratory structure.

Last year, I introduced legislation that defines a three step process by which the Secretary of Energy, in conjunction with Congress and other interested parties, first defines missions for the laboratories, then establishes the criteria for assignment of those missions to laboratories, and finally directs the Secretary to assign a mission or missions to individual labs and possibly streamline the labs themselves through the consolidation of programs or the transfer of facilities or programs. The legislation takes many recommendations from last year's Galvin Task Force report, which found that the lack of clear, well-defined missions resulted in a lack of focus at the laboratories. This report and others found that the laboratories took it upon themselves to develop broad and general mission definitions which do not necessarily meet the political and budgetary realities of the post Cold War era. This conclusion gives credibility to those who would argue that the labs are shopping for things to do. My legislation, H.R. 2142, provides a remedy for this by having the Secretary assign missions consistent with and complementary to the departments core missions. These missions are national security, energy research, basic scientific research, and environmental restoration. An additional mission area to be defined by Presidential prerogative is provided as well.

H.R. 2142 also encourages the laboratories to continue to enter into partnerships with industry, universities, and other agencies of the federal government if and only if these ventures further an assigned core mission. Technology transfer from national labs to industry and in reverse, although frequently and erroneously referred to by some as "corporate welfare," is collaborative work on problems of mutual interest. In fact, the term "technology transfer" has been a misnomer because it implies a one way street in the traffic of scientific knowledge. This kind of leveraging is mandatory for the future because, as budgets are reduced, maintaining the critical mass of researchers and technicians at the laboratories to perform even the most fundamental national security missions will not otherwise be possible.

A good example of how this works is a partnership between Goodyear Tire and Rubber Company and Sandia National Laboratory in my Congressional district in New Mexico. This collaboration has improved the modeling and simulation codes that Sandia uses to solve nuclear weapon component design problems that previously could not be accomplished. Goodyear tire design programs benefited from access to design and experimental techniques used and developed in the nuclear weapons program. This is just one example of how dual use technology leverages, indeed often enables, mission oriented research.

One final point needs to be made on partnerships. The world is becoming an increasingly competitive marketplace for U.S. companies. Industry must support its own competitive commercial research that is focused on product development, improvement, and marketing. But, when the project is consistent with their missions, laboratories should be permitted to partner with the industrial sector to help develop technology and standards. This is not "corporate welfare." It's part of a good strategy for ensuring that America can compete and win in this increasingly competitive global marketplace.

Finally, in an effort to ensure that the future of the laboratories guarantees that they are

able to focus on research and not paperwork, my bill directs the DOE to transfer existing health, safety, and environmental regulation of the labs to other appropriate regulatory agencies that already have the responsibility. Self-regulation has become cumbersome and inefficient, requiring thousands of people on a payroll to oversee and prescribe detailed papers on how jobs should be done. This has resulted in the labs hiring more staff or reallocating research and development resources to respond to the myriad of directives. The result is increased overhead, poor morale, and the largely useless redirection of scarce research dollars. Recent reports to the Secretary of Energy have suggest that externalizing regulation will substantially improve the management of the laboratories, release scarce resources, and enhance productivity and public health and safety.

The future success of our nation and the world is tied to science and technology. The federal government must continue to play an important role in the promotion and support of scientific endeavors. I am optimistic that the Administration and Congress can rise to the occasion and set about working together to create a forward looking science and technology policy for the nation that will ensure the continuation of U.S. superiority for the coming millennium.

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