APS NEWS

June 1996 — The American Physical Society — Volume 5, No 6

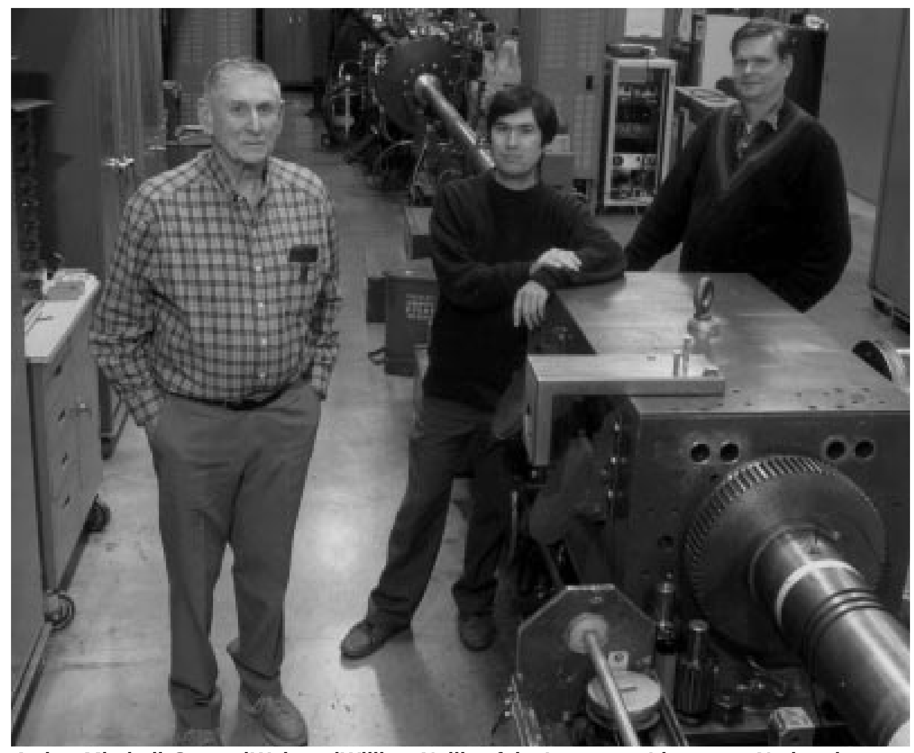
Highlights from St. Louis: Metallic Hydrogen, Magnetic Surgery Mark 1996 March Meeting

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

(continued on page 10)

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

Highlights from St. Louis ... 1
Journal Embargo Policies Spark Controversy ... 1
Livermore Scientists Achieve Metallic Hydrogen ... 1
U.S. Science Policy Shifting in Era of Political Change ... 2
TV Series Documents Changing Face of Science in America ... 2
Magnetic System Promises To Improve Brain Surgery ... 3
Information Theory Provides Unified Framework for Neuroscience ... 3
Stochastic Resonance Can Help Improve Signal Detection ... 4
Scientists Seek Further Improvements to Quantum Measurements and Standards ... 5
Biosensors Provide Near-Single-Molecule Sensitivity ... 4
Women in Physics Make Modest Gains, While Minorities Remain Level ... 5
Opinion ... 6
Session Marks Centenary of Discovery of Radioactivity ... 8
UNESCO Meeting Outlines Current and Future Priorities ... 8
Physics of High and Low Level Waste Management Explored ... 9
Scientists Simulate Vortices Flowing Through Superconductor ... 9
STM Key to Positioning Individual Molecules at Room Temp ... 9
IN BRIEF.... ... 11
Announcements ... 11
The Back Page ... 12
APS Meeting News ... Insert

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

(continued on page 5)

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.