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APS Study Questions Feasibility of Boost-Phase Missile Defense

Boost-phase intercept (BPI) will not be a viable defense against solid-propellant ICBMs, which could be available to countries of concern by the time a US defense system can be deployed. This finding comes from the long-awaited independent APS study into the scientific feasibility of BPI missile defense of the US, in terms of fundamental science and engineering requirements, including specific analyses of threats from missiles launched in North Korea and Iran.

The APS study was co-chaired by Daniel Kleppner of MIT and Frederick Lamb of the University of Illinois, and conducted by a distinguished group of scientific experts (*see box, page 5*). The last APS study, released in 1987, focused on the use of directed energy weapons for missile defense. "It is crucial that decisions about large-scale investments in weapons systems at least be based on scientific feasibility," said APS President Myriam Sarachik of the rationale for the APS study. "This is a much-needed study that fills a gap in our understanding of the problems of missile defense."

Among other findings, the study group determined that BPI has only limited applicability for defense against slower liquid-propelled ICBMs. However, BPI seems technically possible against short- or medium-range missiles launched from sea platforms off US coasts, provided that the interceptor missiles could be based within about 40 kilometers of an offensive missile's launch point. Other key issues examined in the study include munitions shortfall, missile tracking, determination of firing solutions, Airborne Laser requirements, maneuverability of interceptors, and geographic constraints on missile defense.

BPI strategies have received a great deal of media attention recently due to the relative ease of detecting a missile during boost phase (due to the bright plume) and the supposed difficulty in deploying counter-measures.

However, the report identifies effective countermeasures that have previously been used by missiles and shows that the key issue is one of timing.

According to Lamb, even assuming improvements in technology well beyond what is expected in the next 10-15 years, the basic problem is that the BPI strategy only gives two to three minutes for intercept. "Interceptors simply couldn't catch offensive ICBMs in time," he said. "The most optimistic scenarios still provide no time for human decisions and any system would need to be fully automated."

The APS study looked at BPI defense by ground-based interceptors, space-based interceptors and the Airborne Laser (ABL). Ground-based interceptors are primarily limited by the short window of opportunity for intercept and the requirement for basing interceptors close to the launch sites, generally within unfriendly foreign territory for missiles launched from North Korea or Iran.

Space-based interception would require a fleet of thousands of satellites in orbit just to intercept a single missile. Deploying such a fleet would exceed the US' space-launch capabilities by a factor of five to ten over the next decade. The ABL, currently in development, is limited by the

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Above, David Mosher of the BPI study group fields questions during the press conference releasing the report. Flanking him (l to r) are APS Past-President William F. Brinkman and study co-chairs Frederick Lamb and Daniel Kleppner. In the picture at left. Lamb goes over details of the report with journalist Yoichi Nishimura of Asahi Shimbun.

Photo Credits: Jessica Clark

Visa Issue Impacts 2004 March Meeting

Due to added security concerns, physicists who will be traveling from the US to attend the 2004 March meeting in Montréal, Canada will have to think more carefully about their plans. Foreign students, post-docs and visitors are likely to be the ones most directly affected. But recent information obtained by APS indicates that students and post-docs from all but seven countries should be able to make use of the automatic visa revalidation program for reentry to the US from Canada.

To help everyone who plans to attend the March Meeting, the APS has created a website at www.aps.org/meet/MAR04/visa with information on travel and visas that will be updated as circumstances warrant.

"We are most concerned about holders of F-1 visas," said Irving Lerch, head of the APS Office of International Affairs. These visas are granted to graduate students who until last April had been allowed to travel to Canada for up to 30 days and then reenter the US after their visas had been automatically revalidated at the border or arrival airport. Now for students with some additional documentation, as detailed on the above web site, APS has learned that this automated process is still viable, except for students from Cuba, North Korea, Iraq, Iran, Syria, Libya and Sudan. Students from these countries should consult in detail with the office of international students and scholars (ISS) at their host institutions before making plans to travel outside the US.

Because the APS March meeting is so large, planning begins six years ahead of time. "We select the

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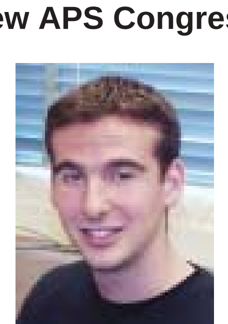
Rosenberg is New APS Congressional Fellow



Adam Rosenberg

A young plasma physicist from New Jersey is the new APS Congressional Fellow for 2003-2004. Adam Rosenberg, a graduate student at the Princeton Plasma Physics Laboratory, will spend the next year broadening his congressional experience through direct involvement with the legislative and political processes.

The APS Congressional Science Fellowship program is intended to provide a public service by making individuals with scientific knowledge and skills available to members of Congress. In turn, the program enables the physicist to gain experience in the political process.

As an undergraduate, Rosenberg majored in applied and engineering physics, and in addition to his technical curriculum, he took courses in natural conservation—which fueled his interest in alternative energy sources—and American politics.

He also participated in Cornell's Engineering Co-Op Program, spending the summer of his junior year as an intern at Argonne National Laboratory to gain some

See ROSENBERG *on page 5*

News Background

Pentagon Seeks Functioning Boost-Phase System by 2010

Editor's Note: In order to place the APS boost-phase study in context, APS News *asked James Riordon to find out what the current and projected plans of the Department of Defense are for boost-phase missile defense. His report follows.*

The Boost Defense Segment (BDS) of the Ballistic Missile Defense System is intended to defeat missiles in the initial, 3 to 5 minute, powered phase of a launch. The ability to intercept a missile in the boost phase could potentially destroy a missile regardless of its range or intended target, and would provide missile defense for the US and its allies around the world. According to Department of Defense (DOD) documents, "When possible, for the global coverage and protection against more lethal payloads it can provide, a capability to intercept a missile near its launch point is always preferable to attempting to intercept that same missile closer to its target."

Missile Defense Agency (MDA) documents often define BDS capabilities in terms of reducing the "safe havens" of potentially threatening states. A safe haven is the region from which a nation could launch a missile that is outside the range of interception by a boost-phase defense system. According to DOD documents, a comprehensive, space-based BDS could theoretically eliminate safe havens entirely. Initial annual funding for the BDS stood at $600 million in fiscal year 2002 (compared to the total missile defense budget of more than $9 billion), and is planned to rise steadily to $2.275 billion in 2007. MDA plans call for a functioning BDS system to be in place by 2010.

Two types of BDS concepts are currently in development: kinetic energy interceptors, and directed energy systems. Boost phase kinetic energy interceptors are rocket-propelled kill vehicles that collide with ballistic missiles. After the launch of a threatening missile is confirmed (this can take about a minute) the interceptor must be fired within seconds. Moreover, the bright exhaust plume—several times larger than the target itself—can obscure the target as the interceptor approaches. The first realistic tests of kinetic energy BDS systems are scheduled for 2008-2009.

The BDS systems currently be-

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Highlights

Visa Rules Must Promote Science As Well As Security

The APS Council has approved a statement addressing the difficulties of foreign students and scientists in entering and working in the United States. The statement was passed by e-mail vote on June 6.

The Council took note, especially after September 11, of the paramount importance of national security concerns, but pointed out that there are many facets to national security. The background material to the statement asserts that "national security has many aspects that must be balanced in a modern and diverse society. In particular, the nation must maintain leadership in science and technology."

The document goes on to say that "recent procedures and rules implemented to secure the nation's borders have resulted in long delays and denials of US visas for many foreign scientists and students."

These and other problems have been widely reported, including front-page stories in *APS News* in March and May of this year, as well as in the current issue.

The background concludes that "our [foreign] partners are increasingly reluctant to participate in joint ventures. This isolation threatens irreparable damage to US economic competitiveness and, ultimately, national security."

The text of the statement follows.

National security and economic vitality critically depend on science and technology and strongly profit from contributions of foreign-born scientists and engineers. The American Physical Society calls on the United States Administration and Congress to implement appropriate and effective visa rules and government procedures that sustain science and technology.

The rules and procedures must protect the nation against terrorism. They must also promote continuing international scientific and technological cooperation and ensure the flow of people and knowledge needed to guarantee economic strength and national security.

APS Selects Three as 2003 Mass Media Fellows

Three young physicists are spending this summer gaining invaluable firsthand experience in communicating science through the media as the 2003 APS mass media fellows. Stephanie Chasteen, a graduate student at University of California, Santa Cruz, is interning at National Public Radio (NPR) in Washington DC. Allison Heinrichs, a recent graduate of Ohio State University, is interning at the *Los Angeles Times*. And Cathy Nangini, a graduate student at the University of Toronto in Ontario, Canada, is interning at the *Milwaukee Journal Sentinel*.

Chasteen attended Bard College in New York's Hudson Valley as an undergraduate, and while she loved physics, she decided to pursue a major in psychology. Chasteen was the only woman in her department, and while her grades were excellent, "I felt intimidated by the physics classes, even though I did very well, because it seemed to come so much easier for the guys," she says. "No one told me I was good at it, so I felt I didn't have what it took."

But physics continued to fascinate her. Her confidence received a boost when a former physics professor expressed his disappointment at her decision not to major in his subject, telling her she'd been one of the best students in the class. Encouraged, she decided to pursue graduate studies at the University of California, Santa Cruz. First, however, she chose to spend two years volunteering with the Peace Corps in Guinea, West Africa.

At Santa Cruz, she elected to specialize in condensed matter physics, working on polymer photovoltaics (solar cells). During this time, she also became interested in science writing. "I have a very general interest in science, from biology to physics to ecology," she says. And I have a great interest in scientific literacy: helping the public to achieve a greater view of the role science plays in their lives, particularly on environmental issues like global warming."

Chasteen decided to apply for the APS Mass Media Fellowship as a means of furthering her career goals in science writing by gaining some firsthand experience. She

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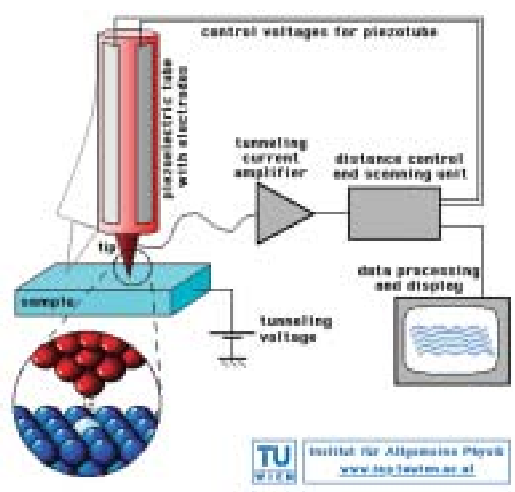
This Month in Physics History

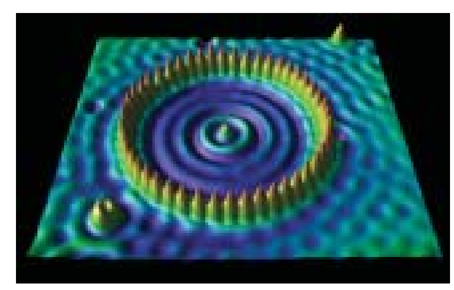
September 1981: Invention of the scanning tunneling microscope

Scientific instrumentation took a huge leap forward in the early 1980s with the development of scanning tunneling microscopy (STM), an analytical technique based on the quantum mechanical phenomenon called tunneling. An electrical potential between the tip of a stylus and the surface causes an electric current to flow between them, despite the fact that they are not in contact — hence the name of the instrument.

Classically, electron flow is not possible without a direct connection, such as a wire connecting the two surfaces. However, on the atomic scale, when the distance between two surfaces is small enough, there is a finite probability that an electron will jump from one surface to another of lower potential In the case of the STM, the tunneling current starts to flow when a sharp tip approaches a conducting surface at a distance of approximately one nanometer. The tip is mounted on a piezoelectric tube, which undergoes tiny movements when a voltage is applied to its electrodes. The tip position is controlled by the electronics so that the tunneling current, and hence the tip-to-surface distance, is kept constant as it scans a sample surface. This movement is recorded and can be displayed as an image of the surface topography. Recording the vertical movement of the stylus makes it possible to study the structure of a surface atom by atom.

When the first conventional optical microscope was invented, it represented a tremendous achievement for scientific research, particularly in biology and medicine. However, as the technology continued to improve, scientists discovered that there were fundamental limits to optical techniques because of the wave characteristics of light. Using light waves, it is impossible to distinguish details smaller than the wavelength of the light. Another significant breakthrough in microscopy occurred when it became possible to produce an image of an object using an electron beam, recorded on a fluorescent screen or a photographic plate. Scientists were even able to increase the magnification by combining two or more lenses. Ernest Ruska, a scientist





with the Max Planck Institute in Berlin, made the most important fundamental contributions to electron optics and designed the first electron microscope.

In Ruska's design, called the transmission microscope, the object to be examined is in the form of a thin section. The electron beam pierces the object in much the same way as light does in a conventional microscope. Then came the complementary scanning electron microscope, in which a sharply focused electron beam strikes the object. The principle behind the STM is quite different. A mechanical device is used to sense the structure of a surface, similar to how the reader's fingers detect the impressed characters in Braille. It is possible to obtain a much more detailed picture of the topography of a surface if it is transversed by a fine stylus whose vertical movement is recorded. The sharpness of the stylus determines the resolution. Because small structural details of the surface can be damaged by mechanical contact, it is necessary to maintain the stylus at a small, constant distance from the surface.

The first researchers to succeed in building an STM were Gerd Binnig and Heinrich Rohrer at IBM Research Laboratories in Zurich, Switzerland, largely because of the exceptional precision of their mechanical design. They eliminated environmental vibrations by building the microscope upon a heavy, free-floating magnet in a dish of superconducting lead. Later on, less bulky but equally effective devices for stable, disturbance-free suspension of the microscope were developed, using piezoelectric elements to control the horizontal movement of the stylus. The vertical movement of the stylus is controlled and measured using another piezoelement. And it is now possible to produce styluses whose tip consists of a single atom, giving unprecedented resolution and the ability to depict individual atoms to study the atomic structure of the surface being examined.

The two scientists submitted their first paper on their invention of the STM in September 1981 to *Applied Physics Letters*. And in 1986, Binnig and Rohrer shared the Nobel Prize for physics (with Ruska) for their work on the STM. Thanks to their achievement, entirely new fields have opened up for studying the structure of matter, particularly in surface physics, which has important applications in semiconductor physics and microelectronics. Another major area of current STM research is the study of self-assembled monolayers (SAMs), a single layer of molecules which aggregates on a surface. In other sciences, surface chemistry plays an important part in catalysis, and it is also possible to fixate organic molecules on a surface and study their structure, a technique that has been used to study DNA molecules.

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Number One

A Model of Leptons

(S. Weinberg, Phys. Rev. Lett. **19** *(1967) 1264), 4602 citations.*

This is the tenth in a series of articles by James Riordon. The first article appeared in the November 2002 issue. The articles are archived under "Special Features" on the APS News online web site.

The most-cited paper on our list of the top ten, highly cited *Physical Review Letters* established the link between the electromagnetic and weak interactions, and laid one of the most important cornerstones of the Standard Model of particle physics. Although Steven Weinberg published the paper in 1967, the electroweak theory attracted relatively little attention until Gerard 't Hooft (at the time, a PhD candidate at the University of Utrecht) showed that the theory was renormalizable. Weinberg shared the 1979 Nobel Prize for Physics with Sheldon Lee Glashow (a co-author of the tenth most cited *PRL*) and Abdus Salam for "their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including, *inter alia*, the prediction of the weak neutral current."

In March, *APS News* correspondent James Riordon visited Weinberg in his ninth-floor office at the University of Texas at Austin, where he holds the Josey Regental Chair of Science in the Departments of Physics and Astronomy. An excerpt of that interview follows.

APS News: *Did you recognize the extraordinary significance of your 1967 paper at the time that you were writing it?*

S. W.: I had the idea that the weak interactions were transmitted by a gauge field like the electromagnetic field, but that the gauge invariance was spontaneously broken, and that's why the particle that transmits the force, the W-particle, is heavy. I thought that idea was very important. I presented that idea in the paper, mostly in the form of a specific example. What I couldn't have known at that time was that nature had chosen this example to be in the real world. For some years afterwards, especially during the period when some experiments seemed to be going against the theory, I wasn't convinced that this was the right model. But I was convinced of the underlying idea that the weak interactions are very similar to the electromagnetic forces, with the difference being made by the phenomenon of spontaneous symmetry breaking.

APS News: *Your paper took on much greater significance after 't Hooft proved that the theory was renormalizable in 1971. Why didn't you immediately set about checking the renormalizability of the electroweak theory back in 1967?*

S. W.: I thought that the theory was renormalizable, and I tried during this period to prove it (in work published later), but I had a hang-up which prevented me from doing what 't Hooft did. There are essentially two approaches to quantum field theory. One is the quantum mechanical operator method. The other is Feynman's path integral method. All the reading I had done used the operator method. I knew about the path integral method, but it looked to me like a way of doing things with a lot of hand waving, things I knew how to do perfectly well by direct calculation in the operator formalism. So it just seemed pointless. What I didn't realize is that the path integral formalism opens up a lot of ways of doing calculations that really aren't available in the operator formalism. In fact, without it you could never prove that the theory was renormalizable. It was because of 't Hooft's work that I then learned the path integral method. I have used it often since then, and of course teach it, and it's in my treatise on quantum field theory, although I still start with the operator method. Anyway, I assigned the problem of proving that the electroweak theory is renormalizable to a student, and the student was not able to do anything with it either. Also, I was writing a book on gravitation and cosmology, and it had taken over much of my time. And I had gotten very much involved with arms control.

Photo Credit: Jessica Clark

APS News correspondent James Riordon chats with Steven Weinberg in his University of Texas office in Austin.

The 1970s were the last golden age of particle physics. Suddenly experiments were coming together with the theory. We haven't really had such a period since then. We need another golden age. That's the way progress is made. I think of the progress of physics a little bit like a log jam in a river. The logs are jammed and nothing is moving. Every once in a while you're able to pick one log out and things move a little bit, then they get stuck again. At a certain point, you pick out a crucial log and all the logs start flowing downstream. The '70s were a period when everything was flowing beautifully, then it jammed up again and we're not really making much progress. It isn't that I think we're departing from some correct way of doing physics, it's just that after a period of success things get hard again. And they're really hard now.

APS News: *Many attempts had been made previously to unify the electromagnetic and weak interactions. Why did you decide to tackle a problem that had evaded so many others?*

S. W.: This did not come out of my sitting down and saying "Let's unify the weak and electromagnetic forces." What I was trying to do was apply ideas of broken symmetry to the strong interactions. In particular I imagined a kind of gauge theory of the strong forces in which there was a spontaneous symmetry breaking which split the particles that transmit the force, so that some of them are much heavier than others. And what I was really thinking of was that the rho meson, which is a negative parity, spin-one particle, and the A1 particle, which is a positive parity, spin-one particle, have really the same mass but it gets split by this spontaneous symmetry breaking.

The idea went nowhere partly because it turned out that the rho meson would have to have zero mass, which was obviously not true. The rho meson was a particle with a mass of about 750 MeV, which is not small at all by the standards of strong interaction physics. I was just going nowhere with it, and I was very frustrated. Then it suddenly occurred to me that this was the solution not of the strong interactions but of the weak interactions and that the thing analogous to the A1 was the W particle and the thing analogous to the rho was the photon, and it did have zero mass. So it came out of work on the strong interactions.

APS News: *In recent years, it appears that you have spent more time writing papers about cosmology.*

S. W.: Yes, I've gone over completely to cosmology. The kind of

See TOP TEN *on page 4*

APS Selects 25 as 2003-2004 Undergraduate Minority Scholars

The APS has awarded Scholarships for Minority Undergraduates to 25 students who are majoring or planning to major in physics.

Since its inception in 1980, the program has helped more than 290 minority students pursue physics degrees. Fourteen new scholars and 11 renewal scholars were selected.

Each new scholarship consists of $2000, which may be renewed once, and each renewal scholarship consists of $3000.

Minority Scholar Barry Barrios has had a deep interest in science since he was a child, and his interest in physics in particular stems from attending an MIT program in which he applied physics to his mechanical engineering class.

He and his group built a robotic model car capable of climbing inclines and performing tasks such as picking up small rings. He hopes to one day be a neurosurgeon, using his physics background to build new surgical tools.

Barrios has also overcome extremely difficult circumstances in his home life, currently in foster care and traveling two hours each way by bus to attend high school. Yet he continues to excel in his schoolwork, and studies Greek twice a week in the mornings to augment his Latin studies.

Music is a prevailing passion for Minority Scholar Laura Burton, who is ranked one of the finest flautists in the state of Florida, and also plays piano and piccolo for Olympia High School's jazz band, symphonic band, wind ensemble and marching band. Yet her dream career is to do astrophysical research at NASA, having always been fascinated by the stars as a child

In addition to excelling at her studies, she tutors other students in physics, and serves as Treasurer of the National Honor Society.

A member of the Cherokee tribe, Joshua Smart cites Sir Isaac Newton as his scientific role model.

Newton's *Principia*, which laid much of the groundwork for classical physics, is what inspired the young man to pursue a physics education, and he hopes to eventually earn a PhD in physics. "I want to have a career in something that will always be challenging to me, a job that won't get monotonous and dull," he said, "and I like the research projects, problem-solving and cutting-edge aspects of physics."

Smart, who has been home-schooled, attends the Ardmore Regional Center of the Oklahoma School of Science and Mathematics, where he is one of the top students, and spent two summers as an agricultural lab assistant at the Samuel Roberts Noble Foundation to gain some practical scientific experience.

The APS scholarship program operates under the auspices of the APS Committee on Minorities in Physics, and is supported by funds allocated from the APS Campaign for Physics.

Scholarships are awarded to African-American, Hispanic American and Native American students who are high school seniors, college freshmen, or sophomores.

The selection committee especially encourages applications from students enrolled in institutions with historically Black, Hispanic or Native American enrollment. After being selected, each scholar is matched with an accomplished physicist to act as a mentor.

For applications for the 2004-2005 competition, contact Arlene Modeste Knowles at knowles@aps.org.

Information can be found at http://www.aps.org/educ/com/index.html.

New Scholarships

Barry Barrios
Laura Burton
Daniel Casanova
Riyad Gargoum
Nicolas Lopez
Michael Maindi
Matthew Ornelas-Kuh
Ayodele Osasona
Alejandro Rodriguez
Joshua Smart
Michael Tambe
Pedro Urquedez
Rebecca Voorhees
Soun-Ja Walters

Renewal Scholarships

Gabriel Arma-Cardona
Daniel Gacias
Micah Hawkins
Julian Holder
Jon Lamberson
Daniel Noval
Manuel Reyes
Amanda Rice
Matthew Sievert
Tonia Venters
Elspeth Whetten Allen

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cutting edge particle physics where you're trying to make the next big step is now in the hands of the string theorists. I think probably they're heading in the right direction, but progress is slow and difficult. It's incredibly demanding, requiring mathematics beyond anything I ever learned. I tried during the 80's to work actively in string theory, but I realized that I could sacrifice everything in my life and try to keep up with the younger people in that area who have the mathematical background I don't have, or I could go into something I was already pretty familiar with.

Cosmology [these days] is fantastically exciting. So it was an obvious choice. I've just done some work in cosmology that I think is moderately important, showing that the gravitational waves that it is hoped may turn up in future observations are significantly damped, an effect that most people have assumed is negligible. I think I can go on making some interesting contributions in cosmology, which I no longer could in string theory.

***APS News:** You've published extensively, but you rarely have coauthors on your papers. Why is that?*

S. W.: I don't collaborate very well. I had one collaborator I really liked working with: Ben Lee. He died tragically in an automobile accident in 1977. But generally speaking, I don't like collaborating, partly because I have very strong views about how the article should be written. Even though in collaborations we each do a fair share of the actual work, I'm always the one who writes the article because I don't like the way other people write.

Also, I don't work well with students because my ideas are usually very ill formed until they crystallize, and then it's obvious what to do. For example in the 1967 paper, I was dithering around with applying the idea of broken gauge symmetries to the strong forces, and if I'd had a student it would have been going nowhere because it was obviously a crazy idea. It wasn't working, and then suddenly everything clicked and I saw it was the answer to the weak forces.

***APS News:** You are one of the most famous living physicists, due to both your research and your popular writing. How does your celebrity status affect your work?*

S. W.: It's an embarrassing thing to ask me about. Well, you said it, I didn't say it. I think physics is a very healthy field; most areas of science are . Working scientists don't have much respect for past achievement when it comes to deciding what they themselves are going to read or do. A lot of the papers I've written in the past decade are pretty unimportant. I wrote them because I was trying to learn a certain field, and I discovered a few odds and ends that hadn't been done or hadn't been done right. Despite whatever reputation I might have, I think the world of physics hasn't regarded them as important either. If I write an important paper, I think it'll be paid attention to. That's the way it should be.

I'd like to think that even without [the '67] paper, I'd be regarded as a pretty good physicist. I've done a lot of things apart from the unification of the weak and electromagnetic forces. There's a an area of physics that people are actively pursuing now, the use of what are called effective field theories, to solve problems in strong interaction physics, including even nuclear physics. This came out of a paper I wrote in 1979, which in turn grew out of work I did in the 1960s.

***APS News:** Are you hoping to make another major breakthrough?*

S. W.: I'd like to do something important again, sure. As you get older, so many things surround you, the list of people you have to write recommendations for becomes longer and longer. You spend more of your time on things like that. And now I've gotten involved in defense issues again. I testified before the Senate Committee on Foreign Relations about the administration's nuclear posture review, I'm giving a talk [at the American Physical Society] in this area, and I've written articles for the *New York Review of Books* on it. Maybe I'm making the same mistake I made from '67 to '71, allowing myself to get too involved in politics. But it's a way of keeping alive.

For the full-length interview with Steven Weinberg, see the online version of APS News at www.aps.org/apsnews.

News Analysis

Visa Problems Continue to Plague Foreign Students

By Susan Ginsberg

In the post-September 11 reality, our physics departments are getting hammered. Accepted students from overseas are arriving late, are being refused visas on a first or second go-round, and are even choosing to enroll in non-US institutions. According to a survey released by the American Institute of Physics in late June, two-thirds of the PhD-granting departments and almost half of the masters-granting departments in the US have reported severe problems with foreign students who were unable to attend due to problems with their visas. With course enrollments dropping, TA slots going unfilled, and research programs hurting, science departments across the country are beginning to be seriously affected.

Within the APS, visa issues are a top priority. With the March meeting in Montréal, Canada a scant seven months away, determining what steps can be taken to improve the situation takes on an added importance. (For fuller details on visas and the March Meeting, see the story on page 1). The Council of the APS recently issued a statement on visa issues (see the story on page 2), emphasizing the importance of the contributions from foreign-born scientists and engineers to the US scientific enterprise. The APS's Office of International Affairs, headed by Irving Lerch, continues to work with the State Department on many of these issues, and Lerch and the APS's Office of Public Affairs have met with the House Science Committee to discuss the challenges facing the visa process.

The problems associated with international student visas have not gone unnoticed in Washington. Congress has taken an active role in investigating some of these same questions. The House Science Committee has taken the lead by conducting a number of hearings on the role of science and technology in homeland security and continuing issues with visa backlogs and tracking system implementation. John Marburger, Director of the Office of Science and Technology Policy and the President's science advisor, assured Congress at one of these hearings that the "Administration is determined not to let terrorism deflect America from its trajectory of world leadership in science."

The Homeland Security Presidential Directive-2 from October 2001, Marburger pointed out, acknowledged that the United States "benefits greatly from international students who study in our country. The United States Government shall continue to foster and support international students." Marburger pledged his office's help in seeing security and openness balanced appropriately.

One of the complications in altering the current situation is that authority for issuing visas, once solely the purview of the State Department, is now split between the State Department and the Department of Homeland Security, which now houses the Immigration and Naturalization Service (INS).

While the Administration can count some recent successes in streamlining the visa application process—the State Department claims that about 90% of visas flagged by the presence of certain technical words on the application are now processed within 30 days—a new set of regulations sent out on May 3 may well muddy the waters again. These new guidelines state that, starting August 1 of this year, every visa application from all but a handful of countries will require personal interviews. Although generally applicants with scientific terms on their visa applications were already slated for interviews, the addition of all other types of visa applicants to the long line of interviewees may cause additional delays. The State Department recently reminded its embassies and consulates of the tight timeline for granting students their visas and suggested giving these interviews priority, but, stresses the May 3 regulations, "[diplomatic] posts must implement the new interview guidelines using existing resources."

See VISA PROBLEMS *on page 7*

ANNOUNCEMENT

APS Seeks New Director of International Affairs

Due to the imminent retirement of Irving Lerch, the APS is seeking a Director of International Affairs beginning January 1, 2004.

Responsibilities include: promoting international exchange and collaboration, helping build and maintain relationships with other national physical societies throughout the world, advancing APS programs in support of developing countries, and working with APS Committees on International Scientific Affairs and International Freedom of Scientists. In addition, the Director advises the APS leadership on international issues of importance to the Society.

Necessary qualifications include: a PhD in physics or a related field; expertise in seeking external funding for project support; substantial experience in the international science area including at least one of the following: living and working abroad for an extended period of time, administrative or program experience within an organization with emphasis on international scientific relations, and extensive overseas travel in connection to physics research or administration.

To apply, send a cover letter detailing your interests and expertise, curriculum vita, and contact information for three references by October 10 to Judy Franz, APS Executive Officer, franz@aps.org.

LETTERS

Hobson's Choice of More Examples

I appreciated Lawrence Krauss's "Viewpoint" article (June 2003) urging scientists to question our government's manipulation of science to support preconceived ideological goals, and presenting five examples. Here are more examples.

After intense industry lobbying, the Bush administration decided to oppose Robert Watson's re-election as chair of the International Panel on Climate Change. The reason: The administration doesn't want to hear the IPCC's message that Earth's climate is changing due to human activities..

In 2002, the Environmental Protection Agency compiled a report, submitted to the United Nations, that agreed with the IPCC's conclusions. Despite the report's origin within the administration, President Bush commented dismissively that "I read the report put out by the bureaucracy," and that he still opposes the Kyoto Treaty to limit greenhouse gas emissions.

In 2002, America cast a lone vote against language in the U.N. Program of Action adopted at the Population Conference in Cairo in 1994. The Bush administration objected strongly to the terms "reproductive health services" and "reproductive rights."

The Department of Health and Human Services disbanded or stacked five committees in order (according to a DHHS spokesperson) "to hear preferentially from experts who share the president's philosophical sensibilities." The Advisory Committees on Human Research Protections and on Genetic Testing were disbanded, and the Advisory Committees on Environmental Health and on Childhood Lead Poisoning were stacked with scientists long affiliated with polluting industries. Three people were rejected for membership in a study section that reviews research grants on physical injuries in the workplace, for at least partly political reasons.

The Bush Administration and congressional Republicans are intensifying their scrutiny of research on sensitive topics. The National Institutes of Health has warned grant applicants to cleanse terms such as "transgender, prostitutes, needle exchange, abortion, condom effectiveness, commercial sex workers," and "men who have sex with men" from their grant applications and reports.

Art Hobson
University of Arkansas

No Discrimination Against Arabs

I met Joel Lebowitz in Israel just before he went to visit Bir-Zeit University in the occupied West Bank. His report on that visit is most interesting. I hope that some day the situation will improve and bilateral visits will be a matter of routine.

I must however comment on Lebowitz's statement that there are few Arabs in the faculties of Israeli universities although Arabs are 20% of the population. There are also few women although they are 50% of the population. In my department, there is one Arab, and there are two women. As a senior professor, I guarantee that there is absolutely no discrimination in hiring new faculty. This would be against the Technion constitution and bylaws. The reasons for the unbalance belong to social psychology, not to politics.

Asher Peres
Haifa, Israel

New Generation of Nuclear Weapons

News reports in the media clearly indicate that the US is about to embark on a program to generate a new generation of nuclear weapons presumably to destroy deeply buried targets. I would like to suggest that as physicists who have some notion of the dangers attendant upon such devices, we should vociferously oppose this proposal. Indeed, members of the APS should actively distance themselves from further proliferation of nuclear devices whose collateral effects are bound to hurt untold numbers of innocents.

S. M. Bhagat
College Park, MD

BPI DEFENSE *from page 1*

range of the intense laser beam and its vulnerability to counterattack. Further- more, the ABL would not be able to disable solid-propellant boosters in the time available for intercept.

North Korea and Iran could develop or acquire solid-propellant ICBMs within the next 10-15 years, according to US intelligences reports quoted in the study, and on that time scale, BPI defenses would be obsolete when finally deployed. "Few of the components that would be required for early deployment of a BPI defense currently exist," said Kleppner of the findings. "We see no means for deploying an effective BPI defense against ICBMs within ten years."

He cited other key issues that need to be further understood before a realistic deployment timeline can be determined, including communication, command and control networks and systems, and the process of an interceptor "hand-over" to the missile body after tracking the plume.

But there is one scenario where BPI defense seems feasible. "The existing US Navy Aegis system using a missile similar to the Standard Missile 2 should be capable of defending against short- or medium-range missiles launched from sea platforms off US coasts," the report concluded. "However, the interceptor missiles would have to be based within about 40 km of the launch point of the offensive missile."

The full report, downloadable in whole or in part is available on the APS web site, www.aps.org. It will be published as a supplement to a forthcoming issue of *Reviews of Modern Physics.*

BPI Study Group Members

Daniel Kleppner

Kleppner is the director of the Center for Ultracold Atoms at the Massachusetts Institute of Technology, where he is also the Lester Wolfe Professor of Physics. His research is in experimental atomic physics and he is a member of the National Academy of Sciences, as well as a Fellow of the American Academy of Arts and Sciences, the APS and the American Association for the Advancement of Sciences. He is the co-author of two textbooks and has received the Davisson-Germer Prize and the Lilienfeld Prize of the APS.

Kleppner

Frederick K. Lamb

Lamb is the director of the Center for Theoretical Astrophysics at the University of Illinois, where he also holds the Brand and Monica Fortner Endowed Chair in Theoretical Astrophysics. He has served as a consultant to the Departments of Energy and Defense, NASA and the US Congress on defense, security and space policy issues. His research has focused on problems in high-energy and relativistic astrophysics, and he chaired the High Energy Astrophysics Division of the American Astronomical Society.

Lamb

David K. Barton

Barton has served as a member of the National Research Council's Air Force Studies Board and has chaired the committees on the E-3A Radar and the Advanced Airborne Surveillance Radar. He is a member of the National Academy of Engineering and an IEEE Fellow, and currently serves a consultant to the radar industry.

Roger W. Falcone

Falcone is on the faculty of the University of California, Berkeley, where he chaired the Physics Department from 1995-2000. He has served on various Technical Review Committees at Lawrence Livermore National Laboratory and is a Fellow of the American Physical Society.

Ming K. Lau

Lau is the manager of the Control Subsytems Department at Sandia National Laboratory, where he oversees projects on precision motion measurements, precision motion controls and precision guidance. He has been on staff at Sandia since 1982, and helped design a missile guidance algorithm using GPS measurements for a moving mass-control system.

Harvey L. Lynch

Lynch is an integration physicist for the BaBar experiment at the Stanford Linear Accelerator Complex, where he has been on and off since receiving his PhD from Stanford in 1966. He was also an NSF research fellow at CERN for two years and worked on e+e- experiments at DESY. He was a member of the US team working in association with the Soviet Academy of Sciences to take precision measurements of the nuclear weapons' emissions aboard Soviet Cruiser SLAVA.

David E. Moncton

Moncton is a Senior Scientist at Argonne National Laboratory, where he advises the laboratory director. Previously he was a senior research associate at Exxon, an experimentalist and group leader at Brookhaven, and a member of the technical staff at Bell Laboratories. He has also been the Executive Director for the Spallation Neutron Source at Oak Ridge National Laboratory. He is an APS Fellow as well as a member of the American Association for the Advancement of Science.

L. David Montague

Montague is an independent consultant with more than 40 years of experience designing, developing and managing military weapons systems. His work has focused on submarine launched weaponry and ballistic missile defense systems. He is a retired President of the Missile Systems Division at Lockheed Martin and is a member of the National Academy of Engineering and a fellow of the American Institute of Aeronautics and Astronautics.

David E. Mosher

Mosher is a Nuclear Policy Analyst at the RAND Corporation, where he has focused on strategic warfare, nuclear weapons and missile defenses. Before joining RAND, he worked in the National Security Division at the Congressional Budget Office analyzing nuclear, missile defense, and arms control policy and budget issues.

William C. Priedhorsky

Priedhorsky has been on staff at Los Alamos National Laboratory since 1978 and was named a Laboratory Fellow in 1997. At Los Alamos, he has been a member of the Space Astronomy and Astrophysics group, the Lead Project Leader for Proliferation Detection Technology, and is currently the Chief Scientist in the Nonproliferation and International Security Division.

Maury Tigner

Tigner is the director of the Laboratory of Nuclear Studies at Cornell University, where he is also the H.A. Bethe Chair of Physics. He was a member of the HEPAP subpanel on the future of high-energy physics and chaired the steering committee of the Accelerator Test Facility at Brookhaven.

David R. Vaughn

Vaughn is a senior engineer in the Technology and Applied Science Department at RAND, where he recently led a project performing operational and technical analyses of airborne boost- and ascent-phase intercept and air-to-surface attack operations. His other experience includes work on surface-to-air interceptor missile performance limits, submarine-launched ballistic missile performance limits and radar tracking and prediction analyses.

ROSENBERG *from page 1*

hands-on research experience.

This experience clinched his decision to pursue graduate studies in plasma physics at Princeton, focusing on nuclear fusion as an alternative energy source.

For his doctoral thesis, Rosenberg decided to broaden his understanding of fusion-related plasma physics, choosing to focus on ion absorption of the high harmonic fast wave in the National Spherical Torus Experiment (NSTX), becoming the first graduate student to plan and lead experiments on this new machine. He is expected to receive his PhD in August.

In addition to his research, Rosenberg is committed to educational outreach. For two summers he taught the "tokamak" portion of Plasma Camp, a program that introduces this advanced science to high school teachers so that they may present it to their own students. He is also one of the first participants in the new Scholars in Schools program at Princeton, visiting local public schools to talk with students about his research.

He also moderates at the DOE-sponsored Science Bowl at PPPL, a competition between regional high school teams, and he answers questions sent to the lab's "Ask a Plasma Physicist" Web site. "I feel outreach is very important, because kids need to know their options," Rosenberg says. "Growing up, I never heard of what I'm studying now, and even though I ended up here anyway, it would be nice if kids could start thinking about those options sooner."

Rosenberg decided to apply for the APS Congressional Fellowship to foster his long-standing interest in politics dating back to his undergraduate years. He found time during his graduate studies and educational outreach to volunteer on the re-election campaign of Rep. Rush Holt (D-NJ). And this past January he was a member of the New Jersey delegation to Capitol Hill for the APS Convocation Lobbying Day. He also proved adept at internal organization and leadership, rallying his fellow grad students to make changes in the university plasma physics program. These experiences solidified his desire to combine his abilities and interests in the area of science policy.

In September, Rosenberg will join Congressional Fellows from other scientific societies for a special orientation sponsored by the American Association for the Advancement of Science, followed by an intensive interviewing process to decide whether he will spend his fellowship year in the office of a member of Congress, which he would prefer, or on the staff of a committee.

Although he loves scientific research, Rosenberg's year on the Hill will enable him to explore the possibility of going into science policy full-time. "I've come to realize how important science policy is, particularly for science funding and future energy needs, and I'd like to make a difference in those areas," he says.

For more information about the APS Congressional Fellowship program, See http://www.aps.org/fellowship/index.html.

PENTAGON *from page 1*

ing studied consist of lasers mounted aboard aircraft or satellites. Lasers are only practical for missile defense during the initial phase of a missile trajectory because they are intended to compromise the integrity of the comparatively delicate booster while it is pressurized. Long range ballistic warheads are hardened to withstand reentry, so, ballistic missiles are typically not vulnerable to laser heating during later stages of their trajectories.

According to DOD officials, lasers have successfully destroyed missiles in a number of tests to date. In the early 1980's, the Airborne Laser Laboratory's carbon dioxide laser, mounted in a KC-135 military aircraft, shot down five AIM9-B Sidewinder air-to-air missiles during proof of concept flights. There was also a successful test in June 2000 using the Tactical High Energy Laser (THEL) to shoot down a Russian-made Katyusha rocket at White Sands Missile Range in New Mexico In August and September of 2000, the THEL shot down four more Katyushas.

The prototype Airborne Laser (ABL) is a high-energy, chemical oxygen iodine laser (COIL) system mounted in a highly modified Boeing 747 airplane. The ABL aircraft is designed to operate above the clouds where it can acquire and track ballistic missiles during boost phase flight. The first ABL aircraft completed its maiden flight over western Kansas on July 18, 2002. The ABL is scheduled to conduct a realistic lethality demonstration, by shooting down a ballistic missile, in 2005. Shortly thereafter, the ABL is anticipated to be available for deployment in emergency situations, although the final BDS will not be in place until 2010. A proof-of-concept Space Based Laser (SBL) experiment is planned for 2012.

BDS systems comprise a portion of the layered ballistic missile defense program, along with mid-course and terminal-course kinetic energy defense systems. According to DOD officials, the boost phase interceptor development is currently on track. Schedules for the three efforts are independent, say officials, and delays in mid-course or terminal programs are not expected to affect BDS development.

Diverse is Yet to Come

Photo Credit: Laléna Lancaster

Roman Czujko, Director of the Statistical Research Center at the American Institute of Physics, addresses the Conference on Increasing Diversity in the Earth & Space Sciences, held at the American Center for Physics in College Park, MD in June. He pointed out that for every 1000 African-Americans earning a Bachelor's degree, only 0.5 are in the Geosciences, whereas 1.5 are in physics. For Hispanics, the analogous numbers are 1.7 and 1.8 respectively.

PHYSICS AND TECHNOLOGY FOREFRONTS

Non-Volatile Storage For Information Access

By Charles C. Morehouse

Most of us are confronted with the need for storing and retrieving information every day. Our expectations for having access to information of importance is with us constantly, and growing all the time. As complex and sophisticated tools became more widely used, particularly in the industrial revolution of the 18th and 19th centuries, a means of "storing" and "retrieving" information for use only by the tools emerged.

Tools Needing Storage

The first storage device for use by a machine only was the music box in the late 18th century. These machines used a handcrafted metal cylinder as the medium for "storing" a musical tune.

At the beginning of the 19th century, a purely industrial use of memory was the pioneering programmable mechanical loom invented by Joseph Jacquard. This invention used a pattern stored on thin cardboard cards. Charles Babbage used punched cards as input to calculations in his 1883 Analytical Engine, a mechanical computing machine. Punch cards were used for the first time in a large data analysis project in the 1890 Census, using an electromechanical machine invented by Herman Hollerith. This machine was the forerunner of an industry, based on punch cards for data storage and analysis.

As mechanical, electromechanical and fully electronic machines developed in the 20th century, memory had to be developed in parallel. Paper cards and other perforated media such as paper and Mylar tape had a long life (nearly a century). Aluminum foil was the first medium used in audio recording, but gave way to wax cylinders and other sturdy plastics.

Magnetic recording of data was first demonstrated by Vladimar Poulsen in the late 19th century, using a wire coated with magnetic particles. Finally, in the 1930s, magnetic recording was demonstrated on thin plastic tape coated with magnetic particles.

Computers became more capable, smaller, less power hungry and much faster during the middle 20th century. The need for a fast means of data storage, both persistent and temporary, drove the development of a number of technologies during the 1940s and 1950s: CRT storage, delay lines, magnetic core and magnetic drums and disks. The first electronic super-computer, the ENIAC, used magnetic core memory for its internal memory.

The characteristics of a useful information storage scheme vary with the intended use: how long the information will be needed, how large a capacity is required, and how fast the information needs to be accessed and transferred.

Paths to nonvolatile storage

As machines have come to dominate the processing of information, the machines themselves have driven the development (and even the naming) of storage and memory technologies. It is primarily the increase in speed of computation that has forced the development of new technologies: *speed of computation requires speed of data access, but speed also drives the required capacity of stored data, and the need for rewritable data storage*.

Digital computers perform almost all of the financial and technical computations performed in the world today. The millions of customers and millions of modest-sized transactions lead to the need for high-speed computation and large amounts of storage. Digital imaging and digital document creation have brought about the need for large data storage, and transforming and distributing these documents and images requires high-capacity storage as well as high-speed computation and communications. So a dual need is established—high-speed data access and very large capacity storage. These two demands are satisfied by different technological solutions.

Landscape of nonvolatile storage

A typical storage device uses a semipermanent scheme for storing information—and the information is usually maintained even if the power is lost to the storage device. We call this kind of storage nonvolatile. Storage devices typically have large capacity, and their design is a compromise to maintain a low price at the expense of access time (the time required to access the first bit of desired information). This compromise is achieved by using a minimum number of the complex, expensive components (recording heads, drive motors, *etc.*) but a large amount of the inexpensive commodity (primarily the recording medium). Rigid disks, flexible disks, magnetic tapes, CD-ROMs, CD-RWs, DVD-ROMs, DVD+RWs are examples of these sorts of devices.

Components that store data briefly within a computer are called memory devices. While the computer is powered up, all the information is kept in memory by the live circuitry. If there is an interruption of power, the majority of the information within the computer memory is lost—the memory is volatile. Some of the memory (DRAM) has to be refreshed even when the power is on. In our own personal experience using computing machines, we never think that some of the volatile memory is being rewritten constantly—the computer is doing that for us in the background. The speed of typical memory is gained by having a random access architecture, which provides an address to every bit whether or not it is needed by the processor at any given instant. The random access designs are achieved through the use of semiconductor technology based on photolithography. Thus, typical computer memory is very similar in cost to other semiconductor devices, like microprocessors. Memory is the most expensive form of information storage, but it can be as fast as the fastest processors (nanosecond delay times to get to the first desired bit).

In many applications, information because of a power loss is acceptable, since it can often be recalculated or recreated when the computer is turned back on. In a growing number of applications, however, the information has taken so long to create, or is so unique to the situation that it should be kept in nonvolatile memory. Thus there is a need to fill in the gap between the slow, inexpensive, storage and the fast, expensive memory. The gap is very large: about six orders of magnitude in "speed" or access time and roughly three orders of magnitude in cost per bit.

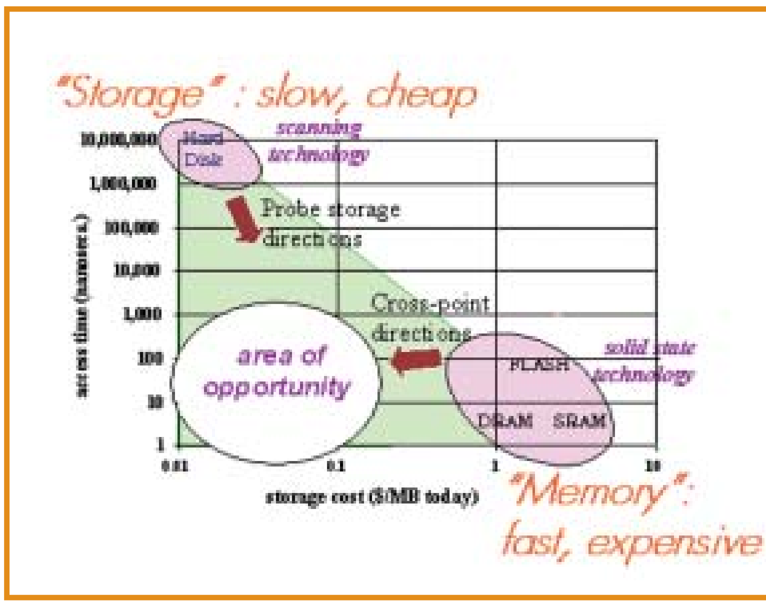


Figure 1 *illustrates the gap in access time and cost between storage and memory.*

Development directions for nonvolatile memory/storage

The fundamental architectural choices behind memory and storage have to do with their data access architecture. Storage is based on a movable read-write mechanism which can be positioned to access any desired bit of information. The only way to speed up the mechanical system of storage is to use smaller components (or employ steerable beams to access the data). The cross-point architecture for memory is achieved via a lithographic process on silicon wafers. The most effective way to reduce the cost of the memory devices (relative to the cost of other semiconductor devices) is to get more bits on the same area of silicon (multi-bit recording or via multi-layering) or to change the fundamental materials of the cross-point memory devices.

Physically smaller storage devices were imagined after the discovery of the Scanning Tunneling Microscope by Gerd Binnig and Heinrich Rohrer in 1986. The STM made everyone aware that atomic scale motion could be achieved at affordable prices. A long period of investigation has yielded a number of active efforts to produce so-called "probe storage" devices, all using Micro-Electro-Mechanical-Systems (MEMS) for the positioning mechanisms, but different schemes for the actual writing and reading of the data bits. The MEMS part of the devices is used to position a small movable element with respect to the read-write components. The very dense packing of the data is accomplished by an x-y mover (Cartesian coordinate system) rather than the rotating disk and radial arm motion of the disk drive (Cylindrical coordinate system). For the read-write mechanism, HP is perfecting a phase-change scheme in its Atomic Resolution Storage program, Carnegie-Mellon University is pursuing a magnetic scheme in its CHIPS program, IBM is working on a physical deformation of a polymer in its Millipede (now NanoDrive) program.

Other approaches are also being tried using charge trapping (Canon), ferroelectric polarization (HP), and probe phase change (LETI) to name a few. These and other "probe storage" approaches are in various stages of development and a race is on to bring them into the hands of customers. The schedules for product introductions are closely held secrets of the participating players.

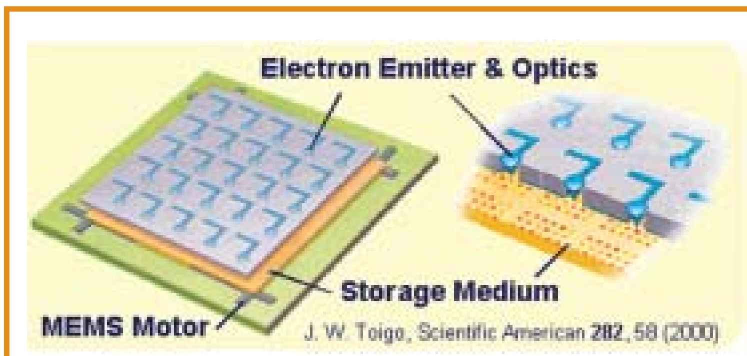


Figure 2. *Example of probe storage-Atomic Resolution Storage*

Nonvolatile memory is also being pursued actively by a large number of parties, and a few examples of these technologies are already on the market. Flash memory exists today, as a nonvolatile memory technology. Flash has the disadvantage that it is not infinitely recyclable and not fast enough in writing to work alongside processors. Researchers are looking at nonvolatile memory technologies different from the flash charge storage scheme. Leading the way are MRAM (Magnetic RAM; a host of companies are announcing or suggesting product introduction dates in 2003 and beyond), FeRAM (Ferroelectric RAM; modest capacity products are available today from Ramtron, and many others working on it), phase change (Ovonyx has announced partnerships with Intel and STM), NROM (charge trapping in nitrides, pursued most actively by Saifun Semiconductors and AMD) and polymer memory (pursued by a number of companies). Each of these nonvolatile memory technologies has its advantages and disadvantages, and the winner will be determined by the extent to which they succeed in addressing problems of customers, and being successful in the marketplace.

These new technologies will address a wide range of requirements, traditional, emerging and future. For example, not all the markets need the full range of capabilities imagined for a "perfect" memory component. A digital camera user does not expect the digital film to be capable of an infinite number of read-write cycles. An archival data storage system does not have to run at nanosecond access times. There will be a large number of products, with a large variety of capabilities squeezing into, between and beyond the spaces occupied by the current magnetic and optical phase- change storage and the high-speed silicon-based computer memory. We technologists have the wonderful opportunity to be both the developer of future products based on the application of many different physical principles, as well as the first users of them.

Charles Morehouse is director of the Information Access Laboratory at Hewlett Packard.

Gammasphere's starring role in *The Hulk*

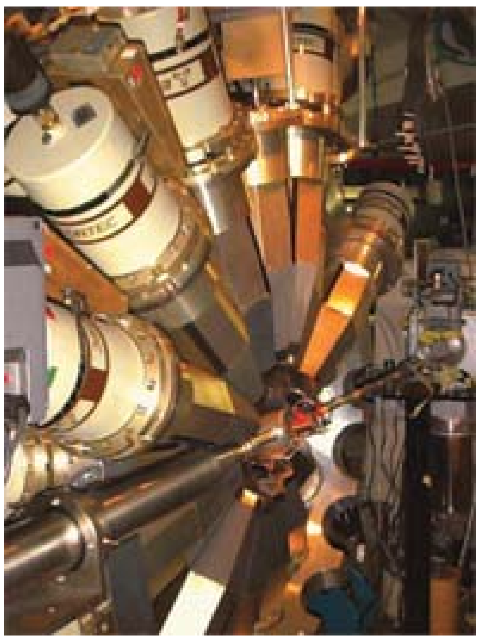
In the summer hit movie *The Hulk*, intrepid Berkeley scientist Bruce Banner is zapped by a machine called Gammasphere. As a result, Banner transforms into a massive green monster at times of stress. Although Banner and his hulking alter ego are the latest fictional characters to emerge from comic book pages and make their way onto the big screen, Gammasphere is not merely a science fiction plot device.

While scientists in real-world labs have never been turned into green giants by the machine, the real-life Gammasphere has provided valuable information about some other monstrosities.

"Gammasphere allows us to study the forces inside unstable atomic nuclei that don't exist in nature," says Paul Fallon, a researcher at Lawrence Berkeley National Laboratory, where key scenes from The Hulk were filmed.

Unlike the machine in the movie, the real Gammasphere doesn't make the monsters...they have another machine for that. "We use a particle accelerator, either a cyclotron or a linear accelerator, to ram ions [electrically charged atoms] into a target," explains Fallon. "The ions combine with atoms in the target to create heavier atoms." This process is known as nuclear fusion. The resulting atoms are not monsters, of course, but like the Hulk they are large and unstable.

Generally, the new atoms are formed at high energy and are spinning, and rapidly disintegrate—emitting a spray of gamma rays along the way. The gamma rays are collected in the bristling and beautiful, spherical array of detectors that make up Gammasphere (see images at http://www-gam.lbl.gov/gamdocs/pictures/index.html).



Close-up of Gammasphere, with the G-factor target chamber installed

"By looking at the pattern of gamma rays," says Fallon, "we can infer the shape and the internal structure of the nucleus. The lifetime [before it decays] tells us something about deformations of the nucleus." The study is important in helping to explain why oxygen, carbon, iron and other common elements that comprise our world are stable.

Atoms that are fused by the accelerator and subsequently disintegrate inside Gammasphere have too many protons to stay together for long. "The goal is to produce new and exotic nuclei," says Fallon. Creating unstable atoms at the extremes of stability lets us isolate different aspects of the problem that may not be evident in stable nuclei."

Although portions of the movie were filmed at the Lawrence Berkeley National Laboratory in California, where Gammasphere sometimes resides, the machine is presently in Illinois at the Argonne National Laboratory.

"Gammasphere was built to be moved," says Fallon. "To date it has resided part of the time at Berkeley, and part of the time at Argonne, as part of a national research project." It takes about four months to disassemble, move, and reassemble the machine. The real Gammasphere itself never appears onscreen, but a faithful replica fills in. "As I understand it," says Fallon, "it's identical to the real thing, even down to the lab property stickers on the back."

One obvious difference between the real machine and the fictional version is the fact that the movie Gammasphere emits gamma rays that cause Banner to transform from human to Hulk every now and then.

The real Gammasphere detects the weak gamma ray signals emitted by decaying atoms, and is harmless. "I think the producers were a little disappointed," chuckles Fallon, "when they found out that ours wasn't dangerous."

— Inside Science News Service

MARCH MEETING *from page 1*

cities for our meetings years in advance," said APS Executive Officer Judy Franz. "Montréal was chosen well before the 9/11 tragedy, when we had no reason to believe it would be a problem. It's now too late to change the location."

In addition to the requirements for re-entry to the US, attention must be paid to the regulations for crossing into Canada from the US. Citizens from certain countries are required to obtain a Canadian visitor's visa. Information on this issue can be found on the APS web site as well.

More information on visa issues can be found on a new Web site launched by the International Visitors Office of the National Academies (www.nationalacademies.org/visas/), which is designed to provide assistance to foreign scientists and scholars.

The members of the APS International Office can be reached by e-mailing: international@aps.org or calling Irving Lerch, (301) 209-3236; Michele Irwin (301) 209-3237; or Jackie Beamon-Kiene, (301) 209-3239.

VISA PROBLEMS *from page 4*

Delays in granting visas and the resulting unpredictability in graduate student attendance have not been the only challenges plaguing our educational system. Physics department chairs have been extremely concerned about the high rate of visa rejection for Chinese applicants.

Although this problem existed even before September 11, the recent AIP study reveals that Chinese students are the group most commonly denied visas in terms of both raw numbers and percentages. Chinese students suffer high rejection rates on what is called the "214(b)" exclusion.

Section 214(b) of the Immigration and Nationality Act forbids the granting of a visa to a student who cannot prove that he will return to his country of origin when his studies are done. Chinese students in particular often have trouble with this provision.

The best strategy, advises Lerch, is for each visa applicant to provide documentary proof of factors that indicate an intent to return (such as family members or property left behind). In addition, the educational institution should issue a declaration of its intent to comply fully with the law and not to influence the applicant to stay in the US.

Implementation of SEVIS, the internet-based Student and Exchange Visitor Information System has also run into problems.

This system, designed by the Immigration and Naturalization Service (INS) to track students and exchange visitors in the country, requires universities to ensure their enrolled students are attending classes.

The deadline for full implementation of SEVIS across the country's colleges and universities has been set for August 1, 2003. The higher education community has recently raised concerns about the difficulty of implementing the SEVIS fee system before the fall semester begins, but quiet indications from the Administration are that the deadlines for the fee system will be relaxed.

The APS Office of Public Affairs in Washington keeps a close eye on the visa issues. Says a spokesperson for the office, "This is a top priority, not just for our members, but for the science community and the country as a whole. We are working closely with other professional organizations to coordinate our efforts and maximize effectiveness."

2003 APS Election Closes September 1

Full information about this year's election, including the list of candidates and their biographies, can be found online at http://www.aps.org/exec/election2003.

Information about the candidates appeared in the July issue of APS News.

The election closes on September 1.

MEDIA FELLOWS *from page 2*

started freelancing over the last year, and plans to go into science communication when she completes her PhD in 2005.

The youngest of the three fellows, Heinrichs just completed an individualized study program at Ohio State University, tailoring her bachelor's degree to suit her interests in astronomy, physics, chemistry and English, with a minor in mathematics. She has always been fascinated by science, particularly astronomy. As an undergraduate, she spent one summer in Tucson, Arizona helping do research at the National Optical Astronomical Observatory.

The experience was very positive, but Heinrichs became convinced that her true interests lay in the communication of science to the general public. She applied for the APS Mass Media Fellowship to gain some firsthand experience, and ended up at the *Los Angeles Times*. Her first story was on monkey pox, a virus from Africa that infected local prairie dogs, which many Midwestern residents keep as pets. "It you were bitten, you'd develop something like a mild version of smallpox," she says.

Heinrich plans to take a year off after her fellowship and move to Seattle, freelancing and working to save money for graduate school. She is applying to various graduate schools with programs in science writing, including University of California, Santa Cruz, MIT and Boston University. "I enjoy scientific research, but the more I see of it, the more I realize that I really don't want to specialize," she says. Ultimately, she plans to go into science writing full time, or perhaps work in a science museum to share her love of science with others.

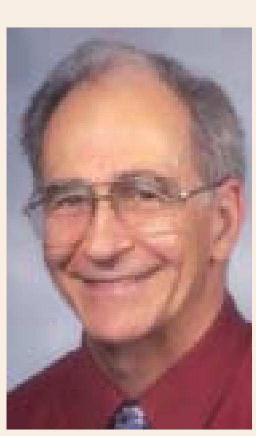
Nangini earned a BS in physics and an MS in geophysics at the University of Toronto before deciding to pursue her PhD in medical biophysics. She specialized in research on functional magnetic resonance imaging (fMRI), a complementary technique to conventional MRI. Whereas the latter provides static anatomical images, fMRI produces an image as a function of time, "so you can see what parts of the brain are working throughout a task or a particular stimulus," she says.

She has always had an interest in writing, having freelanced throughout her undergraduate and graduate education, even establishing a science column in the campus newspaper. She applied for the APS Mass Media Fellowship to further develop her skills in writing, interviewing and critical thinking. "I believe that science has an increasingly important role in shaping society, and hence has a crucial place in the media, which is the primary means by which the public receives their information," she says. "And that can be inspiring. But often the media is misinformed about science, and as a scientist, I hope to play a role in addressing that."

For the immediate future following her fellowship summer, Nangini plans to focus on her graduate studies to complete her PhD, although she hopes to continue to write on a freelance basis. "I actually think the two [research and science writing] are very complementary," she says. "The PhD work pushes my boundary of scientific knowledge and forces me to probe and question, which is exactly what you're supposed to do as a journalist."

For more information on the APS Mass Media Fellowship program, see http://www.aps.org/public_affairs/massmedia/index.html

Jakobsson Is First Director of NIH Center for Bioinformatics



APS Fellow Eric Jakobsson was recently selected as the first director of the Center for Bio-informatics and Computational Biology at the National Institute of General Medical Sciences, an NIH component.

The new center will support research and training in areas that join biology with the computer sciences, engineering, mathematics and physics.

Before coming to NIGMS, Jakobsson was a professor of biophysics, neuroscience and bioengineering at the University of Illinois.

His research focuses on the computational and theoretical study of biological membranes, and he has been a leader in the use of computers and other technology in education.

"The development of modern physics in the last century led directly to great advances in biomedical knowledge," Jakobsson said. "Now the ability to analyze biological systems using high-powered computers will once again enable physicists and other quantitative scientists to advance biomedical research."

The Back Page

Underground Science: The US Effort to Create a Deep Underground Laboratory

By Wick Haxton

The old adage that "the third time is the charm" is being put to the test: the US physics community has rallied once again to create a next-generation deep underground science laboratory.

The effort has had its full share of color and twists, and the final scenes remain to be played out. The main stage is an historic gold mine with connections to General Custer and the birth of solar neutrino astronomy. The players include a Canadian mining company, Barrick Gold, the state of South Dakota, and a group of physicists and earth scientists who have "self organized" to preserve a unique US asset. The resulting interactions have at times produced interesting theater: in one scene reminiscent of the '60s, senior US physicists demonstrated at the mine entrance for continued operation of the pumps.

Physicists have long appreciated that extremely sensitive, low-energy experiments offer a window on subatomic physics quite complementary to that provided by accelerators. Such searches can reveal subtle violations of symmetries and conservation laws, reflecting new physics hidden at energy scales beyond direct reach. Important examples—proton decay searches to probe the stability of matter, tests of the standard-model prediction of massless neutrinos—probe phenomena at 10^{16} GeV, the strong and electroweak unification scale.

Sensitive experiments to measure the spectrum of solar neutrinos or the lifetime of the proton cannot be done on the earth's surface. Unless the detector is placed thousands of feet below ground, the cosmic ray background rate is too high.

Around 1980, as physicists began to contemplate a new generation of massive underground experiments, the community recognized that a new model for such experiments was needed. The parasitic mode of the past—persuading a supportive mining company to provide space and hoist access—would be increasingly problematic as the scale and complexity of experiments increased. In quick succession the USSR, Italy, and Japan established multipurpose underground laboratories. The first of these, Baksan, was created in the late 1970s as the first deep laboratory dedicated to physics.

Under the direction of Chudakov and Zatsepin, a tunnel was excavated in Mt. Andyrchi in the Caucasus. Baksan was built for the study of the penetrating components of cosmic rays—the muons and neutrinos—and was the site of the SAGE solar neutrino experiment, mounted to measure the lowest energy branch of the solar neutrino flux.

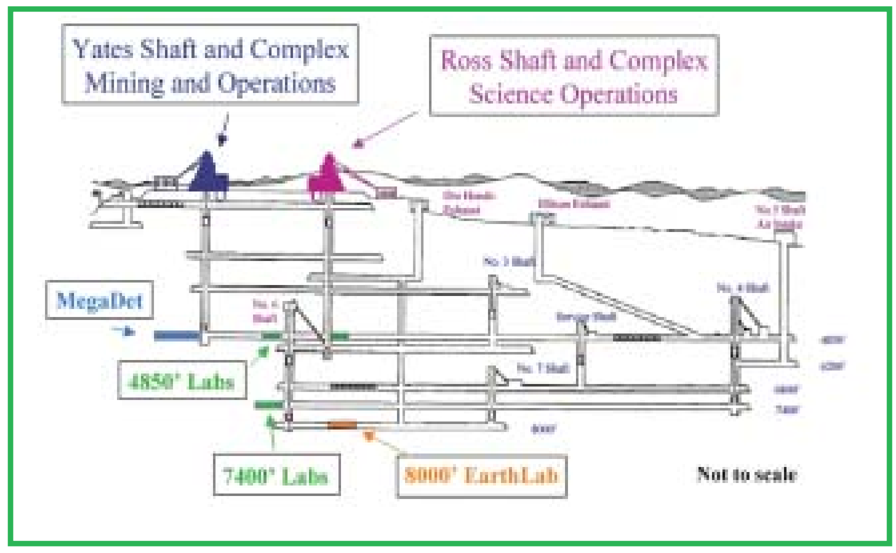
In 1981 Zichichi proposed the world's largest multipurpose facility, the Gran Sasso National Laboratory. Built as part of a highway tunneling project during the early 1980s, the laboratory provides about 3800 meters water equivalent (mwe).

Gran Sasso has hosted (or is preparing to host) the GALLEX/GNO and Borexino solar neutrino experiments, two long-baseline experiments to detect neutrinos from CERN, the MACRO cosmic ray experiment, the kiloton supernova detector LVD, and a rich program of double beta decay, dark matter, and nuclear astrophysics studies.

At about the same time Japan began an underground science program within an operating mine, Kamioka, that produced exceptional results. Kamioka housed Koshiba's proton decay experiment, which also made crucial measurements of the neutrinos from Supernova 1987A and of the atmospheric neutrino flux. Its successor, the 50-kiloton Super-Kamiokande, resolved the atmospheric neutrino puzzle, established new bounds on proton decay, and made a precise measurement of the high-energy portion of the solar neutrino flux.

While Gran Sasso was being planned, a very serious effort to create a US facility was also underway, lead by Al Mann of the University of Pennsylvania and Bob Sharpe of Los Alamos. The US, lacking the deep road and railway tunnels common in Europe, has fewer opportunities for creating such a laboratory. The Mann/Sharpe proposal, as well as one put forth by the UC Irvine group, were "greenfield" projects. The former would have created a vertical shaft at a site near Yucca Mountain, Nevada, while the latter required excavation of a tunnel beneath Mt. San Jacinto, near Palm Springs. Despite considerable advocacy by the community, neither proposal was funded. Nearly twenty years earlier Luis Alvarez, Fred Reines, Aihud Pevsner, and others had advocated a US underground laboratory.

Arguably the lack of a national laboratory has had a profound impact on US underground science. The IMB proton decay experiment, the US effort that paralleled Kamioka, provided early evidence of the atmospheric neutrino anomaly that was later traced to $\nu_\mu \rightarrow \nu_\tau$ oscillations and the discovery of neutrino mass. Yet no US follow-up experiment was approved. The field of solar neutrinos began with the Davis experiment at the Homestake Mine in Lead, South Dakota. Although the GALLEX pilot experiment was performed at Brookhaven, the chemistry of the GALLEX and SAGE experiments largely developed in the US, and the Sudbury Neutrino Observatory (SNO), these experiments were mounted elsewhere. US scientists have played an important but supporting role as the major experiments were hosted by Kamioka, Gran Sasso, Baksan, and most recently, Sudbury.



Schematic showing the proposed layout for NUSEL-Homestake. The main development is on the 7400-ft level, but certain experiments (including the megadetector) will be sited along the drift at 4850 ft. The geomicrobiologists will work at 8000 ft, drilling from there to 13,500 ft, the expected limit for microbial life (120°C).

However, a new window of opportunity may be opening for US scientists. Recent discoveries by SNO and Super-Kamiokande leave open a host of questions about neutrino mass. We know two mass splittings, but not the overall scale of the masses, a parameter crucial to cosmology and astrophysics. The surprising strength of neutrino mixing—the mass eigenstates and weak interaction eigenstates appear to differ almost maximally—opens the possibility of testing neutrino CP violation in very long baseline oscillation experiments. There is a growing suspicion that related symmetry violation—leptogenesis—may explain why our universe has an excess of matter over antimatter. The US has two major laboratories, FermiLab and Brookhaven, capable of producing the neutrino "superbeams" needed for precision studies of neutrino parameters, including CP violation. What is required to complete the equation is a underground laboratory, 2000-4000 km away, housing a megadetector ten times the size of Super-Kamiokande.

This same detector, if placed a mile underground, could extend searches for proton decay by more than an order of magnitude. It would allow experimenters to measure in great detail neutrino emission from the next galactic supernova, determining the structure of the nascent neutron star.

We now know, from measurements of large-scale structure, the cosmic microwave background, and distant supernovae, that the evolution of our universe is governed by unseen sources of matter and energy. The cold, dark matter is many times more plentiful than the ordinary matter visible in stars and gas clouds. Its nature is unclear, and its origin is outside the standard model. Underground experiments provide our best hope for identifying this matter.

These and many other underground physics efforts—double beta decay, nuclear astrophysics, low-level counting for industry and national security—have one aspect in common: increasingly great depths are needed. While experimentalists have become very adept at eliminating many natural radioactivity backgrounds, often the only solution to cosmic ray-induced activities is great depth. Furthermore, the experiments described above are governed by a Moore's law: sensitivities increase by about a factor of two every two years. This implies a simple rule of thumb: each decade experiments must move another 1500 feet deeper, to achieve a proportional reduction in cosmic ray muon backgrounds.

The urgency of the science and the need for depth were under discussion at a community Town Meeting on neutrinos, September 2000, in Seattle, when Ken Lande of the University of Pennsylvania made an announcement and proposal. The Homestake Gold Mine, the deepest in the US, was about to cease operations, after 125 years of mining. Its massive infrastructure—hoists and shafts reaching 8000 ft below ground, phone and fiber optics communications, a sophisticated ventilation and air conditioning system, its own hydroelectric power—might soon be available to science. Lande proposed the National Underground Science and Engineering Laboratory (NUSEL), a deeper next-generation Kamioka/Gran Sasso.

This proposal became the #1 recommendation of the 200 physicists in Seattle. The National Science Foundation and Department of Energy responded by funding a community study, headed by John Bahcall, to consider creation of a deep US laboratory. The Bahcall Committee's influential report was followed by NSAC and HEPAP (High Energy Physics Advisory Panel) recommendations and by two National Research Council studies. A Homestake proposal to create NUSEL-Homestake was submitted to the NSF and has been under review for the past two years.

Two other proposals have also been made. One is a modern version of the Mt. San Jacinto proposal to create a horizontal access laboratory by tunneling. There is a strong preference in the community for horizontal access, if a good site can be found. The other proposes deepening the Soudan Laboratory.

But the path to NUSEL has been difficult. While the Homestake site was recently designated by a distinguished NSF engineering panel as the best proposal, by far, from a geotechnical standpoint (the rock integrity is outstanding, allowing even the largest suggested detector cavities to be built with confidence), the land transfer has proven complicated. South Dakota and Barrick Gold, the Homestake owner, have negotiated for over two years, without resolution. Worse, Barrick turned off the mine pumps in June, arguing that they could not accept federal funds to continue maintaining the mine without a positive NSF decision. This was done despite strong objections from the physicists and earth scientists involved in the project: in addition to physics, NUSEL will host efforts in fields like geomicrobiology. The geomicro-biologists are deeply concerned that flooding will alter biological conditions in the mine, confusing any subsequent studies they might do.

The Ross head frame, Homestake Gold Mine, which provides access to the 4850-ft level of the mine.

While the US process slowly moved along, a Canadian proposal to expand the SNO laboratory was written, approved, and funded. Preliminary construction is under way. The SNOLab addition is considerably smaller than NUSEL and access is shared with miners. Still, SNOLab is now the one laboratory clearly deep enough to accommodate difficult experiments, like those designed to measure the lowest energy branch of the solar neutrino flux.

Where will this lead? The last act is about to play out. The interest in the science community, in the media, and in Washington is intense. Is the ending tragic or triumphant? If we only knew what the script holds for us…

Wick Haxton is professor of physics at the University of Washington in Seattle.

APS News welcomes and encourages letters and submissions from its members responding to these and other issues. Responses may be sent to: letters@aps.org.