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This Month in Physics History:
Ben Franklin attempts to electrocute a turkey.
See page 2

Mile-High City Will Host 2007 March Meeting

The 2007 APS March Meeting will be held March 5-9 in Denver, Colorado. It is the largest annual gathering of professional physicists in the country.

The scientific program will feature more than 90 invited sessions and 550 contributed sessions, at which approximately 7000 papers will be presented, covering the latest research in areas represented by the APS divisions of condensed matter physics, materials physics, polymer physics, chemical physics, biological physics, fluid dynamics, laser science, computational physics, and atomic, molecular and optical physics.

Also taking part will be the APS topical groups on instrument and measurement science, magnetism and its applications, shock compression of condensed matter, statistical and nonlinear physics, and quantum information, as well as the forums on industrial and applied physics, physics and society, history of physics, international physics, education, and graduate student affairs.

Special scheduled events include the annual prize and award presentation, a one-day workshop on professional skills development for women physicists, a panel discussion with APS journal editors, a students lunch with the experts, a physics sing along, and a high school physics teachers' day on Tuesday, March 6.

In addition to the regular technical program, on Sunday, March 4, there will be seven half-day tutorials on magnetism at the nanoscale, teaching statistical and thermal physics with computer-based tutorials, quantum error correction, spintronics, quantum turbulence, graphene, and attosecond science.

The 4th APS Workshop on Opportunities in Biological Physics, organized by the Division of Biological Physics, will be held on Sunday, March 4.

On Saturday, March 3 and Sunday, March 4, the Division of Polymer Physics will host a special short course on Advances in the Use of Atomic Force Microscopy for Studies of the Physics of Macromolecular Materials.

Photo credit: Ted Hodapp

About 85 new physics and astronomy faculty gathered at the American Center for Physics in College Park, MD for the annual New Faculty Workshop. The meeting ran from October 26 through 29, and featured plenary sessions as well as several small group sessions on specific topics like "problem-solving," "tenure and promotion issues" and "supervising undergraduate research." Among the plenary lecturers were Evelyn Patterson of the U.S. Air Force Academy, Eric Mazur of Harvard, Diandra Leslie-Pelecky of the University of Nebraska, and Jim Stith of the American Institute of Physics. The photo shows Britt Scharringhausen of Beloit College, Kanani Lee of New Mexico State University, and David Mitchell of Cal Poly San Luis Obispo hard at work during one of the small group sessions.

New Management Tackles Difficult Problems at Los Alamos

By Ernie Tretkoff

Several months after new management took over at Los Alamos National Laboratory, the lab continues to struggle with security and budget problems and low employee morale.

Until last year, the lab had been managed by the University of California. Following a series of security and safety problems that led to a total shutdown of the lab, the Department of Energy put the management contract out to bid. Last December the DOE selected Los Alamos National Security (LANS) as the new contractor. LANS, a collaboration of the University of California, Bechtel National, BWX Technologies, and Washington Group International, beat out the University of Texas/Lockheed Martin collaboration for the contract. The new management took over in June.

The new director, nuclear physicist Michael Anastasio, came to LANL from Lawrence Livermore National Laboratory, where he had been the director since 2002.

In a recent security incident, classified data were found in the home of a former subcontractor during a drug raid by local police. In addition to drug paraphernalia, police found computer memory sticks containing classified documents from the lab, as well as hard copies of classified documents. The documents had apparently been taken from the lab by a woman who had

LOS ALAMOS continued on page 5

Council Passes Statements on Linear Collider, Careers in Physics

The APS Council approved two new statements at its November meeting, one in support of the proposed International Linear Collider, and the other an updated statement on careers in physics.

The statement on the collider cited the findings and recommendations in the National Academy of Sciences report *Revealing the Hidden Nature of Space and Time: Charting the Course for Elementary Particle Physics* (commonly known as EPP2010), released last spring [see *APS News*, June 2006, and *APS News* Back Page, July 2006 (both available online)]. The statement says, in part, that "within the framework of a balanced national program in the physical sciences that recognizes the need for advancing the frontiers in both large and small science, the American Physical Society strongly endorses the chief recommendation of EPP2010:

'The United States should remain globally competitive in elementary particle physics by playing a leading role in the worldwide effort to aggressively study Terascale physics'."

The statement continues: "To achieve that end in the context of successful international collaborations on large scientific facilities, the American Physical Society, consistent with the recommendations in EPP2010:

•Urges the Administration, acting through the Department of Energy and the National Science Foundation; and Congress, acting through the authorization and appropriations committees, to provide the American share of the 'risk capital' for research and development (recommended in the National Academy report) lead-

See COUNCIL on page 3

Apker Award Honors Three Undergrads



The LeRoy Apker Award is given for outstanding research accomplishments in physics by an undergraduate. Two categories are recognized, one for an undergraduate at an institution that grants the PhD, and the other for an undergraduate at an institution that does not grant the PhD. Normally, there is one award each year in each category. This year, however, an unusually large number of outstanding nominations were received. The selection committee responded by recommending three recipients to the APS Executive Board: two in the non-PhD category, and one in the PhD category.

On the left is Hugh Churchill of Oberlin College, whose senior thesis, done under the supervision of Stephen Fitzgerald, was on "Low-temperature infrared spectroscopy of H_2 in solid C_{60}." He is now a graduate student at Harvard. In the middle is Huanqian Loh of MIT, who, working with James K. Thompson and Vladan Vuletic, wrote her senior thesis on "Applications of Correlated Photon Pairs: Sub-Shot Noise Interferometry and Entanglement". She is spending this year working in a quantum optics laboratory in her native Singapore, and intends to begin graduate work in physics in the US next fall. At right is Stephanie Moyerman of Harvey Mudd College, who wrote her thesis on "Magnetic Structure Variations in Spin Valves with Pico-Scale Antiferromagnetic Layers" under the supervision of James Eckert and Patricia Sparks. Currently studying abroad on a Watson Fellowship, she will begin graduate school at UC Berkeley in the fall of 2007.

APS Kicks Off Campaign to Support Education and Outreach Initiatives

On November 3, the APS 21st Century Campaign celebrated its kickoff at a special event on the evening before the November 4 Executive Board meeting. APS President John Hopfield led the program, which included the announcement of a $3.5 million goal and approximately $1.8 million having been raised to date. The campaign seeks corporate, foundation and individual gifts. APS programs benefiting from campaign funding include:

• PhysTEC (Physics Teacher Education Coalition)–seeks to produce more and better prepared physics and physical science teachers.

• High School Teachers' Days -special events at APS meetings that offer hands-on workshops and research talks, with members joining the teachers for lunch.

• Minority Scholarship Program –awards scholarships and provides mentors to undergraduate physics majors.

• Student Travel Grants–provides physics students with an opportunity to attend APS meetings.

• Women and Minority Speakers Program–women and minority speakers volunteer to give talks at high schools, colleges and universities.

• Career and Professional Development Liaison Program–works with physics departments that are helping students make well-informed career-related decisions.

CAMPAIGN continued on page 5

Photo credit: Sarah Davis

Speakers at the Campaign kickoff celebrate the success to date. From left to right are: Brian Schwartz of the City University of New York; APS Executive Officer Judy Franz; APS President John Hopfield; APS Director of Education and Diversity Ted Hodapp; and Noah Finkelstein of the University of Colorado. Schwartz is a former APS Director of Education, and Finkelstein is one of the leaders of the PhysTEC program at UC Boulder (see *APS News*, March 2006, and *APS News* Back Page, January 2006).

Members in the Media

"One has to be extremely careful with those enthusiastic announcements. This is not because one is doing something wrong. It's because these are very difficult measurements."

***Witold Nazarewicz**, University of Tennessee, on the announcement of discovery of element 118, The New York Times, October 17, 2006*

"We selected a completely different nuclear reaction, performed with completely different people in a different laboratory. Everything we do is checked and double-checked."

***Ken Moody**, Lawrence Livermore National Laboratory, on the discovery of element 118, Los Angeles Times, October 17, 2006*

"Our presence (in Iraq) is not only making Iraq a more dangerous place, it is interfering with our ability to deal with so many (matters) facing us, whether it's climate change, nuclear proliferation of other nations or the impoverishment of our oceans."

***Rush Holt**, U.S. House of Representatives, on the war in Iraq, the Trenton Times, October 18, 2006*

"If you watch science programmes on television, whether its Horizon or children's programmes, it's either a talking head with cuts away to animation or a very dry commentary. Children don't engage too much with that so I wanted to find a different approach."

***Robert Cywinski**, University of Leeds, on animated science films he is developing for children, Yorkshire Post, November 4, 2006*

"A couple of years ago [during the transit of Venus] we detected the drop in the total brightness of the sun by a tenth of a percent. Because Mercury is smaller [than Venus] and because it's more than twice as far away ... we'll be particularly interested to see if we can pick up this event."

***Jay Pasachoff**, Williams College, on the transit of mercury on November 8, Baltimore Sun, November 7, 2006*

"Physicists in particular tend to get almost emotional over helium. Almost all modern research that involves very low temperatures ... depends on helium."

***Robert Park**, U. of Maryland, on helium shortages, Houston Chronicle, November 5, 2006*

"There's nothing to stop the rally in uranium, unless nuclear has a big accident. We had 20 years of low prices. The cost of that is there had been virtually no investment in new mining projects."

***Thomas Neff**, MIT, on the uranium industry, Bloomberg News, November 6, 2006*

"There's no physics theory that can fully explain any baseball pitch, except the knuckleball."

***Porter Johnson**, Illinois Institute of Technology, USA Today, October 26, 2006*

"The idea is to combine two properties with one material."

***Lian Li**, University of Wisconsin-Milwaukee, on trying to create a magnetic semiconductor, Knoxville News Sentinel, November 6, 2006*

Kadanoff Wins Lorentz Medal

APS President-Elect Leo Kadanoff has been awarded the 2006 Lorentz Medal by the Royal Netherlands Academy of Arts and Sciences. He received the medal in Amsterdam on November 27 for his contributions to statistical physics, in particular to the theory of phase transitions.

Leo Kadanoff

According to a press release from the Royal Netherlands Academy, Kadanoff's research has revolutionized the way physicists regard sudden changes in matter such as the transition from liquid to gas or the onset of magnetization at the Curie point. Kadanoff discovered that such phase transitions obey certain laws applying universally. His ideas have also been exceptionally fruitful in other areas of physics. By applying his theory to such diverse phenomena as turbulent water and running sand piles, he developed a systematic approach to what are now called "complex systems." In addition, his work has cast new light on chaotic dynamics beyond physics, such as stock market fluctuations, heartbeat irregularities, and traffic jams.

Kadanoff received his PhD in physics from Harvard, which was followed by a postdoc in Copenhagen.

KADANOFF continued on page 6

This Month in Physics History

December 23, 1750. Ben Franklin Attempts to Electrocute a Turkey

This year marks the 300th anniversary of Benjamin Franklin's birth. Franklin, the tenth son of a soap maker, received very little formal schooling growing up. He was later apprenticed to his older brother, a printer, which gave him the opportunity to read books. Franklin was always curious and eager to learn. This curiosity drove his experiments with electricity, which made him famous as a scientist.

In December 1750, Franklin learned one lesson the hard way, when he shocked himself while trying to electrocute a holiday turkey. Franklin believed electrocuting the turkey made it uncommonly tender.

When he began his electrical experiments in about 1745, Franklin had already retired from his printing business, which was good, because he soon became so absorbed in the experiments he had little time for anything else. "I never was before engaged in any study that so totally engrossed my attention and my time, as this has lately done," Franklin wrote to his English friend Peter Collinson in a letter thanking him for the gift of a Leyden jar with directions for charging it.

To most of Franklin's contemporaries, electricity was mainly useful for parlor games. Few people at the time anticipated any practical use for electricity. Franklin was among the first to study the phenomenon scientifically.

To be sure, Franklin had a great sense of humor and clearly enjoyed the parlor tricks, and he liked having an audience for his electrical amusements. For instance, in the early summer of 1749, somewhat disappointed at not yet having produced anything of great use to mankind with electricity, Franklin hosted an elaborate electrical barbecue. He killed a turkey by electrical shock, then roasted it using the electrical jack, an electric device he invented that would rotate the turkey as it roasted before a fire, which was kindled by an electrified bottle. Guests drank from electrified glasses that gave them a small shock as they sipped their wine, and were entertained as sparks were sent across the river. Franklin also devised a game called "treason," which involved an electrified portrait of the king, with a removable gilt crown. The picture was rigged so that anyone who tried to remove the crown while holding the gilt edge of the picture would be shocked.

Yet Franklin was interested in electricity for more than entertainment. He studied electricity seriously, and made many meticulous experiments, which he recorded in numerous letters to his friends. His investigations used simple apparatus that included Leyden jars, glass rods, silk, cork, various metals, etc. Franklin not only carried out many electrical experiments, he attempted to explain what he was observing. Based on these observations, Franklin determined that the "electrical fire," as he called it, was a conserved quantity. He introduced the notion that positively charged objects contained an excess of electrical fire, while negatively charged objects had a deficit. He investigated which objects could be made to attract or repel each other. He determined that sharp points could "draw off" or "throw off" electrical fire, and later applied this knowledge to the design of lightning rods. He is most famous for his kite experiment showing that lightning is an electrical phenomenon.

But not all of his experiments went well. In a letter dated 25 December 1750, Franklin describes his attempt to electrocute a turkey, which didn't work out as he had intended, "I have lately made an experiment in electricity that I desire never to repeat. Two nights ago, being about to kill a turkey by the shock from two large glass jars, containing as much electrical fire as forty common phials, I inadvertently took the whole through my own arms and body, by receiving the fire from the united top wires with one hand, while the other held a chain connected with the outsides of both jars."

The audience for this accident reported that they had seen a great flash and heard a loud crack, but Franklin didn't notice this, having been shocked senseless. He did record that "the first thing I took notice of was a violent, quick shaking of my body, which gradually remitting, my sense as gradually returned." Franklin felt some numbness for a short while afterwards, and experienced some soreness for a few days, but otherwise, he suffered only from embarrassment at his mistake. He made an effort to warn others against making a similar mistake when conducting such dangerous experiments.

Franklin wrote about this event and his many other experiments in his letters, and in 1751 published a book, *Experiments and Observations on Electricity*, which became very popular. He continued his scientific work for which he was by then well known, and in 1752 conducted the famous kite experiment mentioned above. In addition to his electrical research, Franklin investigated heat conduction, weather patterns, and the Gulf Stream, and invented many practical devices such as the Franklin stove, bifocals, daylight savings time, and the lightning rod.

Further reading: Franklin's electrical writings can be found online at http://www.tufts.edu/as/wright_center/fellows/bob_morse_04/

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Staff Writer .... **Ernie Tretkoff**
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DPP Meeting Features Latest Advances in Plasma Physics Research

The first laboratory-produced plasma mini-jets, boiling plasmas, and the latest advances in laser-driven wakefield accelerators were among the highlights of the 48th Annual Meeting of the American Physical Society's Division of Plasma Physics, held October 30-November 3, 2006, in Philadelphia, Pennsylvania. More than 1500 attendees presented 1600 papers covering the latest advances in plasma-based research and technology.

Bringing Stars and Galaxies Down to Earth. Scientists at Imperial College London have developed a new technique to produce in the laboratory centimeter-sized versions of the powerful jets of plasma observed in young stars, active galaxies, and in supernovae explosions. The results provide new insights into the physics of jet formation and open the door to laboratory studies of some complex space phenomena.

The experiment is designed to reproduce the interaction of magnetic field loops with a plasma environment. Coupled with state-of-the-art simulations, the experiments show that the sudden release of energy produces a magnetic bubble inside the hot plasma, enveloped by a relatively thin shock-layer. Magnetic field and pressure distributions confine the magnetic bubble into a cylinder-like structure that grows taller in time: a "magnetic tower."

Within the bubble, a current-carrying jet appears with the magnetic field lines tightly wrapped around it. The plasma is accelerated to speeds of over half a million miles an hour and compressed to temperatures of a million degrees; then, instabilities in the jet and the "bursting" of the magnetic bubble lead to the break-up of the system.

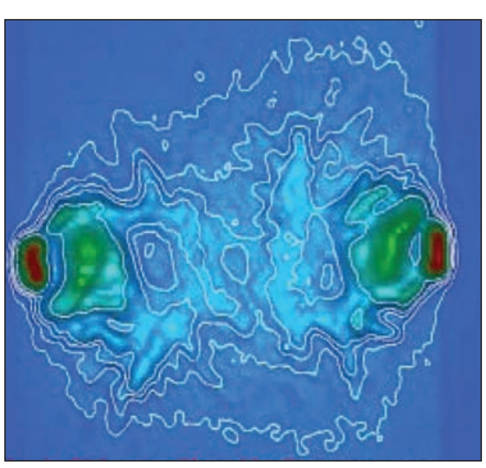
Surprisingly, it was observed in both experiments and simulations that well collimated "blobs" of plasma are left behind, forming a relatively narrow channel of energy and mass reminiscent of the clumpy structure observed in many astrophysical jets. Additional important physical effects, such as poloidal magnetic fields and rotation have resulted in the first rotating jets ever produced in the laboratory.

Boiling Plasmas. Hot, magnetically confined plasma is much like a boiling pot of water, and the intensity at which the plasma is boiling often determines how well it is confined. The chaotic motions of the "boiling" plasma are called turbulent eddies. Recent collaborative experiments on the DIII-D National Fusion Facility by researchers from the University of California, Los Angeles, University of California, San Diego, University of Wisconsin-Madison, and General Atomics have provided detailed measurements of the turbulence, allowing for the creation of more precise models to predict the performance of future fusion reactors.

One of the most interesting developments in our understanding of plasmas has been the discovery that the turbulence actually "stirs" itself by generating flows which limit the turbulence and its associated transport. This stirring has now been measured for the first time by researchers at the UW-M. Using a technique called beam emission spectroscopy that tracks the movement of turbulent eddies, they were able to infer the corresponding flow fields, similar to inferring wind speed by watching cloud movement. These measurements confirmed many of the predicted properties of these flows and were complemented by measurements in the CSDX experiment at the UCSD.

Recent experiments by a research team from UCLA show that "short" wavelength turbulence clearly exists in tokamaks, that the level of this turbulence increases as the electrons are heated, and that the changes in turbulence level correlate with changes in electron heat transport. By contrast, the larger scale, long wavelength turbulence did not change. Understanding small-scale plasma turbulence may hold the key to controlling heat transport in future fusion power experiments. These new observations were made possible by advanced microwave and far-infrared diagnostic systems developed by the UCLA team.

When Dense Plasmas Collide. Astrophysical processes such as supernovae explosions and pulsar wind outflows are often associated with regions of colliding plasmas.



Two rapidly expanding plasma bubbles collide.

Although we cannot create these extreme conditions in a laboratory experiment, a detailed study of interpenetrating dense plasmas can shed light on some of the processes involved. These include magnetic turbulence and the generation of intense localized magnetic fields, electron beams and ion jets, three-dimensional current systems, and magnetic field line reconnection.

In an ongoing basic plasma study performed in the Large Plasma Device (LAPD) the collisions and their aftermath can be studied in great detail. Two carbon targets immersed in a magnetized helium plasma were simultaneously struck by powerful lasers. The plasma and the laser pulses are highly reproducible. Full three dimensional data was acquired for up to a million experimental shots.

In addition to Alfvén waves, lower hybrid, whistler, and ion acoustic waves were observed, all on different timescales and spatial scales. Basic plasma experiments such as this permit highly detailed space-time exploration of phenomena that are related to astrophysical situations. Dimensionless parameters such the magnetic Reynolds number, normalized expansion speed etc., can be used to scale

DPP MEETING continued on page 6

Washington Dispatch

A bimonthly update from the APS Office of Public Affairs

ISSUE: Science Research Budgets

Since the October Washington Dispatch, there has been little movement on the FY07 appropriations bills, except for Defense and Homeland Security. See the chart below for specifics. With Democrats having taken control of both Houses of Congress, action on the remaining bills has been deferred. Unless Congress elects to consider the bills in a December session, the federal government will operate under a Continuing Resolution until February 2007.

Account	FY04 ($B)	FY05 ($B)	FY06 ($B)	FY07 Request		Congress			
				($B)	% Change	House ($B)	Senate ($B)	FY07 Enacted ($B)	% Change
DOE Science	3.48	3.64	3.60	4.10	+14	4.13	4.24*	--	--
NSF	5.61	5.48	5.58	6.02	+7.8	6.02	5.99*	--	--
NIST STRS	0.34	0.38	0.40	0.47	+18	0.47	0.47*	--	--
DOD 6.1	1.36	1.49	1.47	1.42	-3	1.56	1.48	1.54	+ 4.8
DOD 6.2	4.35	4.79	5.17	4.48	-13	5.25	4.81	5.21	+ 0.8
NASA Science	NA	5.50	5.25	5.33	+1	5.41	5.4*	--	--

* Awaiting floor action (11/1/06)

For details of the FY07 budget process, go to http://www.aaas.org/spp/rd/fy07.htm

ISSUE: Panel on Public Affairs Update

At the October 20th meeting of the APS Panel on Public Affairs (POPA) several topics for future action of the committee were discussed. These topics include: a look at Nuclear Forensics technology and techniques; a study of the viability of the United States Nuclear Workforce; and a look at a CO_2 reduction study. These topics will be examined in detail during the February POPA meeting to determine which issues warrant a POPA study.

POPA is an APS standing committee that is charged with advising the Council and officers of the Society in the formulation of APS positions on public policy issues that have a technical dimension of interest to physicists. POPA also investigates the desirability of APS-sponsored expert studies on physics-related topics of importance to society and helps to organize such studies.

ISSUE: POPA Electricity Storage & Interim Nuclear Waste Storage Studies

The APS Panel on Public Affairs plans to complete its two current reports by the next meeting in February, and in time for the new, 110th Congress.

Log on to the APS Web site (http://www.aps.org/policy/index.cfm) for more information.

APS Establishes New Committee On Informing the Public

In June, the APS Executive Board approved the establishment of an ad hoc Committee on Informing the Public, intended to provide oversight of the Society's public outreach and media relations activities. Committee members will also suggest possible future activities, approaches, and outreach opportunities, as well as possible external funding sources.

For the last decade, the APS has been involved in physics outreach activities designed to bring the excitement of physics to the general public, such as the Physics Central website. However, with last year's World Year of Physics celebration, the Society's efforts in this arena have increased substantially. For example, a new ongoing project targeting middle schools, called Physics Quest, has continued beyond the official World Year of Physics.

"A public well-informed about physics and related science is essential for the well-being both of the physics profession and society at large," said APS Associate Officer Alan Chodos of the rationale for having such a committee. "A scientifically well-informed and appreciative public reflects itself in policy choices in Washington, and in a clear understanding of what should and should not be taught in the science classroom. Better motivated and better educated students will also go on to contribute significantly to the economic health and security of the nation."

Chaired by Philip "Bo" Hammer, Vice President of The Franklin Institute Science Museum, the Committee on Informing the Public will review and assess the current portfolio of APS outreach activities and recommend which to expand or contract, and suggest new directions as appropriate. Since it is a new committee, the members will also draft a mission statement summing up the Society's goals in its efforts to inform the public.

"The future of physics depends on two things: our ability to inspire the next generation of researchers, and on the generous support of tax-paying public who enable our great work," said Hammer. "APS has a wide array of successful activities that inform children and adults about the great physics we do, but in a world of YouTube, MySpace, and i-this and i-that, we need to be much more savvy about how we compete for people's time, interest, and good favor. We hope our committee will help APS do an even better job."

The other members of the committee include Sean Carroll (California Institute of Technology); Paul Chaikin (Princeton University); Dan Dahlberg (University of Minnesota); Lawrence Gladney (University of Pennsylvania); Laura Greene (University of Illinois); Ivan Schuller (University of California, San Diego), and Gian Franco Vidali (Syracuse University).

COUNCIL continued from page 1

ing to an engineering design and cost basis for the International Linear Collider project; and

- Further urges the Administration and Congress, to offer to site such a project in the United States, if the outcome of the research and development effort is satisfactory."

The full text of the APS statement on the ILC is available online at http://www.aps.org/policy/statements/06_04.cfm

Acting on the recommendation of the APS Committee on Careers and Professional Development, Council also passed an updated statement on Career Options for Physicists, which the Committee will use as a launching point to provide specific advice, and supporting documentation, to build a case for broader student advising that reaches beyond the traditional academic tracks. The statement reads:

"Degrees in physics have proved to be, and will continue to be, an excellent platform for success across a wide range of career options in the private sector, government, academia, and K-12 education. Physics departments are urged to examine their programs in the light of scientific opportunities, societal challenges and broadly available careers. Preparation should include educational experiences beyond those traditionally considered, including independent research in the undergraduate setting, verbal and written communication skills, teamwork, ethics, and exposure to mentors from outside the academic setting."

Letters

Hydrogen Is Not the Answer

Senator Domenici (*APS News* Back Page, October 2006) was correct on many of the energy issues he covered, but his advocacy of the administration's hydrogen program raises problems. Since the major source of hydrogen in the foreseeable future is the dissociation of water, we must inquire: what is the energy source for the dissociation factory? In an energy-independent state, until enormous discoveries are made, the source will be combustion of coal.

What we will have done is moved the atmospheric pollution of hydrocarbon-based vehicles from urban areas to suburban areas. The effect on climate and atmosphere remain equal. In addition we have placed a potentially explosive tank of high pressure hydrogen on every hydrogen-equipped vehicle, and have created a nightmare for hydrogen distribution and dispensing.

One of the alternatives is the acceleration of the development of liquid coal and biomass. The technology behind the process has been around since the 1920's, and with increased funding could provide a source of gasoline-like fuels for several hundred years. In the meantime we would have the time to develop next generation technologies without bankrupting the nation.

Jerome Eckerman,
Potomac, MD

No Natural Definition of "Natural"

Some of those who contend that science must limit itself to "natural" explanations, including Lawrence M. Krauss (*APS News* Back Page, April 2006), provide no definition for the term. Others disagree with one another about its meaning, for example: Such notable defenders of science as Paul Kurtz and Eugenie Scott say that a "natural" explanation is one based on concepts like matter and energy. This constitutes an unwise limitation on future theories, requiring that they resemble currently accepted ones. Where would we be if Einstein and the founders of quantum mechanics had similarly tied themselves to the past?

Alan D. Franklin (Letters, October 2006) defines the term differently, asserting that "natural" equates to experimentally testable. This of course guarantees that science is "natural," but what benefit follows from assigning a new name to an old concept?

I suggest that it matters little whose definition is accepted, because science can be fully characterized using Occam's razor, assumptions about "naturalism" being entirely superfluous.

John G. Fletcher
Livermore, CA

Don't Demonize Fundamentalists

Alan Franklin's letter ("Unnatural Causes Don't Exist," *APS News*, October 2006) writes that "Only a small subset of religious thought, the fundamentalist believers in a personal God, active in human affairs..., is represented in the challenge to the theory of evolution."

I believe that in any poll, this "small subset" of "fundamentalist believers in a personal God, active in human affairs" would include at least half the U.S. population. It would also include Abraham Lincoln in his Second Inaugural Address–possibly the greatest speech ever given in America. Rather than demonizing "fundamentalists," we need to nurture public support.

James E. Felten
Greenbelt MD

Clarification Eases Visa Procedure

Travelers applying for a visa to travel to the United States are not required to leave their passports with the U.S. Consular Office while waiting for visa processing. This is a clarification, not a change in the regulations.

APS has heard of instances where physicists have been unable to travel for long periods while their passport is held at the U.S. Consular Office during the visa application process. Amy Flatten, APS Director of International Affairs, has now obtained clarification of the procedure from a State Department official.

According to the State Department, passports must be submitted when applying for a visa. In some cases, the consular office retains the passport while the visa application is being processed so that the visa may be issued as soon as any required clearances are completed. However, this is not a requirement. Consular officers do not need to keep the passport during visa processing, and travelers should feel free to ask for their passports back. Visa applicants would then need to return their passport to the consular office once they are cleared so that the visa can be issued. Requesting one's passport back will not cause any delay in visa processing, and there is no reason a traveler should defer or miss travel while their visa is being processed. Physicists who want documentation of the regulations to bring to their visa interview can visit www.aps.org/programs/international/visa/passport.cfm

zero gravity

The Lighter Side of Science

The 2006 Ig Nobel Prizes

On October 5, the 2006 Ig Nobel Prizes were awarded at Harvard University's historic Sanders Theatre. Nearly 1200 spectators were on hand to revel in a ceremony filled with cheese, mosquitoes, opera singers, paper airplanes, and inertia. The event was broadcast live on the Internet, and can be seen in recorded form at http://www.improbable.com.

ORNITHOLOGY

Ivan R. Schwab, of the University of California, Davis, and the late Philip R.A. May of the University of California, Los Angeles, for exploring and explaining why woodpeckers don't get headaches.

NUTRITION

Wasmia Al-Houty of Kuwait University and Faten Al-Mussalam of the Kuwait Environment Public Authority, for showing that dung beetles are finicky eaters.

PEACE

Howard Stapleton of Merthyr Tydfil, Wales, for inventing an electromechanical teenager repellent–a device that makes annoying noise designed to be audible to teenagers but not to adults; and for later using that same technology to make telephone ringtones that are audible to teenagers but not to their teachers.

ACOUSTICS

D. Lynn Halpern (of Harvard Vanguard Medical Associates, and Brandeis University, and Northwestern University), Randolph Blake (of Vanderbilt University and Northwestern University) and James Hillenbrand (of Western Michigan University and Northwestern University) for conducting experiments to learn why people dislike the sound of fingernails scraping on a blackboard.

MATHEMATICS

Nic Svenson and Piers Barnes of the Australian Commonwealth Scientific and Research Organization, for calculating the number of photographs you must take to (almost) ensure that nobody in a group photo will have their eyes closed.

LITERATURE

Daniel Oppenheimer of Princeton University for his report "Consequences of Erudite Vernacular Utilized Irrespective of Necessity: Problems with Using Long Words Needlessly."

MEDICINE

Francis M. Fesmire of the University of Tennessee College of Medicine, for his medical case report "Termination of Intractable Hiccups with Digital Rectal Massage"; and Majed Odeh, Harry Bassan, and Arie Oliven of Bnai Zion Medical Center, Haifa, Israel, for their subsequent medical case report also titled "Termination of Intractable Hiccups with Digital Rectal Massage."

PHYSICS

Basile Audoly and Sebastien Neukirch of the Université Pierre et Marie Curie, in Paris, for their insights into why, when you bend dry spaghetti, it often breaks into more than two pieces.

CHEMISTRY

Antonio Mulet, José Javier Benedito and José Bon of the University of Valencia, Spain, and Carmen Rosselló of the University of Illes Balears, in Palma de Mallorca, Spain, for their study "Ultrasonic Velocity in Cheddar Cheese as Affected by Temperature."

BIOLOGY

Bart Knols (of Wageningen Agricultural University, in Wageningen, the Netherlands; and of the National Institute for Medical Research, in Ifakara Centre, Tanzania, and of the International Atomic Energy Agency, in Vienna Austria) and Ruurd de Jong (of Wageningen Agricultural University and of Santa Maria degli Angeli, Italy) for showing that the female malaria mosquito *Anopheles gambiae* is attracted equally to the smell of limburger cheese and to the smell of human feet.

INTERNATIONAL News

...from the APS Office of International Affairs

The International Atomic Energy Agency: Fifty Years of International Science (and Other Things)

By Mark Goodman

The International Atomic Energy Agency has been much in the news of late, particularly for its nuclear verification activities in Iran, Iraq, Libya and North Korea. This newfound prominence earned the IAEA and its Director General, Mohamed ElBaradei, the Nobel Peace Prize in 2005.

Now often described as the "UN nuclear watchdog," the IAEA first came into the public eye fifteen years ago with its earlier investigation of Iraq's clandestine nuclear weapons program. But its broader missions, including nuclear science and technology and international development, are less well known.

The IAEA was the 1953 brainchild of President Eisenhower. The earliest efforts at international nuclear control had ended in failure. The Acheson-Lilienthal Report and Baruch Plan of 1946 had called for full international control of all aspects of nuclear energy, but were mired immediately in Soviet opposition. In 1949, the first Soviet nuclear test dashed hopes for halting the spread of the nuclear genie.

Eisenhower's vision, presented in his December 1953 Atoms for Peace speech to the UN General Assembly, was to take fissionable material from weapons programs and use it for peaceful nuclear energy. An international Atomic Energy Agency would receive materials and make them available under strict safeguards. It would, Eisenhower said, "encourage world-wide investigation into the most effective peacetime uses of fissionable material."

This proposal led to a series of large international conferences in Geneva to discuss the science and politics of peaceful uses of nuclear energy. One result was the Statute of the International Atomic Energy Agency, an international treaty like the Charter of the United Nations. The IAEA was born when this treaty entered into force in July 1957 and is now approaching its fiftieth anniversary. The IAEA mission, according to its Statute, is to "seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose."

To fulfill this mission, the Statute gives the IAEA a broad mandate in the international scientific arena, including:

- "To encourage and assist research on, and development and practical application of, atomic energy for peaceful uses throughout the world,"
- "To foster the exchange of scientific and technical information on peaceful uses of atomic energy," and
- "To encourage the exchange of training of scientists and experts in the field of peaceful uses of atomic energy."

The benefits of nuclear energy have their roots in physics, and some of the IAEA's work remains close to these roots. The IAEA is one supporter–along with UNESCO and the Italian government–of the Abdus Salam International Center for Theoretical Physics (ICTP) in Trieste, Italy. The mission of the ICTP is to promote theoretical physics research–particularly in the developing world.

Aside from the ICTP, however, the IAEA is not generally in the business of sponsoring physics research. Given its mission and its limited budget, the IAEA focuses its support for nuclear science on enhancing cooperation and information sharing "to increase Member State capabilities in the development and application of nuclear science as a tool for their

ATOMIC ENERGY continued on page 5

LOS ALAMOS continued from page 1

worked as an archivist transferring paper documents to electronic form and indexing them. Lab officials have declined to comment on the details of the ongoing investigation in this incident.

In an interview with *APS News* shortly before this incident occurred, Anastasio said that he felt the lab was moving in the right direction. "We're very pleased with how things are moving forward," he said. "We've made some significant strides in safety and security." Anastasio said that his message to employees on safety and security has been to emphasize personal responsibility. He said he believes this approach has been successful. "If you look at our statistics, albeit for four months, the trends are all very positive," he said.

After the drug raid, Anastasio said in a statement, "This is a serious matter, and we are taking immediate steps to address it."

Susan Seestrom, Associate Director for Experimental Physical Sciences at LANL, said that security had been given increased emphasis under the new management. Many small improvements have been made, some of which started before the new management took over, she said. For instance, the lab has been working to get rid of removable media such as thumb drives, she said. "We're trying to put in things that lessen potential for human error. We've seen a downturn in the most serious security incidents," she told *APS News* shortly after this recent incident. Seestrom is chair of the APS Division of Nuclear Physics.

However, not all employees have noticed significant change. Brad Holian, a physicist who retired from the lab, but still works there part-time, said he hadn't noticed any major changes in the approach to security under the new management, but he did believe Anastasio would handle the incident better than previous management. "Anastasio seems to be a more reasonable and calm individual," said Holian. He points out that Los Alamos' record of safety and security has been similar to that of Lawrence Livermore and Sandia National Labs, but that Los Alamos has received much more publicity.

Although security has been the dominant issue in recent weeks, the new management has faced several other problems as well.

Employee morale had been low leading up to the change in management, due in part to uncertainty about practical matters such as employee benefits, as well as concern over whether the new management would be supportive of science.

Anastasio said that it will take time for the new management to earn the employees' confidence, but that he believes morale has been improving as some of the concerns over practical matters have died down. "I believe communication is really key for the employees. When there's a lack of information, that generates a lot of anxiety," he added.

Seestrom also saw some improvement in employee morale, though she admitted it was spotty. "Where people are really making progress in their technical work, their morale is pretty good. I see a lot of energy in the scientific workplace," said Seestrom.

Holian was less upbeat. "I would say that there's still a sense of demoralization and uncertainty on the part of the staff," he said. Holian has spoken up before against some management decisions and some decisions imposed by Congress and the DOE, but says he is not critical of the lab's scientific staff.

Another physicist who has worked at Los Alamos for many years, who spoke with *APS News* on the condition of anonymity, said he hadn't noticed any significant change under the new management. "The one thing I have seen is that there are more managers. The research environment is about the same," he said. Bureaucratic hassles, including large amounts of paperwork and time-consuming but irrelevant training, continue to make it difficult to do research, he said.

Several other scientists contacted by *APS News* either did not return requests for comment or declined to comment on the record.

Another issue the new management has had to deal with is new expenses. While Congress is expected to keep the budget for LANL approximately flat, new expenses, including taxes, greatly increased management fees, salary increases, and retirement benefits, have led to a budget shortfall of about $175 million.

Anastasio said he will deal with the issue through efficiencies, and by reducing the contract workforce. Fees for the lab's customers will not increase, and there will be no cuts among the regular laboratory staff, though some projects might have to be scaled back, he said. Seestrom said she believed the budget crunch would force the lab to be more efficient.

High overhead costs had already been making it difficult for scientists to obtain outside funding for their research, said the scientist who requested anonymity. "My hopes when the new management came in were high. I thought they would lower overhead and make us more efficient. Unfortunately I haven't seen any evidence of that to date."

Some scientists at the lab have worried that the new management company might not be as supportive of science as they would like, or that Congress or the DOE would push the lab towards more weapons manufacturing at the expense of basic research.

Both Anastasio and Seestrom emphasized that the management supports science. "I see really strong support from management for science in the lab," Seestrom said.

Some employees are uncertain. "They say golden words. Anastasio honestly hopes to promote science," said Holian. However, Holian and other scientists worry that with the current budget situation and a lack of support for science in Congress, the lab management may not be able to promote science.

Seestrom says that the weapons program helps generate good science. "There's a very strong manufacturing component to what we're doing at the lab," she said. "That enterprise supports a lot of basic materials science for our laboratory. We develop new processes for them, and so that keeps us at the forefront of that part of materials science."

Anastasio believes that in the future the lab will continue its mission, which includes not just nuclear weapons, but national security in a broader sense. "I see the laboratory to be a great national security science laboratory. That's my vision. Clearly it encompasses our traditional core mission which is sustaining the US nuclear deterrent. But it also means missions we have in nonproliferation and countering terrorism," he said. "In the future, I think it will mean national security in the sense of economic security, and the interrelationship with energy and the environment and the economic health of the country."

Recruiting scientists to the lab has always been difficult, in part because of its isolated location. "This important mission, as well as the great scientific staff and facilities, can help attract the best scientists to work at the lab," says Anastasio. "We can work on national scale issues that can affect the whole country. So having a really important mission and challenge to work on is a strong attractor."

The physicist who preferred not to be named also said that a dedication to the lab's mission attracted scientists to the lab. "People I work with have a strong commitment to doing work that matters to the country. They believe in what we're doing and why we're here," he said. However, he added, "If I were a young person I would not seriously consider coming here. It's a different place than it was a decade ago."

Holian said that despite problems, there are still pockets of quality at the lab. "People do carry on good work in spite of the trouble," he said.

ATOMIC ENERGY continued from page 4

economic development."

In physics, the IAEA has coordinated projects on neutron sources –both research reactors and accelerators–aimed mainly at helping countries make the best use of those facilities both for research and for isotope production. The IAEA maintains an extensive database both of scientific literature (including atomic, nuclear and radiation physics, plasma physics and particle physics) and a wide variety of nuclear and atomic physics data, all available at no cost to IAEA member states and often to the general public. The IAEA also recently agreed to provide administrative support for the International Thermonuclear Experimental Reactor (ITER).

Like any international organization, the IAEA is a creature of its member states, the vast majority of whom are developing countries. A relatively small number of those countries are interested in direct uses of nuclear energy, either through nuclear power or through research facilities such as reactors, accelerators and tokamaks. But every member state can benefit from the application of nuclear techniques to the problems of economic and social development. This is why the IAEA has focused much of its effort on the development, refinement and application of those techniques.

The IAEA has chosen to focus on the use of nuclear techniques where they offer a comparative advantage in meeting the development needs of its member states: food and agriculture, medicine and health, water resources, and the marine and terrestrial environment. In medicine, for example, nuclear techniques are central to radiology, nuclear medicine and radiation therapy, as well as research using bio-chemicals tagged with radioisotopes. Skill in applying knowledge of the interaction and absorption of ionizing radiation with matter is essential for health physics, to protect patients and to ensure proper radiation doses.

Building on its programs in radiation therapy, the IAEA recently undertook a new cancer therapy initiative called PACT, which is both an acronym (for Program of Action on Cancer Therapy) and a description of how the IAEA operates–through partnerships with other organizations. The IAEA has expertise in some of the techniques necessary for diagnosing and treating cancer, but is far from having a comprehensive approach to the problem.

PACT is a partnership with the World Health Organization, the International Union Against Cancer (representing over 200 organizations worldwide) and others.

The IAEA is also seeking the support of philanthropic and development organizations to meet this rapidly growing need. The roughly $150 million the IAEA has spent over the last 25 years to improve its member states' capabilities in radiation therapy is but a drop in the bucket for a disease that kills over 7 million people a year. Over half of new cases are in the developing world.

In another example of the use of nuclear techniques for development, the IAEA was a pioneer in research, development and application of the sterile insect technique (SIT) for pest control. The SIT uses radiation to sterilize large numbers of male insects; when sterile males mate with fertile wild females, the result is a form of birth control.

As with other methods of insect control, the SIT tends to result in temporary and localized success, followed by re-infestation. However, in one case, the IAEA was able to eradicate completely the tsetse fly from the island of Zanzibar. Tsetse flies carry sleeping sickness, a parasitic disease that affects both humans and particularly cattle. Controlling tsetse flies can lead to healthier, more productive cattle herds and significantly improve the welfare of subsistence herders. The IAEA is now working on a similar project in certain areas of Ethiopia where the tsetse fly is endemic, hoping that their relative isolation will lead to success similar to that in Zanzibar.

The IAEA has also applied the SIT to combat fruit flies in the Middle East and screwworm in the Caribbean, and has begun an effort to control malaria-bearing mosquitoes. As with PACT, IAEA activities in insect control depend on partnerships with other organizations, including the UN Food and Agriculture Organization and development organizations such as the African Development Bank.

There is something of a role reversal in the area of nuclear verification, where the IAEA depends on the technical capabilities of its member states for the technical capability to carry out its responsibilities to apply "safeguards" (a combination of verification inspections and material accountancy) to nuclear material (mainly uranium and plutonium) in peaceful nuclear activities worldwide. Much of the equipment the IAEA uses to monitor nuclear facilities and measure the inventory and flow of nuclear material was developed by member states through Member State Support Programs (MSSPs). The United States has by far the largest and most diverse MSSP, and much of the IAEA's instrumentation was originally developed through the U.S. Support Program by the Department of Energy's National Laboratories, although other countries are playing an increasing role in developing and refining safeguards technology.

As it encounters new verification challenges, particularly the challenge of detecting undeclared nuclear activities and materials, the IAEA relies on MSSPs for the development of new techniques. One of the most successful of these has been the use of environmental sampling and analysis, often using highly sensitive techniques to analyze individual particles in swipe samples taken at declared or suspected nuclear facilities. This technique was instrumental in detecting North Korean cheating on its safeguards agreement in the early 1990s, and has been critical in investigating safeguards violations by Iran and Libya.

The IAEA is now looking ahead at other possible verification techniques, such as noble gas sampling, antineutrino monitoring and the use of hyperspectral commercial satellite imagery, and is seeking the help of MSSPs to evaluate their promise in meeting current and future challenges.

The IAEA is a diverse organization with many accomplishments, not just as a "nuclear watchdog" but also as an engine of international development. But as much as been accomplished over the past 50 years to advance President Eisenhower's vision, much remains to be done to realize his vision of a world where fear of nuclear warfare has receded and nuclear energy is known primarily for its contributions to international peace, cooperation and human development.

Mark Goodman is a physicist in the State Department's Office of Multilateral Nuclear and Security Affairs, which is responsible for US policy toward the IAEA.

CAMPAIGN continued from page 1

• PhysicsCentral Website–provides outreach to the public showing that physics is both exciting and important.

Volunteers leading the campaign include Gordon Moore, founder of Intel, as Honorary Chair; Craig Barrett, Chairman of Intel, as Vice Chair; William Brinkman, Princeton University, as Campaign Executive Advisor, and 31 Nobel Laureates.

For more information, contact Darlene Logan, APS Director of Development, at (301) 209-3224 or logan@aps.org

DPP MEETING continued from page 3

these. (Often these numbers are estimated in astrophysics and cannot be measured). The scaling is never exact but a great deal can be learned in the laboratory, and this can serve as a guide to astronomers and plasma astrophysicists.

Blowing Magnetic "Bubbles." Researchers at the Princeton Plasma Physics Laboratory have successfully used Coaxial Helicity Injection (CHI) to generate plasma current at the National Spherical Torus Experiment (NSTX). While the CHI method has previously been studied in smaller experiments, such as the Helicity Injected Tokamak (HIT-II) at the University of Washington, the results from the much larger NSTX demonstrate the exciting potential of this method on a scale much closer to that of a fusion reactor.

The generation of the plasma current by CHI involves a process called magnetic reconnection, which is also involved in the eruption of solar flares on the surface of the sun. In magnetic reconnection, the magnetic "film" is initially attached to the edges of a gap with opposite polarity, like the north and south poles of a magnet. Once adequately stretched, the magnetic field has a tendency to attract and reconnect, leading to the formation of a doughnut-shaped magnetic bubble.

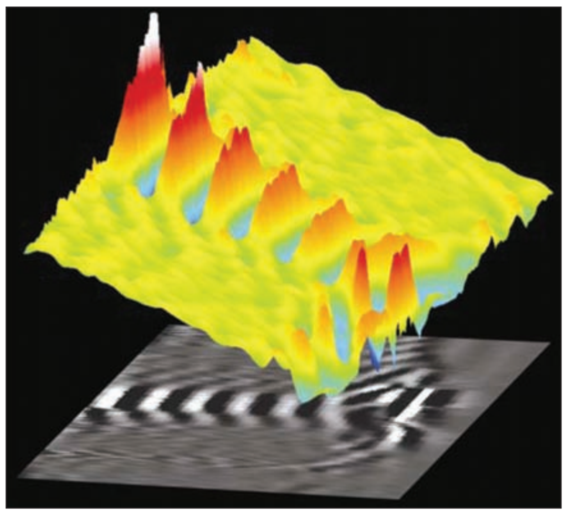
This process of reconnection has been experimentally controlled in NSTX to allow this potentially unstable phenomenon to reorganize the magnetic field lines to form closed, nested magnetic surfaces in the shape of a doughnut carrying a plasma current up to 160,000 Ampères. This is a world record for non-inductive closed-flux current generation, and demonstrates the high current capability of this method.

Surfing Electron Waves. Scientists at the Department of Energy's Lawrence Berkeley National Laboratory, in collaboration with researchers at the University of Oxford, have accelerated electron beams to energies exceeding a billion electron volts (1 GeV) in a distance of just 3.3 centimeters. The researchers anticipate that billion-electron-volt beams from laser wakefield accelerators will open the way to very compact high-energy experiments and superbright free-electron lasers. By comparison, the Stanford Linear Accelerator Center (SLAC) boosts electrons to 50 GeV over a distance of two miles (3.2 kilometers). The Berkeley Lab group and their Oxford collaborators achieved 1/50th of SLAC's beam energy in just 1/100,000th of SLAC's length.

The Berkeley Lab and Oxford researchers were able to increase the acceleration length by lowering the plasma density in order to increase the wake speed, and by using a capillary channel guide carved into sapphire to maintain the collimation of the laser beam. This is the first time a laser-driven accelerator has reached beam energies typically found in conventional synchrotrons and free-electron lasers.

The Berkeley Lab and Oxford collaborators are now working on injection, the insertion of an already energetic beam into an accelerating cavity, and on staging the hand-off of an energetic beam from one capillary to the next and subsequently to others, until very high energy beams are achieved. The researchers believe they can reach 10 GeV with an acceleration structure less than a meter long. These results are essential steps to realizing the potential of laser wakefield accelerators to provide high electron energies over distances much smaller than existing machines.

In addition, other experiments indicate that the duration of the high energy electron beams are tens of femtoseconds in duration, orders of magnitude shorter than existing machines, which will allow unique opportunities in ultrafast science. The waves are the fastest matter waves ever photographed, clocking in at about 99.997% of the speed of light, close to 1 billion miles per hour, and give rise to enormous electric fields, reaching fields higher than 100 giga-electron volts/meter (GeV/m).



Images of a wakefield produced by a 30 TW laser pulse in plasma of density 2.7 x 10^{18} cm^{-3}. The color image is a 3D reconstruction of the oscillations, and the grey-scale is a 2D projection of the same data. These waves show curved wavefronts, an important feature for generating and accelerating electrons that has been predicted, but never before seen.

Melting Diamond. Diamond is one of the materials being considered as an ablator material in the design of fuel capsules for inertial confinement fusion (ICF) experiments at the National Ignition Facility. ICF uses high-powered lasers to vaporize a target capsule containing fusion fuel, creating an implosion that compresses the fuel in the capsule to the temperatures and pressures necessary for fusion. Understanding diamond's shock melting properties is critical to designing capsules and radiation drive pulse-shapes that minimize microstructure effects from mixed solid and liquid phases during this implosion phase.

In most materials this shock melting pressure is a few million times atmospheric pressure. In diamond the shock melting pressure was found to be remarkably high; a shock wave strength of 6-7 Mbar was required to reach the onset of melting in diamond. Furthermore, for shock strengths between about 6 and 10 Mbar the resulting material was a mixture of molten carbon and solid diamond. Shock strengths of greater than 10 million times atmospheric pressure were required to fully melt the diamond upon shock compression.

This 3-4 Mbar coexistence region observed for diamond, the pressure regime where the shocked state lies on the melt line, is extraordinarily large. In comparison, the coexistence region for beryllium, another candidate capsule ablator material, was found to be approximately 0.5 Mbar, with the onset and completion of melt at about 2.1 and 2.6 Mbar, respectively. The high pressures required to achieve complete melting in diamond and the very large coexistence region place significant constraints on the design of ICF capsules with diamond ablators.

"Unsociable" Electrons. It is a common assumption that electrons with different energy in plasma "socialize" due to collisions and form an equilibrium Maxwellian electron velocity distribution function (EVDF). Recent experimental, theoretical and numerical studies revealed that this assumption is, in general, incorrect. In low-pressure discharges, electrons do not have time to "socialize"; they retain their "differences" according to origin and individual life-time experience. As a result, for the first time, it has been demonstrated that the EVDF is noticeably anisotropic.

The "unsociability" of electrons in low-pressure plasma devices makes them a remarkable tool for many applications, because it gives the opportunity to selectively control populations of electrons with different energies. Understanding and controlling the electron population help material processing, high-intensity lighting, electric propulsion, and other such devices.

Metallic Water. Scientists at Sandia National Laboratories have significantly altered the theoretical phase diagram of water at high energy densities. Their computational study shows that an electronically conducting phase of water could occur at a temperature of 4000 K and a pressure of 100 GPa, which is significantly lower than the previous estimates (7000 K and 250 GPa, respectively).

In addition, the superionic phase of water (with frozen oxygen atoms and mobile hydrogen atoms) is demonstrated to extend to higher temperatures than previously concluded and, on a pressure versus temperature phase diagram, directly borders the conducting phase. Importantly, these revisions are in the region of the phase diagram that corresponds to conditions that exist inside giant planets like Neptune and could have significant consequences for planetary models.

The motivation driving the research is the desire to better understand, from basic physics principles, conditions on Sandia's large pulsed-power Z machine which uses water as both an insulator and a breakdown dielectric for switching. The study significantly expands the range where water's electrical conductivity is known, enabling more accurate simulations of the extreme environments encountered during operation of the Z accelerator.

The Z machine is currently in the process of being upgraded, a large project which is to be completed in July 2007. With new capacitors, the expected amperage sent through the machine to a target placed at its hub is expected to rise from 20 million to 26 million amps. Compression of Z's amperage in time is the cause of its huge power–equivalent to 50 times the electrical production of all the generating plants on Earth, albeit for a few nanoseconds.

MuCap Results, Nucleon Spin Structure Highlight 2006 DNP Meeting

To a non-scientist, nuclear physics calls to mind atomic bombs and power plants. However, physicists know that the field encompasses a much wider range of topics, from fundamental research on muon capture reaction rates and nucleon spin structure, to more practical applications such as particle radiotherapy, using gas-electron multipliers to inspect cargo containers, and non-destructive elemental analysis of paintings and metal artifacts.

Those were just a few of the highlights during the 2006 annual meeting of the APS Division of Nuclear Physics held October 26-28 in Nashville, Tennessee. In addition to the technical program, Friday evening's banquet included a dash of local color with a performance by the acclaimed Nashville band Brazilbilly. Meeting program notes described their music as "an eclectic blend of traditional country roots with a unique Latin flair."

MuCap First Results. Peter Kammel (University of Illinois, Urbana-Champaign) reported on the first results obtained from data analysis of the MuCap experiment, designed to measure specific muon capture reaction rates. This has been a controversial area for the last 30 years, since prior experimental results were subject to large uncertainties in the data interpretation. By combining novel detector techniques, the MuCap experiment managed to overcome many of the problems that plagued earlier efforts. According to Kammel, the data "surpass all previous experiments both in statistics and in reduction of systematic uncertainties."

Nucleon Spin Structure. The exploration of the spin of the proton and its relation to the angular momenta of the quark and gluon constituents is still a classic topic of nuclear physics, according to Marco Stratmann (RIKEN), who gave an overview of our present understanding, theoretical concepts, and recent developments of the field. Those developments include new results on single-spin asymmetries obtained with semi-inclusive deep inelastic scattering and polarized pp-scattering tools, as well as results from new experiments conducted at Jefferson Lab enabling physicists to study various aspects of nucleon spin structure. Furthermore, experiments by HERMES, COMPASS and at RHIC are underway to determine the polarization of gluons within spin-polarized protons.

Gas Electron Multipliers. The latest innovation in micropattern gaseous detectors is the gas electron multiplier (GEM), developed at CERN by Fabio Sauli and introduced a few years ago. GEMs have proved valuable for fast tracking at numerous high energy physics experiments because of their excellent high rate capabilities. According to Sauli, they've been used as end-cap detectors in time projection chambers, and also as a hadron-blind detector at Brookhaven. Enhanced with a photosensitive layer, GEMS can detect and localize single photons, and they have also found use in neutron detection, and for measuring x-ray polarization in astrophysics.

On a more practical level, Tony Forest of Idaho State University has been developing a system to image cargo containers in order to detect small shielded radioactive cargo. Current cargo container inspection systems use gamma rays or x-rays with resolutions designed to detect contraband, but these may suffer from false alarms due to naturally radioactive cargo. It is even more difficult to detect small shielded radioactive elements. GEM-based imaging systems could address those challenges.

Proton Radiotherapy. Radiation has been used in medical applications since it was first discovered, and the advent of higher energy particle accelerators in the latter half of the 20th century made it possible to use mega-voltage (MV) X-rays to deliver high doses of radiation to treat malignant cancers. Those doses must be limited, however, because they also severely damage surrounding tissue. In many cases, according to Jonathan Farr (Indiana University), "heavy" particle radiotherapy using protons and light ions can be a desirable alternative, allowing either a higher dose of radiation, or maintaining the same dose with less collateral damage to healthy cells. The latest advances in such systems are making treatment with fast protons more widespread. More than 20 facilities now operate worldwide, and several more are under construction.

PIXE Artifact Analysis. It can be difficult to do sample analyses of precious art objects because most techniques can cause some damage. In fact, sampling is often prohibited, because of the uniqueness and fragility of such valuable items. At the DNP meeting, Andrea Denker (Hahn-Meitner-Institut) discussed her work non-destructively analyzing ancient paintings and Bronze Age and medieval metal artifacts using proton-induced X-ray emission (PIXE). High energy protons with energies of around 60 MeV have a large range in the material being investigated, and can thus provide useful information from deep inside the object, complementing data obtained through other analytical methods, such as neutron autoradiography.

KADANOFF continued from page 2

He taught at the University of Illinois (1962-1969) and Brown University (1969-1978), before moving to the University of Chicago where he is John D. and Catherine T. MacArthur Professor of Physics and Mathematics.

The Lorentz Medal was established in 1926 by the Royal Netherlands Academy, in honor of the 50th anniversary of the doctorate of Hendrik Antoon Lorentz. The gold medal is awarded once every four years in recognition of important contributions to theoretical physics. Out of 19 previous Lorentz medalists, 11 went on to win the Nobel Prize.

ANNOUNCEMENTS

Meeting Briefs

• The APS Texas Section held its annual fall meeting October 5-7 at the University of Texas in Arlington. Invited speakers discussed a broad range of topics, including recent developments in superconductivity and light element systems; materials under pressure; excitonic superfluidity in quantum hall bilayers; applications of slow light physics; and plasmonics. Non-technical highlights included two planetarium shows, one on black holes, and the second on the "stars of the pharaohs." Friday evening's traditional banquet featured a special performance by actor and professor Dennis Maher of selections from Peter Parnell's play *QED*, based on the writings of Richard Feynman.

• That same weekend, the APS Four Corners Section also held its annual fall meeting at Utah State University in Logan, featuring a broad range of invited lectures from various physics subfields. Topics included modeling how space weather impacts Earth; the sustainable hydrogen economy; creating cold molecules; integrating nanotechnology; gravitational holography; the quantum universe; and imaging coherent electron flow in 2D gases. Friday evening's banquet speaker was NASA's Mary Cleaves, who gave an overview of some of the highlights of her agency's space program.

• The APS Northeastern Section held its annual fall meeting October 13-14 at the College of the Holy Cross in Worcester, Massachusetts. The technical program had an unusual focus: the physics of sports and athletics, with invited talks on the dynamics and kinematics of baseballs, baseball bats, footballs, dancers, the variability of sports records, and the effects of technology on sports. Speakers included Yale University's Robert Adair (*The Physics of Baseball*) and University of Nebraska's Timothy Gay (*The Physics of Football*). There were also technical talks on time's arrow, large momentum transfer collisions off simple atoms, and the kinematics of liquid crystals.

• Also holding its annual fall meeting October 13-14 was the APS Ohio Section, which convened at the University Akron/Wayne College in Orrville, Ohio. The technical program featured invited talks on Benjamin Franklin and the honor of Dutch seamen; elastic instabilities in rubber; adhesion of model polymer membranes; Raman spectroscopy of surfaces; and neutron reflection studies of confined polymers.

APS CONGRESSIONAL SCIENCE FELLOWSHIP 2007-2008

THE AMERICAN PHYSICAL SOCIETY is currently accepting applications for the Congressional Science Fellowship Program. Fellows serve one year on the staff of a senator, representative or congressional committee. They are afforded an opportunity to learn the legislative process and explore science policy issues from the lawmakers' perspective. In turn, Fellows have the opportunity to lend scientific and technical expertise to public policy issues.

QUALIFICATIONS include a PhD or equivalent in physics or a closely related field, a strong interest in science and technology policy, and, ideally, some experience in applying scientific knowledge toward the solution of societal problems. Fellows are required to be US citizens and members of the APS.

TERM OF APPOINTMENT is one year, beginning in September of 2007 with participation in a two-week orientation sponsored by AAAS. Fellows have considerable choice in congressional assignments.

A STIPEND of $50,000 is offered in addition to allowances for relocation, in-service travel, and health insurance premiums.

APPLICATION should consist of a letter of intent of approximately two pages, a list of key publications, a two-page resume, and three letters of reference. Please see the APS website (http://www.aps.org/policy/fellowships/congressional.cfm) for detailed information on materials required for applying and other information on the program.

ALL APPLICATION MATERIALS MUST BE POSTMARKED BY JANUARY 15, 2007 AND SHOULD BE SENT TO THE FOLLOWING ADDRESS:

APS Congressional Science Fellowship Program
c/o Jackie Beamon-Kiene
APS Executive Office
One Physics Ellipse
College Park, MD 20740-3843

Now Appearing in RMP: Recently Posted Reviews and Colloquia

You will find the following in the online edition of *Reviews of Modern Physics* at http://rmp.aps.org

Dynamical principles in neuroscience
Mikhail I. Rabinovich, Pablo Varona, Allen I. Selverston and Henry D.I. Abarbanel

One of the more challenging problems in nonlinear science is the goal of understanding the properties of neuronal circuits. This review covers the dynamical description of individual neurons, advances in understanding the emergent properties of circuits containing them, aspects of information transmission and processing, and the generation of spatiotemporal patterns related to learning and behavior.

NSF Seeks Deputy Director Physics Division

Application Deadline: December 8, 2006

See http://www.nsf.gov/publications/pub_summ.jsp?ods_key=s20070016c for details.

Professional Skills Development for Women Physicists

Do you want to improve your negotiation skills? Do you have great ideas that you want to communicate to your colleagues? If so, the **Committee on the Status of Women in Physics** invites you to attend one of the workshops entitled "Professional Skills Development for Women in Physics." These workshops will:

- Coach women in key skills that are needed to enhance their careers.
- Provide training in persuasive communication, negotiation, and leadership presented by experienced professionals, with an aim towards increasing the influence of female scientists within their own institutions.
- Provide a special opportunity for networking among participants.

Workshops in 2007 will be aimed at senior women physicists in industry and government labs. Workshops will be offered on Sunday, March 4 (Denver) and on April 13 (Jacksonville, FL) in association with the APS Annual Meetings. Deadline to apply for the March workshop is December 4, 2006 and January 10, 2007 for the April workshop.

Workshops will be limited in size for optimal benefits. Participants are eligible to receive a stipend to help cover the cost of travel and up to two nights lodging.

These workshops are funded by the National Science Foundation.

Details at http://www.womeninphysics.org and click on "Learn More" under Professional Skills Development.

Decker Finds the Physics in Building Graphite Guitar

Though it sounds like a major career shift to most people, going from doing plasma physics research in Boston to making graphite guitars in Hawaii has been a smooth transition for long-time APS member John Decker. There's a lot of physics in guitars, says Decker. He was even able to draw on some of his work in acoustic waves in plasma as he developed the RainSong Graphite guitar.

Decker earned a PhD in plasma physics in 1966. After receiving his PhD from Cambridge University, Decker worked as a research physicist for the Air Force, and then moved to the Sperry Rand Research Lab in Sudbury, Massachusetts, where his research focused on plasma stability. But just as he and his colleagues were celebrating the success of their project, they discovered that the effect they thought they had seen was an artifact of their apparatus. This effectively put an end to the entire area of research Decker had been working on.

He then worked at several other jobs, mostly in technical management, and even went into business for himself. In 1981, Decker moved out to Hawaii as manager of the Air Force's optical observatory.

The idea for RainSong Graphite guitars came about in 1985, when Decker, an amateur classical guitarist himself, became frustrated with the damage that Hawaii's extreme heat and humidity would do to an instrument.

He happened to attend an outdoor wedding reception, during which there was a sudden downpour. The shower caught the guitarist in a dilemma: should he run for cover, and risk angering the bride's family, or keep playing, and buy a new guitar in the morning?

Sympathizing with the guitarist, Decker had a brainstorm: he would make a waterproof guitar.

He did what any good physicist would do: he sat down and wrote out equations describing the sound in a guitar.

The equations were familiar from his earlier work on acoustic waves in plasma. "Magneto-acoustic waves, like the sound waves in a guitar soundboard, are funny acoustic waves that have different properties in different directions," he explains. In plasma, the direction is typically defined by the magnetic field; in the soundboard (top) of a guitar, the direction is typically defined by the grain direction of the wood. Properties such as acoustic velocity and stiffness are very different along and across the grain. "There's no explicit magnetic field terms in the equations for a guitar, but the rest of it I recognized," Decker says.

Setting out to imitate the qualities of a good spruce soundboard, Decker got data on the stiffness, density and other properties of wood, and figured out what composite materials would have similar properties. He quickly rejected most plastics (not stiff enough) and fiberglass (too heavy), before settling on "graphite" (a composite material of carbon fibers in an epoxy matrix).

John Decker

Once they had some potential materials, they had to listen to the sound. A human ear, even an untrained one, can easily distinguish a high quality guitar or violin from a junk one, but no instrument can tell the two apart, says Decker. "I'm an instrumentation specialist. It's what I've spent most of my career doing. And instrumentation is all but useless in making musical instruments. You can record a spectrum, you can record mode shapes on the soundboard surface, but it's basically the same for junk stuff and high quality stuff."

Decker also enlisted the help of a master guitar maker to show him how to make guitars himself. Decker's approach to the guitars had been scientific, but "he insisted that I couldn't just do it as a scientist or a businessman. I had to know how to make guitars with sawdust under my fingernails and lacquer in my hair," says Decker.

Producing the graphite guitars posed a number of technological problems, which took about ten years to fully iron out. RainSong Graphite Guitars now sells about 700 guitars a year.

Although Decker's original goal was to produce a weatherproof guitar, he realized that few people would buy an instrument solely for this property. "You sell them on the sound, pure and simple," he says. And it turns out that graphite has a really good sound.

Compared to a traditional wood guitar, a graphite guitar sounds clearer and brighter, especially at high frequencies. Above about a kilohertz, wood is highly damping, meaning that vibrational energy goes into heat instead of audible sounds, so the guitar sounds "muddy," Decker explains. "By the time you get to high harmonics on the high E string, what you hear is the attack, because the vibration of the top only lasts a few cycles, then damps out almost immediately."

Graphite, on the other hand, is much less damping, giving a graphite guitar a clearer sound, he says.

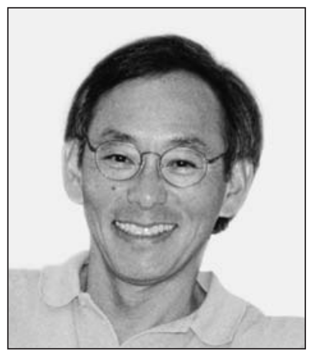
Having successfully developed and marketed the graphite guitars, Decker has now retired, leaving the day-to-day operations of the business to his son-in-law. Decker still plays classical guitar, and, somewhat ironically, now makes classical wood guitars in his workshop, by hand. He says he is now hooked on the challenge of trying to make a wood guitar with some of the properties of the graphite ones.

–Courtesy of Physics Central

The Back Page

The Road to Energy Security:
A Conversation with Steve Chu and Steve Koonin

Editor's Note: Steve Koonin is Chief Scientist of BP and Steve Chu is the Director of Lawrence Berkeley National Laboratory. The conversation was led by Francis Slakey, APS Associate Director of Public Affairs.



Steve Chu

Steve Koonin

Q: As a result of the spike in gas prices over the summer, petroleum analysts claimed that the US is facing an energy crisis. Are they right?

KOONIN: The world is not running out of energy any time soon. There are plenty of fossil fuel resources in the ground, and there are other large-scale sources such as nuclear, hydro, electric, and wind. Particularly for oil and gas, though, there are concerns about access to resources because a lot of the countries that hold resources are not as politically stable as one would like.

CHU: There is plenty of carbon-based fuel available for at least 400 years. Eventually, there is going to be a plateau in the production of oil, probably about mid-century. But there is not a problem with the fossil fuel energy supply of unconventional oil and gas. We won't run out of fossil fuel energy any time soon.

Q: Is energy independence a realistic goal? Or is energy security a more achievable goal?

KOONIN: "Energy independence" is the wrong phrase. The US is dependent on the rest of the world in many different ways and will remain so for the foreseeable future. The world is globalizing rapidly. "Energy security" is a much better phrase. This can be obtained, for example, by having a diversity of suppliers of a given type of energy, or by having the many different kinds of energy available to us. The fundamental problem is that most readily available and cheapest sources of energy are among the most polluting.

Q: Is the atmospheric concentration of CO_2 at crisis levels or at warning levels? If it flattened out in the next 50 years, would it be manageable?

CHU: Climate change could have some very significant impacts, and these risks should be weighed in decisions. One doesn't really have to say it is a certainty that these things will happen before you should be doing something. Just as we have health insurance, fire insurance, disaster insurance, we should be doing something to mitigate these risks. Once carbon is in the atmosphere, it circulates between the oceans and the land where the overall time it will take natural processes to recapture the carbon is hundreds of years. So the idea that you can wait and see what happens just to be very, very sure, given this long time constant, is not wise. You've got to do something now.

Q: The generation of electricity produces 40% of greenhouse gas emissions. Will sequestration technology lead to any significant reductions in emissions over the next few decades?

CHU: Carbon sequestration can make a very significant contribution, but sequestration is going to add cost to the generation of electricity. There is no technological addition that would make it cheaper than just venting CO_2. One cost which is hard to estimate at present will have to do with the regulatory environment, and possible resistance to pumping thousands of atmospheres of CO_2 underground –because there is a small chance it might leak. There are maybe a half a dozen small pilot projects going on now.

KOONIN: I believe that the technology can be developed to the point where it can reach the wholesale cost of electricity. It has yet to be demonstrated that the CO_2 will stay down in the brine reservoirs for the required time, but we have good reasons to believe that it will. There are also above-ground technical issues. You need to be operating a power plant coupled to a chemical plant. They have very different time constants and operating characteristics. But the urgency is such that one has got to start on these things very soon because power plants last for 40 or 50 years.

Q: Some critics believe that pursuing sequestration technology locks the country into coal-fired power plants and prevents aggressive development of renewables. Can sequestration and renewables peacefully coexist?

KOONIN: It is not sequestration versus renewables; it's sequestration *and* nuclear *and* renewables. The first two are the only technologies we know that can scale now to the magnitudes needed. Nuclear power is certainly a proven technology, and the incremental costs of the sequestration and nuclear are about the same. The fundamental problem is that all of these technologies cost more than just using the coal or the gas. While in the US and in Europe people will be willing to pay the incremental costs, half or more of the emissions in the next century will come from the developing world.

CHU: Both wind and solar, for example, are transient in nature. Photovoltaics need to achieve a factor of five or more lower cost before wide-scale deployment. The cost of wind-generated power is competitive with gas, but because it is a transient source, without efficient and cost effective energy storage, the base line will be nuclear power and coal in the near-term future. So you can put your pedal to the floor in sequestration and it's not closing the door to renewable sources.

Q: What energy choices are being made in the developing world?

KOONIN: China is putting in 60 gigawatts a year of electrical generation capacity. That's as much capacity as the UK has *in total*. Fifty of those 60 gigawatts are coal fired because that's the fuel that is the cheapest. Who will pay the Chinese or the Indians not to emit? Businesses are not charities. So the government is going to have to step up to the plate.

CHU: China and India are looking at nuclear sources of energy, but it doesn't come on instantly. You're not going to build nuclear power plants as fast as you can build coal-based power plants because of the long construction periods, the regulatory issues, and so forth.

Q: Transportation generates 25% of greenhouse gas emissions. Do we need to be developing new fuels? What are the opportunities for improvements in fuel efficiency?

KOONIN: Efficiency is the first thing you do. There's no reason that the US fuel economies couldn't be improved by a factor of two if the political will was there. As for new fuels, it's hard to beat liquid hydrocarbons for energy density, so they won't disappear entirely from transport over the next 30 to 40 years. The real question is where you are going to get your liquid hydrocarbons. To make a megajoule of ethanol from corn takes about 0.3 megajoules of gas and 0.4 megajoules of coal, but only 0.05 megajoules of crude oil. So you're multiplying the crude that goes in by a factor of 20. It doesn't matter whether you lose energy in that process, because the liquid fuel is what you want. We generate electricity from coal and that throws away roughly 60% of the energy. But we still do it.

CHU: I agree. It's really about the carbon balance. You might be throwing away factors of two and a half or more in total energy, but you're converting something you've got a lot of to something you're going to run out of, eventually. Biofuels, particularly going to cellulose-based fuels, is something that looks very fruitful, especially given the rapid development of the science and technology that can be brought to bear in this area. In the end, you want to transition from ethanol to a better fuel as quickly as you can. A lot of the research will be done on developing much less costly and energy-intensive ways of breaking down cellulose and turning it into a transportation fuel.

Q: What other technologies could help us transition to a carbon-reduced economy?

KOONIN: Building efficiency. Half of the world's energy is used in buildings, so we need to learn how to use energy more efficiently in heating, ventilation, cooling, and lighting. Urban design is another important area. Right now, half of the world's people live in big cities. By 2050, around 75% of the world's people will live in big cities. How those cities are designed in terms of housing, transportation, and communications will greatly affect energy use.

CHU: We should also be paying a lot more attention to new technologies for long-distance electricity transmission. The most favorable technology would be very high voltage DC transmission: you have less current or discharge, so you have less radiation losses. DC is turning out to be cheaper once you go over 700 kilometers. It also makes the system much more robust because the synchronization to local AC lines is easier.

Q: If the US accepted a carbon cap and trade system, what amount would carbon have to be trading at to stimulate change?

CHU: It's not as simple as that. What you really want in order to stimulate long-term investments is the assurance that there will be a bottom to the price of carbon trading. This is what Europe did in the development of wind technology. They said, "If the price of fossil fuels goes down below a certain amount, we will step in and make sure you're not wiped out." It was not seen as a huge subsidy, but a level of protection against volatility. If you adopt a carbon cap and trade system, you also need to be sensitive to the fact that it can't be totally free market. With a stabilizing and reasonable floor, we would see a degree of long-term investments in R&D that could far exceed government investments.

KOONIN: If large companies are going to commit to developing and deploying low-emission or zero-emission energy sources, there must be some reasonable expectation of the economic environment–what the price of carbon will be on a 20-year time scale. At about $40 a ton of CO_2, capture and storage and nuclear become quite competitive with the emitting sources. You will get carbon out of the power sector starting at $40 a ton. If you want to get carbon out of the transport sector, you probably can't do it by economics because it's about a factor of four or five more expensive per ton to save it in transport than it is to save it in power. So you're going to have to get it out of transport by regulation.

CHU: A cap and trade system would stimulate further investments in developing far less carbon-emitting methods of producing bio-fuels.

Q: Does the US R&D enterprise need to be refocused in some way in order to transition to a carbon-reduced economy?

CHU: Yes. The good news is that a lot of scientists who were focused on very basic research are now waking up and saying, "Maybe I should start thinking about this problem." Solving the energy problem is of such importance that it needs our best and brightest.

KOONIN: I think we are beginning to engage the world's best scientific talent in these problems. But it also requires a research program that is rationally based, that certainly has a blue-sky component but also focuses on those technologies that look most promising. The program management needs to be much more technically informed. It needs to be sustained. And it needs to be able to fail.

CHU: …and we need to fail quickly. That's the key to success. After some initial research tells you that a potential solution won't scale properly, it is important to move on as quickly as possible to other opportunities.

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