

PPPL NEWS

The Princeton Plasma Physics Laboratory is a United States Department of Energy Facility

Powerful Computers Advance Fusion Research at PPPL

By Anthony DeMeo

Scientists at the U.S. Department of Energy's (DOE's) Princeton Plasma Physics Laboratory (PPPL) reported a major advance in the computer modeling of fusion plasmas in the September 18 edition of *Science*. The new results were obtained utilizing the Massively Parallel Processing (MPP) capabilities of the DOE's National Energy Research Scientific Computing Center (NERSC) at the Lawrence Berkeley National Laboratory (LBNL) in Berkeley, California.

In general, the formation of stars results from the dynamic behavior of hot ionized gases known as plas-

mas. Fusion researchers use magnetic fields to confine such hot gaseous fuel at the temperature, density, and duration required for the controlled production of significant amounts of fusion energy. However, turbulence can spoil the efficiency of this approach by causing accelerated loss of particles and energy from the plasma.

As pointed out in a Perspectives article in the same issue of *Science*, good news from toroidal confinement experiments indicates that the suppression of turbulence

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PPPL Nobel Laureate is Bringing Hands-on Science to Libraries

By Patti Wieser

PPPL's Russell Hulse is not one to rest on his laurels. Through his efforts, hands-on scientific displays soon may join book collections and hushed areas of contemplation at the local library. Hulse and Plainsboro Public Library Director Jinny Baeckler are spearheading a project called "Contact Science," which will create, disseminate, and support small-scale traveling science exhibits in public libraries. The prototype exhibit would be located at the Plainsboro, New Jersey library and travel to other libraries from there.

"We would like to provide informal science education to children and their parents by placing science centers in libraries through the use of traveling compo-

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The Contact Science team includes, from left, former PPPL'er Dick Rossi, consultant Barbara Graham, PPPL's Nobel Prize Laureate Russell Hulse, and Plainsboro Public Library Director Jinny Baeckler.

Computers

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can enable transitions to newly discovered enhanced confinement regimes.

In the work reported in *Science*, PPPL scientists have used the full power of the SGI/Cray T3E supercomputer at NERSC to create three-dimensional nonlinear particle simulations of microturbulence in the plasma. The use of NERSC's massively parallel processor capabilities enabled scientists to perform calculations involving 400 million plasma particles (i.e., 100 million guiding centers) in 5,000 time-steps — an achievement impossible without the use of powerful MPP computers.

“The information obtained from these advanced computer simulations is providing valuable new physics insights and correlates well with trends observed in experiments.”

—William Tang

“The information obtained from these advanced computer simulations is providing valuable new physics insights and correlates well with trends observed in experiments. This work builds on the excellent knowledge base developed internationally and complements related research efforts at other national laboratories, such as Lawrence Livermore National Laboratory and General Atomics [both in California], as well as at universities such as UCLA and the University of Colorado,” noted PPPL's Chief Scientist, William M. Tang. “The results in our *Science* article help support the increasingly accepted position that high-performance scientific computing has matured to a level where it can be considered a new tool for discovery, complementing traditional theory and experiment. It is evident that plasma science, along with many other fields, will benefit greatly from the development of the advanced computational capabilities envisaged and strongly encouraged at the DOE/National Science Foundation Workshop on Advanced Scientific Computing held this past July at the National Academy of Sciences.”

Powerful Unclassified Supercomputing Center

NERSC was originally established in 1974 to support fusion energy research programs sponsored by the DOE. The center, one of the nation's most powerful unclassified supercomputing centers, provides both computational resources and technical support to researchers at PPPL, as



PPPL scientists involved in using the full power of the SGI/Cray T3E supercomputer at NERSC to create three-dimensional nonlinear particle simulations of microturbulence in the plasma are, from left, (standing) PPPL Chief Scientist William Tang and Roscoe White; and (seated) W. Wei-li Lee, Zhihong Lin, and Taik Soo Hahn.

well as a wide range of research efforts in various scientific disciplines at other DOE sites.

“These results are exciting in that they again demonstrate the value of computational science as a complement to experimental science. It's particularly exciting that this significant fusion result was achieved using a highly parallel computing system,” said William Kramer, Deputy Director of NERSC. “We're also pleased to see that NERSC continues to play a critical role in helping plasma physics scientists make new advances in the field. Collaborations such as this really are the future of large-scale scientific research.”

NERSC (www.nersc.gov) provides high-performance computing services to DOE's Energy Research programs at national laboratories, universities, and industry. The DOE's LBNL (www.lbl.gov) conducts unclassified research and is managed by the University of California.

—Jon Bashor of NERSC contributed to this story.

Editor's Note: The citation for the PPPL *Science* article is: “Turbulent Transport Reduction by Zonal Flows: Massively Parallel Simulations,” Z. Lin, T.S. Hahn, W.W. Lee, W.M. Tang, and R.B. White, *Science* **281**, (1998) 1835. There is also a Perspective article by Keith Burrell of General Atomics Corporation and a highlight of the article in the same issue of *Science*. ●

Libraries

Continued from page 1

nents,” said Hulse, a Principal Research Physicist at PPPL who shared the 1993 Nobel Prize in Physics. These components would be tabletop size or smaller and include signage and supporting materials. Each exhibit would be integrated into a display suitable for a library and would have stand-alone appeal, as well as serving as a centerpiece to draw people back for other activities. These associated community-based mentoring activities, building on the main exhibit, are an important part of the complete Contact Science concept.

“We want to make learning about science fun and engaging. The purpose of Contact Science is not to teach a science course or serve as a classroom, or be an amusement park. Instead, our goal is to capture the imagination,” said Hulse, who is also on an advisory committee for the Hubble Space Telescope traveling exhibit being created by the Smithsonian Institution in collaboration with the Space Telescope Science Institute.

Hulse said Contact Science teammate Baeckler already runs a wonderful, exciting science center and science activities out of the Plainsboro Public Library. Several years ago, the library’s science center received the American Library Association’s Fyan Award for the most innovative public library program in the country. An interactive science display would complement the center.

“Jinny’s enthusiasm and vision of having community-based science in a public library is part of the genesis of this project,” said Hulse. Besides Hulse and Baeckler, the Contact Science team includes former PPPL’er Dick Rossi and consultant Barbara Graham.

Said Baeckler, “This could be absolutely revolutionary. We are ever so close to establishing hands-on science as a basic library service. At a time when science is one of the nation’s top six education goals, it is important for all public institutions to make significant contributions. By offering high quality science materials, together with pragmatic ‘how to’ instructions for local librarians and their volunteer demonstrators, Contact Science will enable a whole new avenue for informal science education.”

Procter & Gamble, Inc. is funding the Phase I scoping and program development studies for Contact Science, a nonprofit corporation. Contact Science will seek corporate sponsorship for Phase II, which will provide the exhibits to libraries for free, including transportation and maintenance costs. This is a critical aspect of the program, as typical libraries, especially in disadvantaged communities, do not have budgets allowing them to pay for such initiatives.

Hulse, who is involved in various science education activities — including Contact Science — for PPPL, stressed the importance of instilling in children a sense of adventure about science. “Science is not just something you learn in the classroom. It is an exciting, fun part of life,” said Hulse. ●

Richardson Named New Energy Secretary

On August 18, United Nations Ambassador Bill Richardson was sworn in as the ninth Secretary of Energy. He replaced Federica Peña.

He is the highest ranking Hispanic in the Clinton Administration and the first New Mexican to serve as the Secretary of Energy. Upon nominating Richardson to the energy post, President Clinton remarked, “If there’s one word that comes to mind when I think of Bill Richardson, it really is energy.”

Richardson is putting that energy and his strong background in national security, energy, and environmental issues to work at the Department of Energy. His priorities include protecting our national security, advancing the frontiers of science and technology, helping to solve the challenge of global climate change, making



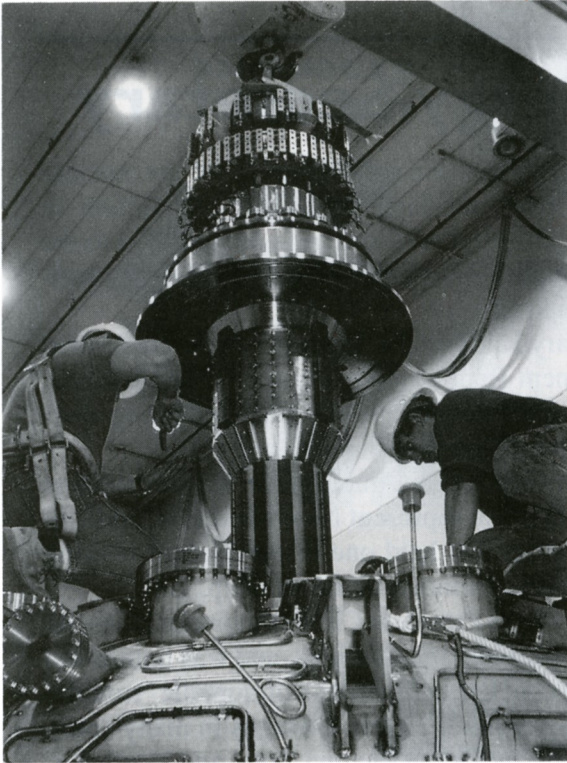
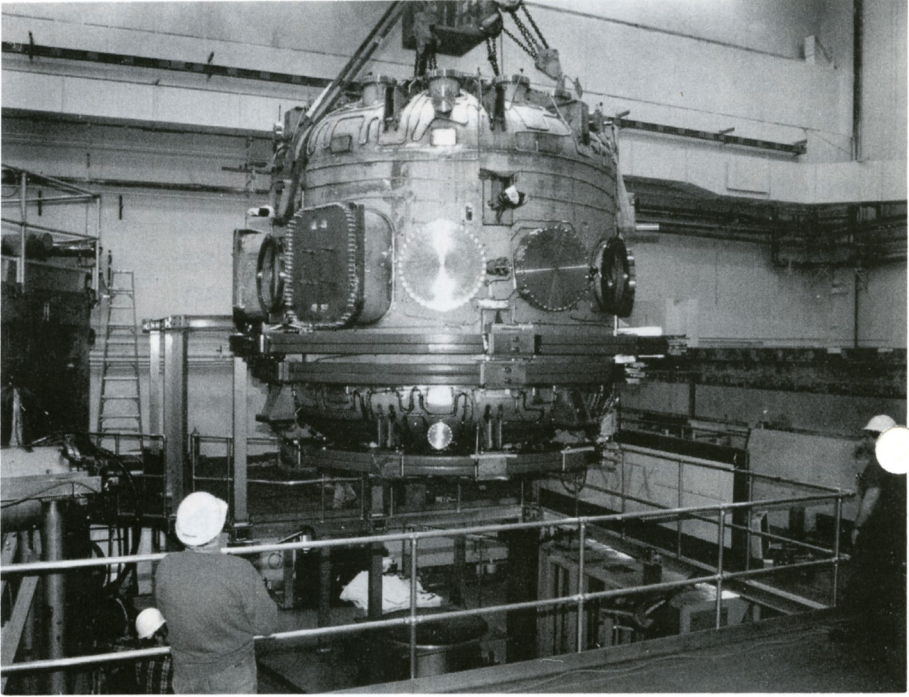
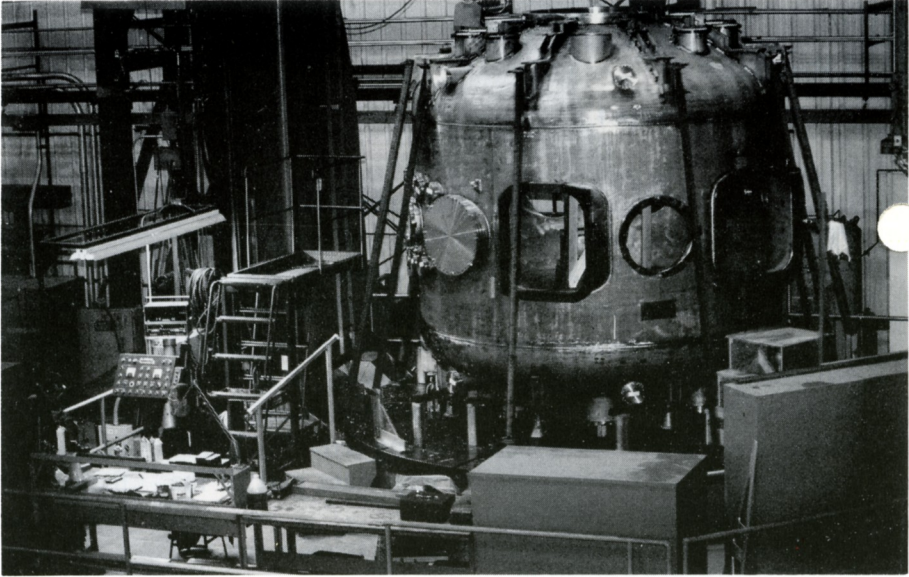
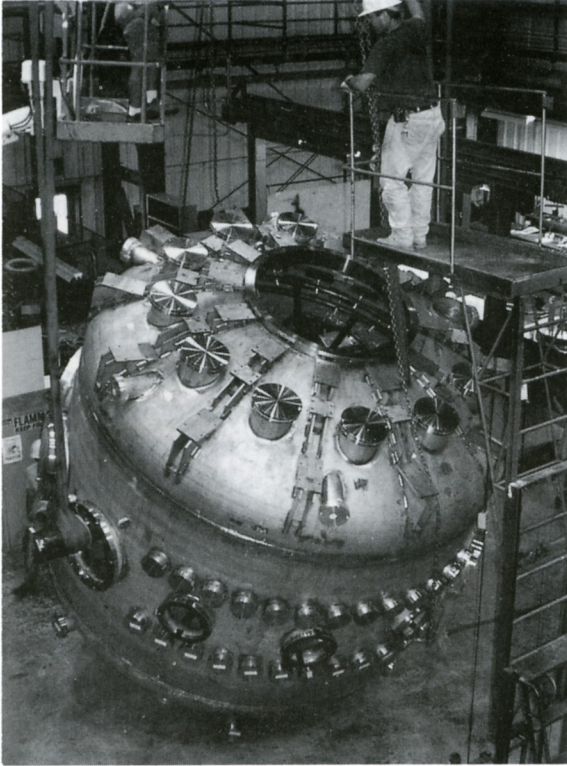
progress on the environmental cleanup of the nuclear weapons complex, working to deliver \$20 billion in savings to the consumers by bringing competition to the electricity industry, and ensuring a balanced energy portfolio for our nation.

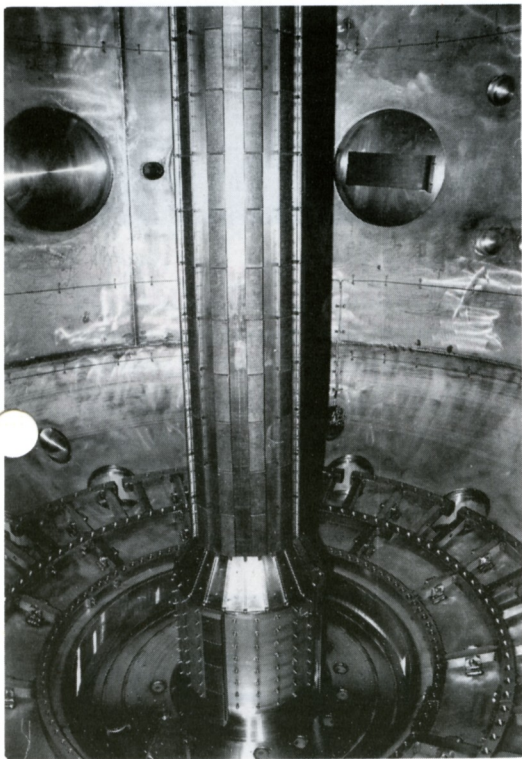
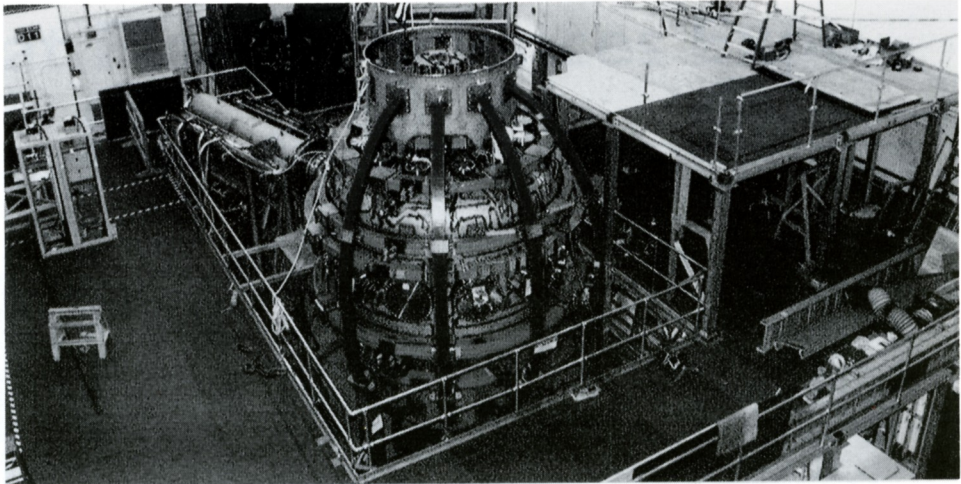
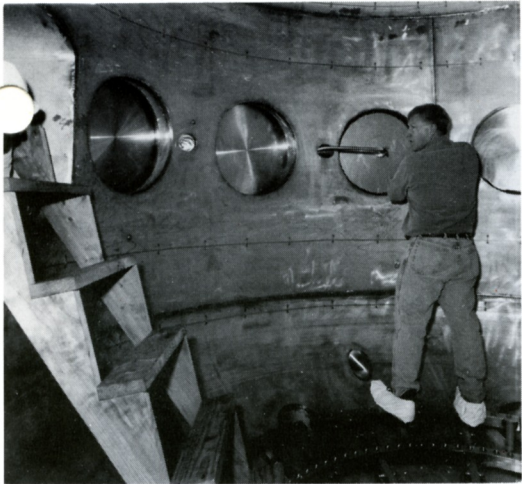
On February 13, 1997, Richardson became the United States Permanent Representative to the United Nations. He has addressed difficult international negotiating challenges and crises from Afghanistan to Zaire.

Prior to serving as U.N. Ambassador, Richardson was elected eight times to represent New Mexico’s 3rd Congressional District. He held one of the highest ranking posts in the House Democratic Leadership.

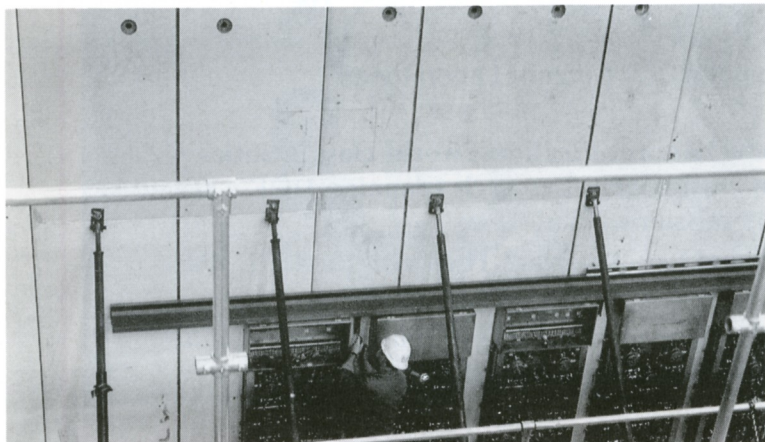
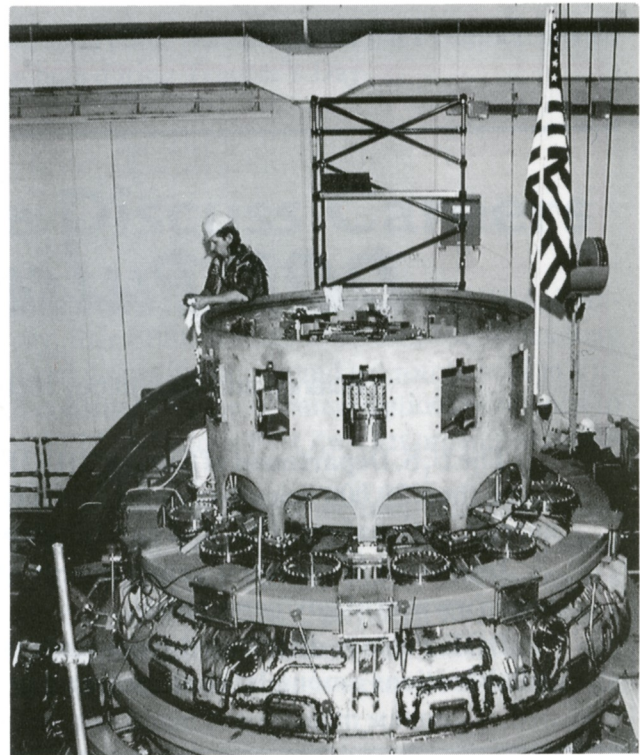
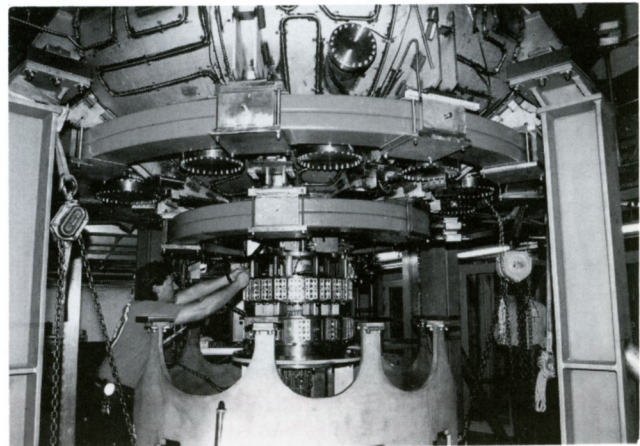
He has served as President Clinton’s special envoy on many sensitive diplomatic missions, and was nominated twice for the Nobel Peace Prize. As a diplomatic “troubleshooter,” he has worked to free hostages in many countries including Bangladesh, Burma, Iraq, and North Korea. ●

NSTX Update





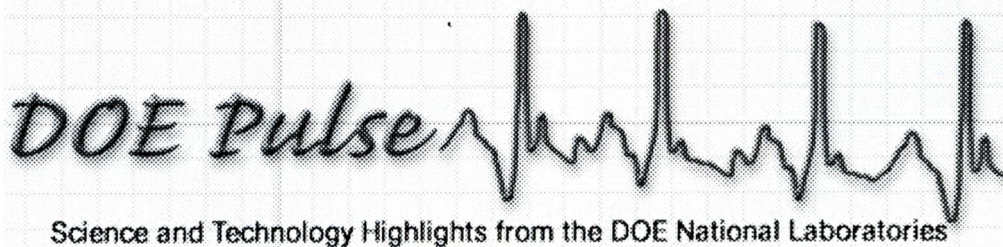
Progress continues on the construction of the National Spherical Torus Experiment (NSTX). NSTX is a national collaborative experimental fusion device sited at PPPL. Clockwise from top left (page 4), turning over NSTX's vacuum vessel; machining the vessel; lifting it into place; inspecting the vessel's legs; and installing the center stack; (page 5) leaktesting the vessel; a view of the NSTX Test Cell; installing connections to the center stack; installing the outer toroidal-field coils; installing water racks; and an interior view of the vacuum vessel.



PPPL Wins Small Business Award



In recognition of its outstanding efforts to provide subcontracting opportunities to small businesses, PPPL recently garnered an "Award of Distinction" from the U.S. Small Business Administration (SBA). Small businesses include small disadvantaged businesses and women-owned businesses. PPPL is one of 26 recipients out of 2,500 large businesses in the SBA's portfolio nationwide to have been honored with the citation. Representatives of the SBA presented the award to PPPL Director Rob Goldston on November 23 at the Laboratory. From left are PPPL Business Operations Head Ed Winkler, SBA Area Director for Government Contracting Jannette Fasano, SBA Commercial Market Representative Andrew Zuber, PPPL Procurement Head Rod Templon, PPPL Director Rob Goldston, SBA Regional Administrator for Region II Thomas Bettridge, U.S. Department of Energy Contracting Officer Raymond Kimble, and Deputy District Director of the SBA's New Jersey District Office James Kocsi.



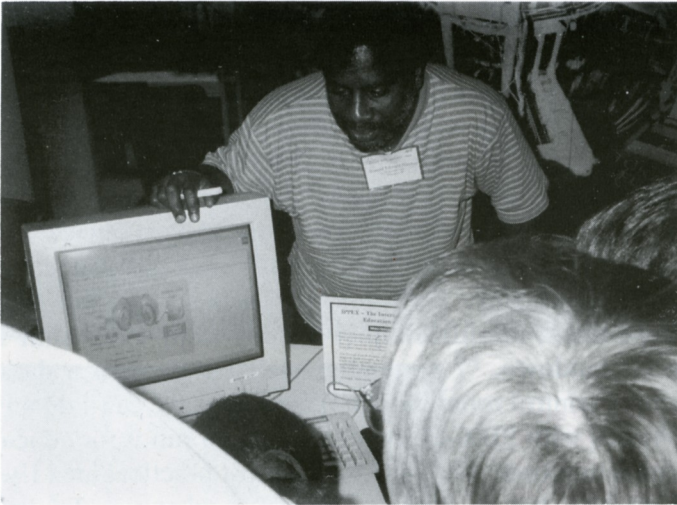
The U. S. Department of Energy's (DOE's) National Laboratories house world-class facilities where more than 30,000 scientists and engineers perform cutting-edge research spanning DOE's science, energy, national security, and environmental quality missions.

Interested in the latest achievements of the National Laboratories? Then visit the DOE Pulse at: <http://www.ornl.gov/news/pulse/>.

DOE Pulse is distributed twice each month. Each issue includes research highlights, updates on collaborations among laboratories, and profiles of individual researchers.

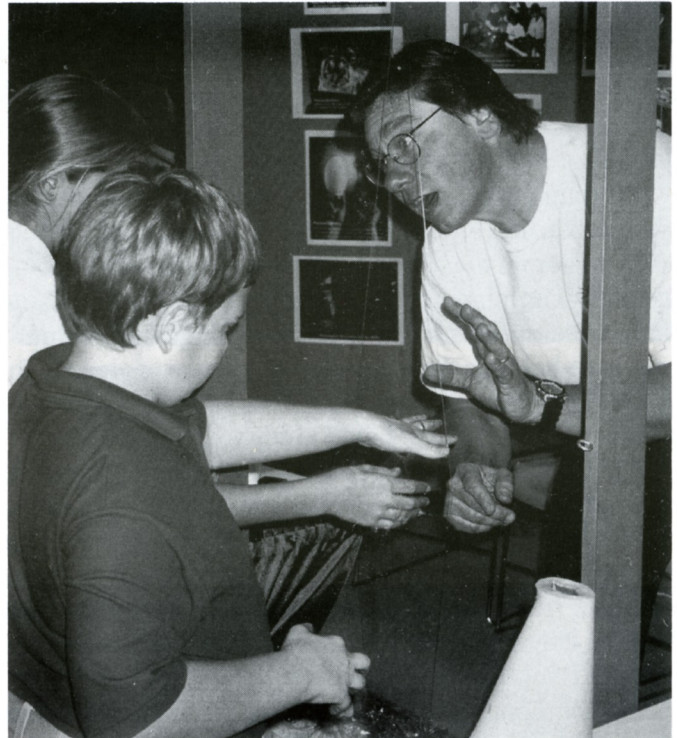
PPPL Builds Bridges with Educators and Students at Plasma Sciences Expo

Photo by James Morgan



PPPL's Ron Hatcher discusses IPPEX with a group.

In November, PPPL participated in the 1998 Plasma Expo and Science Teachers Day at the American Physical Society-Division of Plasma Physics (APS-DPP) annual conference held in New Orleans. PPPL's Henry Carnevale, John DeLooper, Ron Hatcher, Bob Heeter, Bob Kaita, James Morgan, Andrew Post Zwicker, Martha Redi, Barbara Sarfaty, and Ron Strykowski, along with Rick Kessler of Princeton University's Office of Government Affairs in Washington, D.C., participated in the Expo, which drew more than 4,000 students. Post Zwicker,



PPPL's Ron Strykowski demonstrates turbulence with a flowing bubble apparatus to young visitors at the Expo.

Morgan, and Peddie School teacher Nick Guilbert hosted 138 teachers during Teacher's Day. ●

PPPL Women in Science Discuss Careers



From left are Phyllis Roney, a student, Martha Redi, and a student.

During a recent roundtable discussion at the Laboratory, four PPPL women in science and technology encouraged young women from Foxcroft School in Virginia to consider a range of career options now open to females. PPPL's Andrew Post Zwicker organized activities for the students.

Lab participants in the talk included Virginia Finley, Martha Redi, and Phyllis Roney, visitor Boel Denne Hinnov, and moderator Pamela Lucas. Discussing the progress of women in science, physicist Redi showed a *New York Times* article, "Women in Antarctica," and noted that until recently women were not allowed to do research at the Antarctica research station. ●

PPPL Hosts a Different Kind of Summer Camp

Science Education Institute Helps Teachers Bring Plasma Physics into the High School Classroom

There's no hiking along trails flanked by lush woods, no swimming in a lake, and no singing by the campfire.

During the summer, PPPL hosted a different kind of camp — "Plasma Camp" — an intensive two-week summer program of lectures, lab work, and curriculum design for high school physics teachers.

Through the camp, officially called the Plasma Science and Fusion Energy Institute, 10 extraordinary teachers from across the nation traded hikes for lectures about fusion, swimming for experiments with plasmas, and campfire harmony for curriculum planning. The institute's goal is to help teachers develop curricular materials for introductory physics teaching, making the subject of plasma and fusion accessible to high school pupils.

"We hope that by studying the richness and complexity of plasmas through experimentation and exploration of its basic properties, the participants will have the means and the motivation to use plasmas as a new and engaging teaching tool in their existing curricula," said Andrew Post Zwicker, Senior Program Leader in PPPL's Science Education Program.

At the conclusion of the institute, the participants developed unique, new curricula. One teacher developed software that allows students to follow the motion of a

charged particle in both a straight and curved magnetic field, while another came up with a classroom laboratory project for measuring the index of refraction to microwaves of various materials. Other examples of new curricula included the creation of plasma and fusion-related test questions, as well as an after-school project to study the absorption spectrum of chlorophyll from various plasma sources and how these sources affect plant growth.

The institute was the brainchild of Post Zwicker, a former post-doctoral researcher from the Oak Ridge National Laboratory who worked on the Princeton Beta Experiment-Modification (PBX-M) from 1992 until it was shutdown. "I remember walking through a dark, empty control room and thinking that if we can't do any physics with PBX-M, maybe we could run it for educational purposes. That wasn't the most practical idea I've ever had, but it was the basis for what we did this summer."

He added, "Although plasma may be the most prevalent form of matter in the universe, plasma-based curricula may be one of the rarest phenomena in the universe of the introductory physics classroom. Few high school students are exposed to the principles or applications of plasma physics. Demonstrations or laboratories are nearly non-existent and most teachers are not equipped to teach about plasmas beyond the most cursory introduction. This workshop was designed to address some of these issues."

Participants included a teacher with a Ph.D. in philosophy, two former engineers, a patent holder, a Benedictine monk, and a co-author of a *Physical Review Letters* paper. They were from private and public schools, varying economic districts, and rural, urban, and suburban areas. In recruiting teachers for the institute, Post Zwicker sought those with experience in an experimental setting and a track record of innovative instruction.

A typical day for the teachers consisted of hearing a lecture on a plasma or fusion-related topic; performing experiments in the direct current breakdown of a gas, in plasma spectroscopy, and in microwave interferometry at PPPL's Grad Lab; and discussing how to bring their new knowledge and skills to the classroom. The lecturers included Troy Carter, Phil Efthimion, Bob Kaita, Dick Majeski, Jon Menard, Martha Redi, and Greg Schmidt, all of PPPL, as well as Martin Peng, of the Oak Ridge National Laboratory, Bruce Draine, of Princeton University, and Denise Mauzerall, of the National Center for Atmospheric Research. In addition, PPPL Director Rob



During "Plasma Camp," PPPL physicist Andrew Post Zwicker (left) discusses an experiment with high school physics teachers Brian Wargo and Uma Jayaraman. They are using an apparatus at PPPL for studying the conditions under which air can become a plasma. Wargo teaches at Freedom Area High School in Freedom, Pennsylvania, and Jayaraman teaches at Lambertson High School in Philadelphia.



The 10 teachers who participated in "Plasma Camp" at PPPL are, from left, (back row): Uma Jayaraman, Brian Wargo, Sophia Gershman, Rick Nestoff, Father Michael Liebl, John Wheaton, and Karen Powe; (front row, kneeling): Dennis Robbins, Boris Dirnbach, and Marc Sabb.

Goldston had lunch with the teachers one day, discussing topics such as whether someone needs a knowledge of physics to be a productive member of society. Evaluating the camp, one teacher commented, "I worked harder at this institute than at any other summer project I have been involved with. But I didn't mind. It was worth the effort. I was sorry to see the two weeks end."

Post Zwicker was assisted by Nick Guilbert, who teaches physics at The Peddie School in Hightstown. Guilbert spent close to six weeks at PPPL providing his expertise as a teacher in planning the camp, overseeing the program, and giving advice to the teachers.

"The key to the workshop's success was working with Nick Guilbert early in the design process. His input as an exceptional teacher, communicator, and creator of innovative curricula, as well as the fact that he spent several summers at PPPL as a researcher, were all instrumental in adapting graduate student material to an appropriate level," noted Post Zwicker.

Offered Guilbert, "The teachers took away even more than we had hoped. They learned a lot about plasmas and

seemed excited about taking their new knowledge back to their classrooms."

Plans for next year's workshop are already underway and include inviting all of this year's participants back in addition to bringing in a new set of teachers. The veterans will continue their work in the Grad Lab, as well as design and perform an experiment on the Current Drive Experiment-Upgrade. They will also be responsible for teaching the new group some of what they learned during their first year.

"The idea is to move from scientist-teacher learning to teacher-teacher learning so the ideas taught here can be disseminated to a much wider audience throughout the country," said Post Zwicker. "It is also to demonstrate that a group of high school teachers can use a tokamak to do good science while learning first-hand about some of the intrinsic difficulties faced on a daily basis in fusion research. If we want people to understand what we do and why it is important, what better way than to let teachers perform research here and then take the experience back to their students?" ●

PPPL Names Three Distinguished Fellows



From left are 1998 PPPL Distinguished Research Fellows W. Wei-li Lee and Ernesto Mazzucato with PPPL Director Rob Goldston and 1998 Distinguished Engineering Fellow Long-Poe Ku.

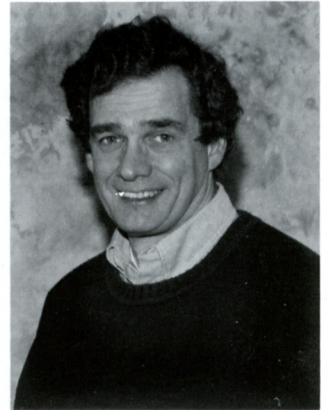
In recognition of their excellence in research and in engineering, two physicists and one engineer at PPPL have been named PPPL Distinguished Fellows for 1998. The Distinguished Research Fellows are W. Wei-li Lee and Ernesto Mazzucato and the Distinguished Engineering Fellow is Long-Poe Ku. The recipients were honored during a formal ceremony in October at the Laboratory.

The Distinguished Research Fellow Program, which is funded by the U.S. Department of Energy (DOE), was created in 1993 to recognize members of the Laboratory's Research Staff. Fellowships are awarded to those who have achieved extraordinary records of creativity and accomplishments in research over an extended period of time. The Distinguished Engineering Fellow Program was created in 1995 to honor members of the engineering and scientific staff who have achieved outstanding records of innovation and accomplishment in engineering over an extended period of time. Fellows receive one-time gifts of \$5,000 and qualify for priority in regard to their research and engineering programs. ●



Neilson Named 1998 APS Fellow

In honor of his contributions to the field of plasma physics, PPPL scientist George "Hutch" Neilson was recently named a Fellow by the American Physical Society (APS). Neilson, a Principal Research Physicist, received the lifetime appointment from the APS's Division of Plasma Physics during the November APS meeting held in New Orleans.

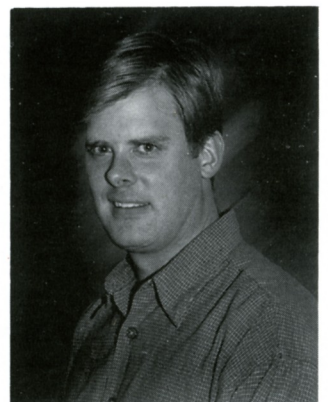


Neilson, Project Manager for the National Compact Stellarator Experiment, was cited "For his pioneering work in the exploitation of magnetic equilibrium diagnostics and for his leadership in the physics design of fusion experiments." ●

Ernst Honored for Doctoral Thesis

PPPL Associate Research Physicist Darin Ernst received the 1998 American Physical Society (APS) Award for "Outstanding Doctoral Thesis in Plasma Physics" during the APS Division of Plasma Physics Annual Meeting in New Orleans in November.

The APS citation honored Ernst "For elucidating the role of radial electric field shear in reducing local heat transport in supershot tokamak plasmas." The award was established in 1985 (originally as the Simon Ramo Award) to provide recognition to exceptional young scientists who have performed original thesis work of outstanding scientific quality and achievement in the area of plasma physics. It consists of a certificate and \$2,000. ●



Fu and Nazikian Awarded Kaul Prizes

P PPL physicists Guo-Yong Fu and Raffi Nazikian are the 1998 recipients of the Kaul Foundation Prize for Excellence in Plasma Physics and Technology Development. Fu, along with Nazikian's wife, Fumiko, accepted the awards during a ceremony at PPPL in October. Nazikian was in Japan working on experiments at the Japan Atomic Energy Research Institute at the time of the ceremony.

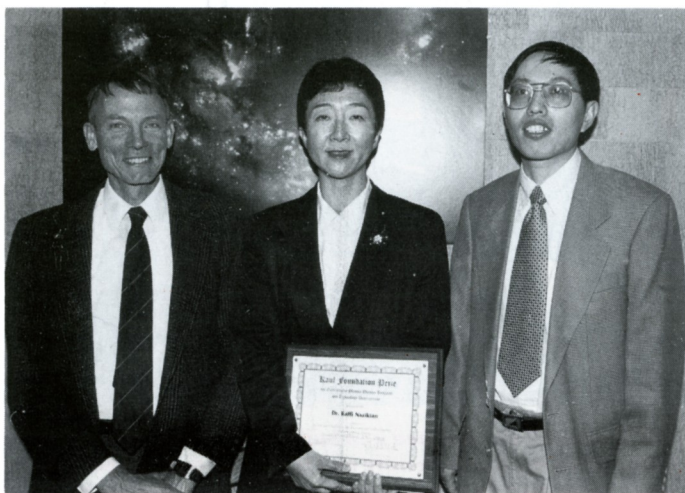
Fu and Nazikian were cited "for their work leading to the discovery and understanding of alpha-particle-driven Toroidal Alfvén Eigenmodes (TAEs) in the Tokamak Fusion Test Reactor (TFTR)." This discovery is helping

scientists gain an understanding of the magnetic confinement of hot, ionized gases known as plasmas at the temperature, density, and duration required for the controlled production of significant amounts of fusion energy. TFTR was PPPL's flagship experimental fusion machine for 14 years, concluding experiments in 1997.



Raffi Nazikian

The Prize is awarded by Princeton University to recognize a recent outstanding technical achievement in plasma physics or technology development by a full-time, regular employee of PPPL. It includes a cash award of \$2,000, which is divided equally between the two honorees. Nominations for the award are submitted to the Prize Selection Committee, which includes the Princeton University Provost, the Chair of the Princeton University Research Board, the PPPL Director, PPPL Deputy Director, and PPPL Chief Scientist. Former PPPL Director Ronald C. Davidson created the prize by directing that \$40,000 of the \$100,000 gift he received as the 1993 recipient of the Award for Excellence in science, education, and physics from the Kaul Foundation be given to Princeton University to endow the Kaul Foundation Prize for Excellence. This is the second time the prize has been given. The first was in 1996 to Richard Hawryluk, who is now the Deputy Director at PPPL. ●



Will Happer, Chair of the Princeton University Research Board, presented the Kaul citations to recipient Guo-Yong Fu and to Fumiko Nazikian, who accepted on behalf of her husband, Raffi. From left are Happer, Mrs. Nazikian, and Fu.

Lab Noted for Outreach Program in Recycling

This fall, PPPL received the 1998 Award for "Outstanding Achievement in Recycling" from the New Jersey Department of Environmental Protection. The Laboratory was cited for its outreach efforts in recycling, and was noted, in particular, for its pollution prevention activities during Earth Week in April. The Lab sponsored a Pollution Prevention Poster Contest for students, as well as hosted 125 youngsters from area schools for "Pollution Prevention Awareness Day." PPPL's Thomas J. McGeachen and Margaret King, who organized the poster contest and events, accepted the award during a luncheon in September at the Princeton Marriott. From left are Scott Larson, PPPL Director Rob Goldston, McGeachen (holding the award), King, Rich Gallagher, and J.W. Anderson. ●



PPPL Team Collaborates with Japanese Group



Through a \$660,000 contract with the Japanese corporation AmTechs, PPPL researchers designed and built a correlation reflectometer for JT-60U at JAERI in Japan. The correlation reflectometer measures fluctuations in plasma density and is proving to be important for relating plasma turbulence to transport. PPPL physicist Raffi Nazikian spent three months in Japan during the summer helping to install and operate the device. Project subcontractors General Atomics and Millitech provided much of the hardware. The Lab recently negotiated a \$200,000 contract for the control upgrade for the reflectometer. Members of the team, shown with Japanese counterparts, are, from left, Larry Guttadora, Kouji Shinohara, Richard Hawryluk, Takashi Kondoh, Raffi Nazikian, Jun Takahashi, Ken Young, Fumio Nagashima, Mike Choi, and Bob Simmons. Not pictured are Don Long, Phil Heitzenroeder, Art Brooks, Westley Reese, and Bob Cutler.

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