

# PPPL *NEWS*

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

## First Two NCSX Modular Coil Winding Forms Arrive



*Two of the 18 modular coil winding forms for the National Compact Stellarator Experiment (NCSX) at PPPL have arrived since October. Manufactured by Energy Industries of Ohio, the first three-ton coil was wound and the second is ready for winding at PPPL's modular coil manufacturing facility. NCSX, a fusion experiment being constructed at PPPL in partnership with Oak Ridge National Laboratory, is scheduled to begin operation in 2009. Above, staff uncrate the first winding form and at right Doug Voorhees works on the coil. Modular coils provide uniquely shaped magnetic fields key to stellarators.*



## PPPL Provides Small Plasma Lab to Goshen College

By Patti Wieser

**A** small plasma lab from PPPL recently became operational as a teaching tool for undergraduate students at Goshen College in Indiana. The tabletop lab is the first PPPL has created specifically for use by undergraduates outside of the Laboratory.

Prompted by a conversation between Goshen physics professor Carl Helrich and PPPL physicist Stewart Zweben, Laboratory staff designed and built the experimental device. In 2004, Helrich was at PPPL for a week when Zweben took him on a tour of the experimental facilities. Along the way, they stopped by Sam Cohen's Grad Lab, where they saw a small plasma lab. Zweben wondered if Goshen might like a similar lab. Helrich said the college indeed would be interested in getting help establishing an undergraduate research experiment in plasma physics.



*Surrounding the tabletop plasma lab (from left) are Goshen College Professor Carl Helrich and PPPL's Stewart Zweben, Lane Roquemore, and Mike DiMattia. Zweben designed the experiment, DiMattia built it, and Roquemore helped locate equipment and diagnostics.*

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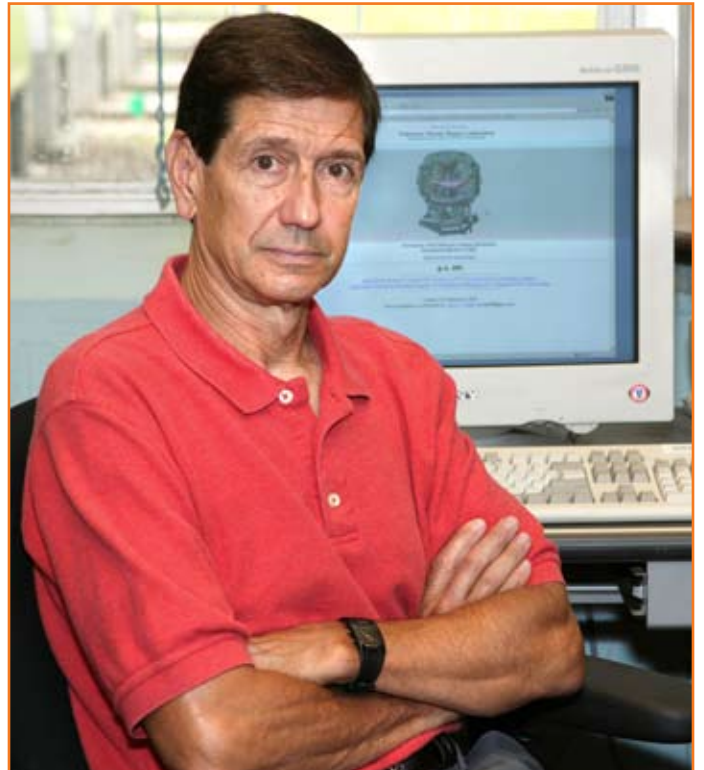
# PPPL's Monticello Focuses on "Fourth State"

Whether his gaze is tilted toward the heavens or at a computer screen, the focus has always been plasma for PPPL scientist Don Monticello. Plasma is the fourth state of matter — a hot, gaseous, electrically charged state that makes up the sun and the stars, and is used as the fuel to produce fusion energy. At PPPL, physicists use a magnetic field to confine plasma.

Monticello is a theoretical physicist whose research leads to advances in understanding the behavior of plasma and how fusion devices operate. His pioneering work focuses on modeling plasma disruptions and three-dimensional computational simulations of laboratory plasmas. Presently, his primary responsibility is calculating equilibria — various modes of stable plasma performance — for the National Compact Stellarator Experiment (NCSX), an experimental fusion device being constructed at PPPL. He is part of a team that has developed a computer code capable of calculating the shape a three-dimensional plasma would take in fusion devices called stellarators. This was a key tool in the design of NCSX.

Don joined the Laboratory's Theory Group in 1975 after receiving a bachelor's degree and a Ph.D. in physics from the University of Rochester and spending two years at the Institute for Advanced Study in Princeton, N.J. At the Institute, Monticello and coworkers involved in computational science were among the first to do large-scale computations involving the motion of electromagnetic waves along the magnetic field lines in a plasma. At PPPL, he continued this work, developing a set of reduced equations that allowed one to simulate the evolution of the plasma in fusion devices on computers, which previously had not been feasible.

"Understanding the behavior of the plasma in fusion devices is essential in the successful design and operation of fusion devices," says Monticello, whose work has significantly contributed to this understanding.



The father of five and grandfather of six, who devotes his outside time to family, fitness, sports, and astronomy, freely shares his enthusiasm for fusion and plasma science research — as well as astronomy — with the public through talks for various groups. "It is really rewarding to work in fusion because the potential benefits to society are enormous," says Monticello. "Astronomy also is a very exciting area. It leads to our understanding of our origins and the origins of the universe."

Monticello is a Fellow of the American Physical Society and a recipient of the 2001 UT-Battelle Award for Scientific Research by a Team for research on the physics of plasma confinement in three-dimensional systems. ●

## PPPL NEWS

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## Goshen

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Helrich was talking to the right person. Zweben is Head of PPPL's Off-site University Research Support Program, which is supported by the Department of Energy through Darlene Markevich, Office of Fusion Energy Sciences, and has a mission to reach out to small colleges. "The idea is for PPPL to act as a resource," said Zweben. Being a resource means offering staff time and expertise to work with university colleagues, for example, to help design and build experiments and their components.

### Idea to Do a Small Clone

"I had an idea to do a small clone of Sam's lab and adapt it for undergraduate students at Goshen. I thought we could assemble a plasma source from spare parts around the Lab," said Zweben. He pitched the project to the higher ups and then to Markevich. PPPL management, including Director Rob Goldston, Deputy Director Rich Hawryluk, and Plasma Science and Technology Head Phil Efthimion, joined Markevich in supporting the pursuit. With the go-ahead, Zweben began working with PPPL technician Mike DiMattia.

"Mike took my idea for the lab and built it from scratch using old but serviceable equipment and spare parts from the Laboratory. Much of the surplus was from the 1970s and 1980s, yet everything worked," said Zweben. "Mike worked half time on the plasma lab from January to June and did a really excellent job. He designed the vacuum and gas delivery systems for it, and showed a lot of creativity and initiative in the project."

When DiMattia was finished with construction, Zweben tested the device and wrote a manual on physics and safety issues that is used by Goshen to operate the plasma lab. "Experiments that can be done range from basic — how to create a plasma — to complicated — looking at waves, instabilities, and the effect of magnetic fields on plasmas," said Zweben.

The lab is designed to give students some hands-on experience in experimental physics and to teach them some plasma physics, specifically giving them experience with vacuum systems, basic electrical measurements, optical measurements and spectroscopy, plasma diagnostic techniques, and data analysis. It also allows for creativity and the design of new experiments.

The lab uses helium and neon gases for plasmas and consists of two glass plasma-filled tubes, one at the left of the workbench or tabletop, which is X1, and a second larger one at the right, which is X2. Both X1 and X2 use the same vacuum system, gas delivery system, and high-voltage power supply, so experiments may not be done

using both at the same time. X1 is for the simpler experiments and X2 is for the more advanced experiments.

The small lab received a complete safety analysis at PPPL, and Helrich returned to PPPL to see how it operated and to review its manual before it went to Goshen. "I am first very grateful to Stewart Zweben who had this idea during my visit to PPPL in August of 2004," said Helrich. "The hospitality shown me by PPPL also made working through the experiments a pleasure. Specifically, I am grateful to Mike DiMattia, who helped with details of the apparatus, and to Sam Cohen, who made me feel like a true colleague."

Through a Department of Energy agreement, PPPL loaned the experiment to Goshen for an initial one-year period, which may be renewed annually. As the plasma science program at Goshen develops, the experiment may be transferred to Goshen under DOE's Energy Research and Laboratory Equipment grant program. The experiment began operating at Goshen in September 2005.

"It was fun for me," said Zweben. "Plus, I could play with plasmas that I could actually see with my own eyes."●

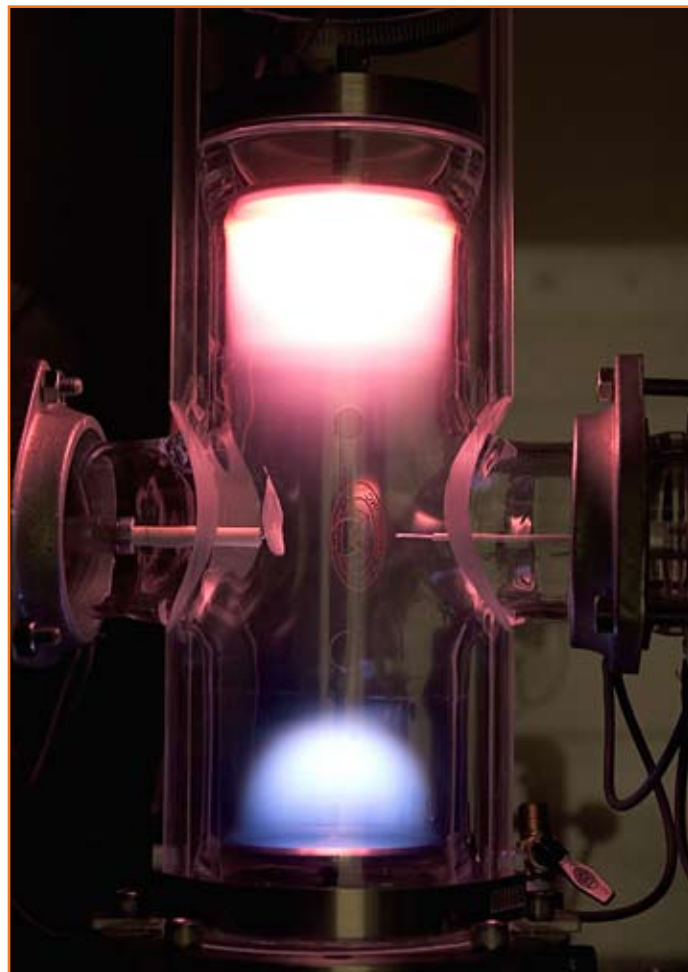


Photo by David Zweben

Above is a neon plasma in the plasma lab for Goshen College.

# Director Goldston Delivers State-of-the-Lab Talk



**PPPL Director Rob Goldston presents his State-of-the-Lab address to a full house in the MBG Auditorium on November 22. He shows the audience a sextant while comparing fusion research with solving the problem of longitude at sea. The sextant is used for finding latitude.**

**O**n November 22, PPPL Director Rob Goldston delivered his annual State-of-the-Lab talk, this year titled, “What is Fusion Research Like?” Addressing a full house in the MBG Auditorium, Goldston summarized the answer by saying, “Fusion research is long term, scientifically challenging, and critical to the nation and the world.”

As in previous years, this talk was marked by a nautical theme. Goldston noted that budget issues and the challenges of explaining fusion are similar to those faced



*The staff enjoy Goldston's talk.*

by 18th century scientists trying to determine longitude at sea.

Goldston also discussed the Lab’s accomplishments during the past year and plans, the importance of doing all operations safely, noted new employees and promotions, and congratulated staff on awards received during the past year. “Teamwork is how we succeed,” he said.

Prior to the talk, the Director hosted a breakfast for all staff in the LSB Lobby. Following it, he presented the Kaul Prize for Excellence in Plasma Physics Research and Technology Development to PPPL physicist Taik Soo Hahm and the PPPL Distinguished Engineering Award to PPPL engineer Wayne Reiersen (*See page 6*). ●

## PPPL Celebrates America Recycles Day

**T**he Laboratory celebrated America Recycles Day on November 15 with a lunchtime information event in the Lobby. Organized by PPPL’s Margaret Kevin-King and Thomas McGeachen, it included displays and promotional items from the Federal Energy Management Program, Marcal, the Mercer County Improvement Authority, the New Jersey Department of Environmental Protection, and PPPL.

“We had a good turnout — about 10 percent of the Lab’s staff stopped by for information about recycling and buying recycled products,” said McGeachen. This was the eighth consecutive year the Lab marked the day.

The PPPL display included information about the Laboratory’s recycling program and its efforts to buy recycled products. Kevin-King said, “In Fiscal Year 2005, the office trash recycling rate at PPPL was 53 percent, which is 2 percent more than it was the year before. The construction trash recycling rate was only 12 percent, so

we have to improve in this area.” She added, “Thanks to all PPPL staff for their continual support and efforts in recycling and buying recycled content products!” ●



*PPPL'ers stop by the Lab's recycling display during the America Recycles Day event in the LSB Lobby.*



# Science on Saturday — Twenty Two Years and Going Strong

Operations on the Tokamak Fusion Test Reactor were in full swing and the Princeton Beta Experiment — after being converted from the Princeton Divertor Experiment — was creating kidney-shaped plasmas for one second. And for the first time, a group of high school students came to hear science lectures through a new program called Science on Saturday.

The year was 1984 and the place was PPPL. By 1989, the Science-on-Saturday program drew more than 100 high school students, parents, teachers, and area residents to hear talks that focused on fusion, lasers, space studies, fiber optics, and immunology. The program, initiated by former PPPL'ers Fred Dylla and Dennis Manos, was part of the Lab's educational outreach. As Dylla stated in a 1990 letter, "The intent of the program is to bring together students and scientists from Princeton University and New Jersey corporate research laboratories for lectures and discussions on recent developments in science and technology ... We hope this program will generate enthusiasm for science and, perhaps, motivate interested students toward pursuing science careers."

Fast forward to the present.

The goal is still the same, and now the wintertime Saturday morning lecture series draws an average of more than 300 people of all ages to hear about topics that range from evolution to fusion and from forensics to microbiology. This year's series kicked off on January 14 and will conclude on March 11 (see link to listing of talks on the web at [www.pppl.gov](http://www.pppl.gov)).

PPPL engineer Ronald Hatcher, co-organizer of the series, said, "Our challenge is to present a program that is timely in terms of research topics, varied, and accessible to a primarily lay audience. It is encouraging to see how well the lectures are received by the community, and that with each year the popularity of Science on Saturday continues to grow."

Co-organizer James Morgan, involved with the program for the past eight years, said, "Almost every lecture draws an overflow capacity crowd. Our team begins working on getting speakers months before the series begins, always with an eye for a balance of interesting, current, and sometimes provocative science-based talks. It is so rewarding to see how much everyone who attends — students and seniors alike — get out of the lectures." ●



*A collage with a sampling of photos from Science-on-Saturday talks, including PPPL physicist and Nobel Laureate Russell Hulse (far left, second row), PPPL's David Cylinder (far right, third row), and U.S. Congressman Rush Holt (middle, fourth row).*

# PPPL Researchers Receive Accolades

**P**PPPL physicist Taik Soo Hahm received the Kaul Prize for Excellence in Plasma Physics Research and Technology Development. Hahm was cited for his analysis of plasma simulations and measurements in fusion energy research. Plasma is a hot, gaseous state of matter used as the fuel to produce fusion energy — the power source of the sun and the stars. Princeton University awards the Kaul Prize to recognize a recent outstanding technical achievement in plasma physics or technology development by a full-time, regular employee of PPPL. ●



**P**PPPL's Nathaniel Fisch has been named the 2005 recipient of the American Physical Society's James Clerk Maxwell Prize for Plasma Physics. The prize recognizes Fisch for his outstanding contributions to the field of plasma physics. It was given at the APS-Division of Plasma Physics annual meeting in Denver in October. Fisch was cited "For theoretical development of efficient radio frequency-driven current in plasmas and for greatly expanding our ability to understand, to analyze, and to utilize wave-plasma interactions." He was honored for his work in predicting new ways to drive electric current in hot, magnetized plasma by means of electromagnetic waves, and for his larger innovations in techniques to use radio frequency waves to interact with particles in plasmas. The wave-induced currents predicted by Fisch can enable fusion reactors, called tokamaks, to operate continuously, which is necessary for an economical and practical fusion reactor.



Fisch is Professor of Astrophysical Sciences and Director of the Program in Plasma Physics at Princeton University. He also is an Associated Faculty in the Department of Mechanical and Aerospace Engineering. At PPPL, he is the Associate Director for Academic Affairs and the Head of the Laboratory's Hall Thruster Experiment. ●



**W**ayne Reiersen, an engineer at PPPL, received the PPPL Distinguished Engineering Fellow Award in November. The Lab honored Reiersen for his technical and leadership contributions to many machine design studies and most notably the National Compact Stellarator Experiment (NCSX). NCSX is a fusion experiment being built at PPPL. ●

**B**ill Tang, PPPL Chief Scientist, recently received the Chinese Institute of Engineers-USA (CIE-USA) Distinguished Achievement Award. The Institute honored Tang "for his outstanding leadership in fusion research and contribution to fundamentals of plasma science." He received the award at the 2005 CIE Convention in October in Newark.



Tang also is the Associate Director for the Princeton Institute for Computational Science and Engineering. The Institute was recently established at Princeton University to stimulate progress in innovative computational science via interdisciplinary alliances involving computer science, applied mathematics, and prominent applications areas in the physical sciences and engineering disciplines. ●

**P**PPPL's John Krommes was among four Princeton faculty members named as recipients of Graduate Mentoring Awards by the McGraw Center for Teaching and Learning. They were honored during the Graduate School's hooding ceremony in May. The McGraw Center, together



with the Graduate School, instituted the award in 2002 to recognize Princeton faculty members whose work with graduate students is particularly outstanding. It is intended to honor faculty members who nurture the intellectual, professional and personal growth of their graduate students. ●





**Hong Qin (left) and DOE Office of Science Director Ray Orbach during the DOE Award ceremony on June 13.**

**P**PPPL physicist Hong Qin received the Presidential Early Career Award for Scientists and Engineers at a ceremony in Washington, D.C., June 13. Qin was among 58 researchers supported by eight federal departments and agencies who received the award. The Presidential award is the highest honor bestowed by the U.S. government on outstanding scientists and engineers who are beginning their independent careers.

Each Presidential award winner received a citation, a plaque, and a commitment for continued funding of their work from their agency for five years. John H. Marburger III, Science Advisor to the President and Director of the Office of Science and Technology Policy, presented the awards.

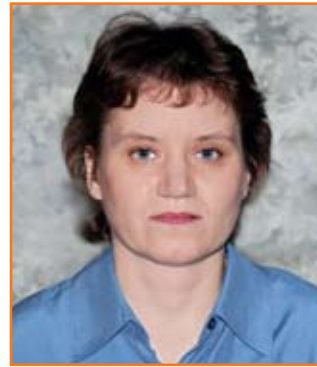
Qin also received the DOE's Office of Science Early Career Scientist and Engineer Award at a separate ceremony June 13 at DOE Headquarters.

Both the Presidential and DOE awards cite Qin for his contributions to the physics of high-intensity particle beams, with application to ion-beam fusion energy, and for his work on electromagnetic effects in magnetically confined plasmas, with application to magnetic fusion energy. ●



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**T**he American Physical Society's Division of Plasma Physics (APS-DPP) named PPPL physicist Cynthia Phillips an APS Fellow in October. Phillips received the lifetime appointment in recognition of "her theoretical and experimental contributions to the understanding of radio frequency wave-particle interactions in fusion plasmas." In fusion experiments, radio waves are used to heat and drive current in the plasma. Researchers choose waves with characteristics for interacting with the ions or electrons in the plasma that cause the ions or electrons to move faster and thereby raise the temperature. ●



**I**n October, the American Physical Society's Division of Plasma Physics (APS-DPP) honored PPPL scientist Elena Belova by presenting her with the Katherine E. Weimer Award for Women in Plasma Physics. The Weimer Award recognizes Belova for her outstanding achievement in plasma science research,

citing her for pioneering analytical and numerical contributions to the fundamental physics of magnetically confined plasmas. The award is given to recognize and encourage outstanding achievement in plasma science research by a woman physicist in the early years of her career. Weimer (1919-2000) was a pioneering woman physicist at PPPL. ●



**D**ale Meade, who recently retired from PPPL, has been named a recipient of the Fusion Power Associates (FPA) 2005 Distinguished Career Award. The FPA announced the honorees in July. In selecting Meade, the FPA Board recognizes his decades of "outstanding contributions to the fusion effort, including but not limited to his roles in leading the Tokamak Fusion Test Reactor (TFTR) and Next Step Options programs and his inspirational guidance in the search for an affordable path to fusion power." ●

# PPPL Receives Funds for Mathematics Research

PPPL's Wei-li Lee, along with Mark Adams of Columbia University, has been awarded \$1.7 million over three years for plasma particle simulation research. The research award is funded by the Department of Energy (DOE) Office of Science's Multiscale Mathematics Program, which addresses science problems that span many time scales — from femtoseconds\* to years — and many length scales — from the atomic level to the macroscopic. The problems cannot be easily broken down into simpler problems for solutions using traditional mathematical techniques.



Wei-li Lee

“Science is replete with examples that range over orders of magnitude in length and time scales,” said Raymond L. Orbach, Director of the Office of Science. “Brute force computational simulation, even on the most powerful present-day computers, cannot handle these ranges, so new mathematics is needed. This initiative is meant to surmount this barrier to our understanding of nature.”

Lee and Adams, joined by PPPL's Stephan Ethier, Hong Qin, and Ed Startsev, will develop numerical algo-

gorithms\*\* and computer codes that describe the complex behavior of magnetized plasmas. These cover a range of time and spatial scales and will be used to solve equations relating to ion cyclotron waves and various modes of plasma behavior that affect plasma stability and confinement. Ion cyclotron waves are used to heat plasma.

## Wide Applications

The codes developed by the team will have wide applications in fusion and space physics, as well as astrophysics, and will provide training for graduate students and post docs who are interested in computational plasma physics. The new project will sponsor a short summer school in collaboration with the interdepartmental Program in Integrative Information, Computer and Application Sciences (PICASSo) of Princeton University, for the students and young researchers from the U.S. and abroad.

In DOE's Multiscale Mathematics Program, 13 major research awards totaling \$20 million will go to 17 universities and eight national laboratories. The program will fund more than 100 researchers who will use higher-level mathematics to help solve problems in energy production, pollution cleanup, manufacturing ever smaller computer chips, and making new nanomaterials. ●

\* A femtosecond is one millionth of a nanosecond.

\*\* An algorithm is a procedure or formula for solving a problem.

# Department of Energy Honors Meade and Schmidt



During a joint retirement party for PPPL scientists Dale Meade and John Schmidt in July, N. Anne Davies, Associate Director for Fusion Energy Sciences at the DOE Office of Science, presented Meade (left) and Schmidt with DOE Distinguished Associate Awards signed by Energy Secretary Samuel Bodman.