DOE Princeton Plasma Physics Laboratory

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# HOTLINE

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

# Energy Confinement Breakthrough Achieved on CDX-U Machine


*Outside the CDX-U/LTX test cell are (from left) Dick Majeski, Leonid Zakharov, and Bob Kaita. The trio headed a team of PPPL researchers whose work led to the energy confinement breakthrough on CDX-U.*

Confining energy long enough in plasmas for fusion reactions to occur is a key concern for making fusion energy a practical reality. The challenge of controlling energy loss from the cool plasma edge is one of the reasons why fusion reactors have to be very large. One possible solution is to use liquid lithium as a plasma-facing material that can retain cool particles, and keep the plasma edge hot. For the first time, experiments on PPPL's Current Drive Experiment-Upgrade (CDX-U) have demonstrated that a liquid lithium plasma-facing surface can dramatically increase the energy confinement in a fusion device. These results were presented by PPPL physicist Bob Kaita at the American Physical Society's Division of Plasma Physics meeting, held in Philadelphia October 30 through November 3.

Three conditions must be satisfied for fusion reactions to occur. The ions in the plasma all have the same charge, and thus repel each other. This means that first of all, the temperature of the plasma has to be high enough, so that the ions have enough energy to overcome this repulsion and fuse together. Second, the plasma must have sufficient density, so that the ions collide often enough for fusion to occur. Finally, the energy in the plasma has to be confined for a sufficiently long time, so that high temperature required for fusion can be maintained.

Up until now, it was commonly thought that fusion reactors had to be very big to satisfy these three criteria. This is because when the plasma hits the solid wall of a conventional tokamak, some of its particles are neutralized. These cool particles reenter the plasma where they are re-ionized. The process is called "recycling," and it cools the plasma edge. "It means that to maintain a hot plasma core, you must keep it away from the cool edge. The principle is similar to why hot water cools off a lot faster in a small cup than a large kettle, and it determines the size of fusion reactors," noted Kaita.

A few years ago, a team of PPPL researchers, led by Kaita, Dick Majeski, and Leonid Zakharov, began an effort to challenge this idea in CDX-U. Inside the device, they put

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## ITER Leader Speaks at PPPL

*Norbert Holtkamp, the Principal Deputy Director General Nominee for ITER, spoke to PPPL staff about the status of the ITER Program on September 25 in the MBG Auditorium. His visit to PPPL also included a tour and a fusion presentation by PPPL Director Rob Goldston.*

# PPPL Honored for Pollution Prevention Efforts

*At the presentation of the Pollution Prevention and Environmental Stewardship Accomplishment Award are, from left, Margaret Kevin-King, Thomas McGeachen, Joe Franchino, Charles Kircher, PPPL Deputy Director Rich Hawryluk (holding plaque), DOE Princeton Site Office Manager Jerry Faul, Craig Salmon, and Keith Rule.*

Use of bio-based products in Fiscal Year 2005 landed PPPL a pollution prevention award. The U.S. Department of Energy (DOE) presented the Laboratory's Maintenance and Operations, and Materiel and Environmental Services staffs with the Pollution Prevention and Environmental Stewardship Accomplishment Award this spring in recognition of "outstanding commitment to pollution prevention and environmental stewardship through the use of bio-based products in hydraulic systems and cleaning products." This is the second year the Lab received the award.

PPPL was honored for using bio-based hydraulic fluid in the renovation of the L-wing building and RF building elevators, as well as Restore products to clean all restrooms and floors. Restore uses no OSHA listed hazardous ingredients in its products.

"When the L-wing elevator was being replaced, we had to clean up contaminated dirt at the bottom of the elevator because petroleum-based fluid was used to operate it. The removal process was costly. The new elevator at L-wing and at the RF building now use vegetable-based hydraulic fluid, which won't contaminate dirt at the base if there is a leak," said PPPL Pollution Prevention Coordinator Tom McGeachen. While bio-based fluid is more expensive, there is significant savings in environmental and potential clean-up costs, he noted.

DOE Princeton Site Office Manager Jerry Faul gave PPPL Deputy Director Rich Hawryluk a plaque in September. Staff involved in the elevator renovations and maintenance received certificates. "I feel good the Lab received the award two years in a row," McGeachen said. ●


## Hotline

**Editor/Writer:** Patti Wieser **Graphic Artist:** Greg Czechowicz
**Photographer:** Elle Starkman **Layout:** Patti Wieser and Greg Czechowicz

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## CDX-U

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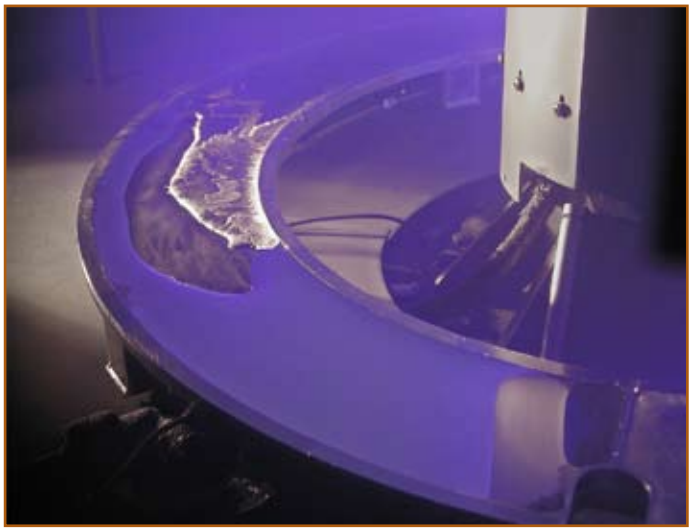
a tray that completely encircled the bottom of the machine, and filled it with liquid lithium (See photo). This small pool of lithium was about 4 inches (10 centimeters) wide and only a tenth of an inch (3 millimeters) deep.

Lithium is the same element that is commonly found in commercial batteries. It reacts very readily with hydrogen, which is the primary constituent of fusion plasmas. By reacting with the hydrogen, the lithium "soaked up" the particles in the edge of the CDX-U plasma. This lowered the recycling, so the particles that made it to the edge did not reenter and cool the plasma. It was as if the plasma was enclosed in a thermos bottle that reduced the outward flow of heat.



***Plasma in CDX-U, resting above liquid lithium in a tray on the bottom of the machine. The lithium pool is about 4 inches (10 centimeters) wide and a tenth of an inch (3 millimeters) deep.***

From earlier investigations on CDX-U, an energy confinement of about one millisecond was expected. This is what was observed before lithium was introduced into the CDX-U tray. When the tray was filled with lithium, however, energy confinement times up to six milliseconds were measured. This indicated an enhancement in energy confinement time that was far greater than anything ever achieved for resistively-heated plasmas.

Kaita said, "These results have exciting implications for the practicality of fusion energy. If the walls of fusion reactors can be made of a low-recycling material like liquid lithium, they can be made more compact. Bigger machines mean more cost, so any scheme that would reduce their size will help make fusion commercially feasible."

CDX-U is now being converted to the Lithium Tokamak Experiment (LTX). *(See PPPL Information Bulletin, June 2006.)* LTX will continue CDX-U's promising innovative work. In CDX-U, the plasma just contacted the lithium in the tray at the bottom of the vacuum chamber. By contrast, the LTX plasma will be enclosed in a heated conductive shell coated with molten lithium on the inside and shaped to conform to the boundary of the plasma. PPPL researchers believe that LTX may herald in a new regime of plasma performance with improved stability, lower impurity levels, better particle and temperature control, and more efficient operation. The new device will begin operation in the spring of 2007. ●

# Dog Heaven — PPPL's Zimmer Receives High Marks for Dog Park

***Zimmer (above with two visitors to the park) opened Rocky Top in 2001 off Route 27 north of Kingston. For more information about the park, check out the web site at: http://www.rockytopdogpark.com/***

Gretchen Zimmer's Rocky Top Dog Park fetched a spot in PETA's list of North America's Best Dog Parks. PETA (People for the Ethical Treament of Animals) and visitors to the group's web site named the top 10 dog parks in North America, where Rocky Top bit off the number four spot. Congratulations, Gretchen! ● *— From PETA Media Center*

### *PPPL's Starkman Takes Hound to Rocky Top Park for Special Occasion*

PPPL staff photographer Elle Starkman took Neo (both at right) to Rocky Top Dog Park recently to participate in Doodle Romp. Neo met furry friends of his persuasion (Labrador-Poodle combinations) as well as Golden Retriever-Poodle mixes, romping in the pond and along the wooded paths. ●

## Spotlight

**Name:** Jim Graham

**Position:** Facility Services Manager in the Environment Safety & Health and Infrastructure Support Department, with responsibility for space allocation, office planning, and office and lab renovations. Graham also develops PPPL's 10-year facilities and infrastructure site plan, and manages the Cafeteria contract, as well as the Lab's procedures policies, and organization and mission statements. In addition, he supports safety initiatives and wrote the Integrated Safety Management (ISM) description document. He also serves as the Technical Standards Manager, interacting with the Department of Energy on standards.

**Quote:** "At PPPL, I get to do a lot of different things. I am constantly learning and facing new challenges," Graham says.

He came to PPPL as an Ebasco subcontractor in 1989 and a year later joined PPPL's staff as a quality assurance engineer. Eventually he joined the Lab's process improvement group and became involved in the ISM program.

Among his duties, Graham reviews technical standards drafts from the Department of Energy. These range from qualifications for safety workers and quality standards for the use of HEPA filters to electrical and chemical safety, tritium standards, and fusion device safety standards.

Graham described a typical day at work. He begins each morning dropping by the Cafeteria to make sure it is fully staffed and all the equipment is operating. Some days he attends a status meeting about the Cafeteria subsidy, followed by checking on the status of various maintenance improvements on an existing lab at PPPL, working closely with members of the maintenance and operations staff on improvements. Next, he might test water from some of the Lab's 25 water fountains, and consider options when copper content is found in the samples. Each day includes meetings, writing, and revising documents and schedules, updating procedures and reviewing revisions, as well as looking at minor modifications to facilities such as planning the relocation of staff and offices.

Graham began his professional career as a mathematician. After receiving a bachelor's degree in mathematics from the Polytechnic University of New York, he began working as a cryptologic mathematician at the National Security Agency. He then worked at Ebasco for seven years as a quality assurance engineer. At PPPL, a combined focus on education and new opportunities keep him interested in staying on staff.

He recently began a management certificate course at Princeton University, and is working on an MBA at the New York Institute of Technology. "It's nice here because you get to round yourself off with different tasks, but also you get to work on continuing your education."

**Other interests:** Graham is a Brooklyn native who grew up in Cooperstown, surrounded by seven older siblings and the constant celebration of baseball. "I played baseball through high school and college, and a little after that," he says. Some of his college teammates formed a team after they graduated and competed in local Brooklyn leagues for a few years. Graham later coached his two sons when they were on baseball and basketball teams.

In addition to baseball — he is a diehard Dodgers fan, which he attributes to his Brooklyn roots — Graham enjoys improving the home he shares with his wife, Mary Jean, and sons James and Daniel. Work includes redoing rooms, tiling, and window replacements. "I like to go into a room I've remodeled and look at how the space has been improved. It gives me a sense of accomplishment," he says. ●