PPPL
U.S. DEPARTMENT OF ENERGY

PRINCETON PLASMA PHYSICS LABORATORY WEEKLY

MONDAY, NOVEMBER 7, 2011

At PPPL THIS WEEK

TUESDAY, NOVEMBER 8 (Election Day)

PPPL Logo Rollout Party
2 p.m. - LSB Lobby

WEDNESDAY, NOVEMBER 9

PPPL Colloquium
4:15 p.m. ◆ MBG Auditorium

Climate Sensitivity

Professor Richard Lindzen (MIT)
CLICK HERE FOR ABSTRACT

THURSDAY, NOVEMBER 10

United Way Kickoff Meeting
1:30 p.m. - 2:30 p.m. ◆ MBG Auditorium

Presentations–Refreshments–Giveaways

GFDL Events and Seminars
2 p.m. - 3 p.m. ◆ GFDL
Smagorinsky Seminar Room

Quantifying Uncertainty in Predictions of 21st Century Warming

Dan Rowlands
(University of Oxford, UK)
www.gfdl.noaa.gov/events
(Gov't, Univ. or 2 other forms of I.D. needed)

MacLean House Lecture
3 p.m. - 4 p.m.
101 McCormick Hall, Princeton Univ.

Climate Change, Nuclear Power and Nuclear Proliferation: Magnitude Matters

Robert Goldston (PPPL)

FRIDAY, NOVEMBER 11 (Veteran's Day)

Veteran's Day Observance
8:30 a.m. ◆ Princeton Univ. Chapel

Remarks by Alan W. Lukes

DIII-D Science Meeting
1 p.m. - 2:30 p.m. ◆ B-233

Directors Corner

Positive Reviews for NSTX-Upgrade

By **Stewart Prager** - Director, Princeton Plasma Physics Laboratory

Last week was a terrific and significant one for NSTX. DOE held a review — a "Lehman Review" — of the NSTX-Upgrade project to assess the validity of the final design, cost and schedule, and management practices. This review lays the basis for the upcoming decision of DOE (critical-decision-3) to authorize the start of upgrade construction. The outcome was enormously favorable. The review committee recognized the superb work of the NSTX-Upgrade team in all aspects: engineering, construction, management, openness and transparency. With this endorsement of the project, we anticipate receiving CD-3 approval shortly. This series of DOE reviews assures that projects adhere to the highest levels of excellence. We congratulate the NSTX-Upgrade team on their superb accomplishments to date and a very successful review.

The NSTX-Upgrade will establish the basis for the spherical tokamak as a candidate for a fusion nuclear science facility, will explore novel solutions to the plasma-material interface, and will provide access to new regimes to reveal physics key to the spherical tokamak, to ITER, and beyond. PPPL will have the pleasure of hosting the newest magnetic fusion facility in the U.S.

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Bottling Magnetic Reconnection

By John Greenwald

With the click of a computer mouse, a scientist at the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) sends 10,000 volts of electricity into a chamber filled with hydrogen gas. The charge heats the gas to 100,000 degrees Centigrade. In an instant — one-thousandth of a second, to be precise — a process called "magnetic reconnection" takes place.

Researchers have run this and similar experiments — called "shots" — more than 100,000 times since 1995 and amassed volumes of data and numerous scientific papers. The carefully controlled shots recreate one of the most common but least understood phenomena in the

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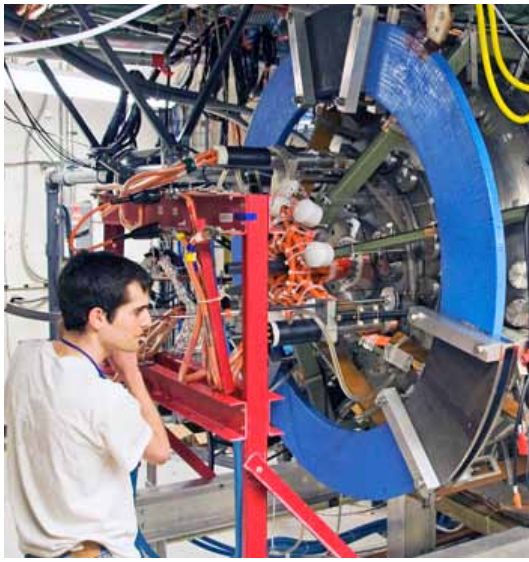

The Magnetic Reconnection Experiment (MRX) at PPPL.

MRX

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universe — one that gives rise to the northern lights, solar flares and geomagnetic storms and that can disrupt cell phone service, black out power grids and damage orbiting satellites.

Researchers at PPPL have brought this basic process down to earth in miniature where it can be studied under laboratory conditions. "Here we can actually recreate reconnection," said Masaaki Yamada, a PPPL physicist and principal investigator for the Magnetic Reconnection Experiment (MRX), the leading project of its kind in the world. "This is not theory or a computer simulation." Hantao Ji, principal research physicist at PPPL for MRX, concurred: "This provides a chance to see what's really going on in reconnection."

The experiments seek to unravel the secrets of magnetic reconnection and gain insights whose benefits could include:

- Improved prediction of solar outbursts and dangerous geomagnetic storms to allow for advanced warning.
- Greater control of the nuclear fusion reactions that PPPL researchers are studying as a clean fuel for generating electric power.
- Increased understanding of the formation of the sun and stars.

Magnetic reconnection takes place when magnetic lines of force — or field lines — break apart and reconnect with a violent burst of energy that in huge bodies like the sun and stars has the explosive power of millions of tons of TNT. This occurs when superheated and electrically charged gases called plasmas converge. Plasmas consist of electrons and ions — atoms that have been stripped of one or more electrons — and are the basic stuff of the sun and stars.

"Plasma processes, such as reconnection, influence the behavior of astronomical objects of all sizes, from solar flares to jets that travel through galaxies," said Stewart Prager, director of PPPL. "One of the goals of PPPL is to understand the plasma universe, and MRX is making enormous contributions to that mission."

A key puzzle is why magnetic reconnection takes place in the sun many thousands of times faster than the best theories say that it should — a puzzle that makes volatile "space weather" hard to forecast. "You can't predict solar storms when you don't understand reconnection," noted Princeton University astrophysicist James M. Stone.

Such tempests occur when reconnection causes huge plasmas to erupt from the sun and slam into the Earth's magnetosphere — the magnetic field that surrounds the planet — with a potentially damaging impact. One such eruption stirred up a geomagnetic disturbance that blacked out the Canadian city of Montreal and most of the province of Quebec for nearly 12 hours in 1989. Solar outbursts occur in 11-year cycles with a new cycle now starting and expected to reach a peak — or "solar maximum" — in 2013.

MRX researchers are gradually zeroing in on the mechanism behind the mysterious rate of reconnection that triggers the storms. Laboratory findings show that the electric current that is embedded — or "frozen into" — merged plasmas suddenly dissipates, enabling reconnection to take place. Further experiments have confirmed that part of the reason for the abrupt dissipation is that the ions and electrons inside the plasmas have different velocities. The electrons thus behave differently from the ions, as measured by a phenomenon called the "Hall effect," and carry away the current to help speed up reconnection.

Such discoveries are redefining traditional notions of how reconnection works. "The MRX is uncovering new physics that is modifying the theories that we thought had explained reconnection," said astrophysicist Russell Kulsrud, a Princeton University professor emeritus who is participating in the project. Through the MRX, PPPL scientists have "made many detailed measurements and (are) discovering many new things that we don't understand," Kulsrud added.

MRX findings will help guide a four-satellite exploration of reconnection that NASA scientists plan to launch in 2014. The spacecraft will sweep through the magnetosphere on a multi-year mission to study the regions where reconnection takes place. "We hope to provide a database that will tell (NASA) what kind of data-taking is most efficient," Yamada said.

Knowledge of space weather will be vital to the safety of crews of possible future missions to Mars. The astronauts could be exposed to high levels of radiation if solar storms were to break out during flight. So the ability to pinpoint the timing of reconnection events that could lead to such storms is crucial, Yamada noted.

Magnetic reconnection underlies the brilliant auroras that light the night sky near the north and south poles. Auroras occur when relatively low-energy plasmas that stream from the sun connect with the magnetosphere and produce heated particles that give rise to the light shows. These plasma flows from the sun are known as "solar wind."

Magnetic reconnection is also suspected to be behind the extraordinary bursts of radiation that have emerged from the center of the Crab nebula — the remains of an exploded star — some 6,500 light years from Earth. Scientists

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MRX

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trace the bursts to electrons that have accelerated to the highest level of energy ever observed in a fixed celestial body.

"You need something like reconnection to explain these very high-energy particles," said astrophysicist Jonathan Arons of the University of California at Berkeley.

Perhaps the most basic issue related to magnetic reconnection is its role in the creation of stars, which begin as clouds of charged particles that collapse under gravity into fiery plasma spheres. Accompanying this process is the reconnection of magnetic field lines that are present in the original cloud and must separate out for the star to be born. All this happens much faster than current theory indicates, noted Kulsrud. So MRX experiments "are constructed to find out the physics of what's actually going on."

Closer to home, reconnection creates a disruption in plasmas during nuclear fusion experiments like those under way at PPPL. This disruption can force fusion reactors to shut down. Improved knowledge of reconnection would thus advance the development of fusion as a clean source of energy for generating electricity.

PPPL launched the MRX project in 1995 under the direction of Yamada to increase understanding of the disruptive turbulence. The experiment soon caught the eye of the astrophysical community, which saw a benefit for its own field of study. "If you're in space you observe what happens," said University of Maryland physicist James Drake.

"In the lab you can vary the experiments, which provides a new avenue for exploring the process."

This approach centers on the MRX device, which resembles a large steel barrel attached to arrays of tubes and wires. Inside are two doughnut-shaped coil systems called "flux cores" that produce plasmas whose magnetic field lines reconnect while tiny probes measure the results. "The important part is that we can create with control and then study the reconnection process," Yamada said. "In nature you cannot."

Such hands-on capability is the key to the MRX project, which is funded by several federal agencies including: the U.S. Department of Energy; the National Science Foundation; the Office of Naval Research; and NASA. ■

Trick or Treat

PPPL'ers celebrated Halloween on October 31st. From left are Marianne Tyrrell, Cassandra Pugh, Gretchen Zimmer, Sonja Patterson and Michael Gonzalez.

Photo montage by Elle Starkman

Lehman Review

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This review caps a tumultuous summer for the NSTX team. On July 20, an arc in the toroidal field center stack terminated experimental operations. Through the technical investigation and extensive strategic discussions that followed, it became clear that the wisest course is to begin the 2.5 year outage for the upgrade as soon as possible, leading to an earlier beginning of experiments with the upgraded NSTX plasma. While this will increase our physics productivity when viewed over five years, we are currently constructing a collaborative research program for the NSTX team that will assure its continued productivity in the near-term and provide an exciting research program for each NSTX researcher.

A closing recommendation of the review committee is to "proceed aggressively with the advanced early finish schedule" for the upgrade. The team is now going full blast to do just that. ■

2011
United Way Campaign
PPPL KICKOFF

Thursday, November 10

1:30 P.M. - M.B. Gottlieb Auditorium

Presentations Refreshments Give-A-Ways

Princeton University contributes an additional 15% for all gifts made through payroll deduction or 10% for all gifts made by cash or check.

LIVE UNITED™ United Way

Submit your pledge cards on or before the kickoff meeting to participate in the raffle.

PPPL

PPPL and Princeton University UNITED WAY CAMPAIGN

November 9 to December 7

COLLOQUIUM

CLIMATE SENSITIVITY

PROFESSOR RICHARD LINDZEN
(Massachusetts Institute of Technology)

Wednesday, November 9
4:15 p.m. (Coffee/Tea at 4 p.m.)
M.B. Gottlieb Auditorium, Lyman Spitzer Building

PPPL

PPPL LOGO ROLLOUT PARTY

TUESDAY, NOVEMBER 8
2 P.M. — LSB LOBBY
EVERYONE IS INVITED
REFRESHMENTS — SOUVENIRS

America Recycles Day
November 15

CELEBRATE America Recycles Day with PPPL

Lobby Displays ♻ Presentations
Come and learn what happens to PPPL's compostables.

Take a pledge and enter to win a free lunch in the Cafeteria or a Plasma Hutch $10 gift card!

Tuesday, November 15
10:30 a.m. to 1:30 p.m.

PPPL CAFÉ MENU

MONDAY, NOV. 7

Santa Fe Chicken with Roasted Corn Salsa, Rice
Grill: ***Triple X Turkey Burger Wrap***
Deli: Turkey, Swiss Wrap
SOUP DU JOUR: CREAM OF BROCCOLI

TUESDAY, NOV. 8

Create Your Own Vodka Rigatoni Bar
Grill: ***Chicken Cheese Steak***
Deli: Waldorf Chicken Salad on Pita
SOUP DU JOUR: EGG DROP SOUP

WEDNESDAY, NOV. 9

Top Round Roast Beef with Brown Rice and Vegetable
Grill: ***Italian Hot Dog + Spicy Fries***
Deli: Salami, Pepperoni, Provolone
SOUP DU JOUR: PUMPKIN BISQUE

THURSDAY, NOV. 10

Turkey Meatloaf with Mashed Potatoes & Veg.
Grill: ***Chicken Finger Parm. Hoagie***
Deli: Tuna Nicoise on Brioche
SOUP DU JOUR: 7 BEAN

FRIDAY, NOV. 11

Chicken Divan served with Steamed Potatoes
Grill: ***Chicken Quesadilla***
Deli: Turkey, Provolone, and Bacon
SOUP DU JOUR: TURKEY CHILI

MENU SUBJECT TO CHANGE WITHOUT NOTICE

CLICK HERE FOR FULL WEEKLY MENU

WEEKLY

Editor: **Patti Wieser** ◆ Copy Editor /Graphic Design: **Gregory Czechowicz**
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PPPL WEEKLY is published by the PPPL Office of Communications on Mondays throughout the year except for holidays.
Deadline for calendar item submissions is noon on Thursday. Other stories should be submitted no later than noon on Wednesday.
Send to: pwieser@pppl.gov ◆ Comments: commteam@pppl.gov

PPPL WEEKLY is archived on the web at: **http://www.pppl.gov/ppplweekly.cfm**