PPPL U.S. DEPARTMENT OF ENERGY

PRINCETON PLASMA PHYSICS LABORATORY WEEKLY

MONDAY, NOVEMBER 12, 2012

SPECIAL APS physics ISSUE

At PPPL THIS WEEK

MONDAY - FRIDAY, NOVEMBER 12-16

Emergency Management System Annual Surveillance Audit
All Day ◆ PPPL

MONDAY-TUESDAY, NOVEMBER 12-13

Synergize 2012
All Day ◆ Princeton University

MONDAY, NOVEMBER 12

United Way campaign begins

WEDNESDAY, NOVEMBER 14

PPPL Colloquium

4:15 p.m. ◆ MBG Auditorium
"Airborne Wind Energy - Harnessing a Vast, Untapped Renewable Energy Source" Click here to view flyer

Kenneth Jensen, Makani Power Inc.
Refreshments at 4 p.m. in the LSB Lobby

THURSDAY, NOVEMBER 15

America Recycles Day

10:30 a.m. - 1:30 p.m. ◆ LSB Lobby

I ♻ DO YOU? GET INVOLVED > America Recycles Day 11.15.12

UPCOMING EVENTS

November 19 - 22
TOKI Conference - Japan

November 22 - 23
Lab closed for Thanksgiving

November 28
Open Enrollment ends
(Date extended due to Hurricane Sandy)

INSIDE...

Exploring plasma science advances from fusion findings to astrophysical achievements

By John Greenwald

The latest advances in plasma physics were the focus of more than 1,000 scientists from around the world who gathered in Providence, R.I., from Oct. 29 through Nov. 2 for the 54th Annual Meeting of the American Physical Society's Division of Plasma Physics (APS-DPP). Papers, posters and presentations ranged from fusion plasma discoveries applicable to ITER to research on 3D magnetic fields and antimatter. In all, more than 1,800 papers were discussed during the week-long event.

Researchers from PPPL reported on experiments and computer simulations related to tokamak confinement and a variety of other research interests. These included specialized areas such as laboratory and astrophysical plasmas, where PPPL physicist Hantao Ji was prominent as a topic chair and speaker at a tutorial session. Members of the Laboratory's National Spherical Torus Experiment Upgrade (NSTX-U) team gave a tutorial and three invited talks. Physicist Dennis Mueller presented the tutorial on "Physics of Tokamak Plasma Start-up."

The Laboratory sent 135 physicists, science educators and graduate students to the meeting and saw some of its research highlighted in news releases on the APS-DPP website (http://www.aps.org/units/dpp/meetings/vpr/2012/index.cfm). Of the 15 papers highlighted in this manner, seven came from PPPL.

Focus on boundary physics

The meeting focused considerable attention on boundary physics and plasma-material wall interactions, an area of growing emphasis at PPPL. Dennis Whyte, a professor of nuclear science and engineering at the Massachusetts Institute of

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PPPL puts on a hair-raising show at Plasma Science Expo

By Jeanne Jackson DeVoe

Some 2,000 middle and high-school students were electrified by the plasma and energy demonstrations given by PPPL Science Education staff and volunteers during a two-day Plasma Science Expo at the Rhode Island Convention Center in Providence as part of the American Physical Society's Division of Plasma Physics Conference.

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Arturo Dominguez, a postdoctoral fellow in PPPL's Science Education department, and a group of students watch a student's hair stand on end in a static electricity demonstration. (Photo by Deedee Ortiz)

Plasma Science Expo

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Young people who ventured over to the PPPL science booth and tried out the Van de Graaff generator, an electrically charged metal ball, felt their hair stand on end from a static electricity charge.

PPPL's wide variety of activities spread out over four tables was a popular stop for the youngsters at the Expo on Thursday, Nov. 1, and Friday, Nov. 2, which had 10 booths by various national and university plasma science laboratories. Some laboratories did not attend due to the storm.

"I think it went really well," said Arturo Dominguez, a postdoctoral fellow in Science Education. "It was fantastic. We had so many toys and so much cool stuff. I think it really attracts a lot of people and it's a lot of fun."

Youngsters got their hands wet when they moved a soapy bubble around to learn about turbulence in plasmas. They also got a first-hand lesson on energy when they used a bicycle-powered generator to power electric light bulbs. The students soon found that it took much more effort on the bicycle to make the incandescent light bulbs light up versus the LED light bulbs.

The Science Expo is a popular yearly event at the conference that is organized by a committee of representatives from various plasma physics laboratories that includes PPPL Science Education administrator Deedee Ortiz. "It's a way to reach out to communities around the country about what we're doing and why we're doing it," said Andrew Zwicker, head of Science Education.

In addition to John DeLooper, head of Best Practices and Outreach, and the Science Education staff, 16 PPPL scientists and staff members volunteered at the Expo. "The individuals who volunteered had a great time talking to the kids," DeLooper said.

From left, Arturo Dominguez, Xiaoyin Guan and John DeLooper show a teen how to use his energy to light up an incandescent light bulb. The demonstration can switch from incandescent to LED lights to show students how much more energy is needed to light up an incandescent bulb compared with an LED bulb. (Photo by Deedee Ortiz)

The Science Education team arrived in Providence on Sunday, one day ahead of Hurricane Sandy, with a van full of items for the Expo. While there were some power outages in Providence and schools there were closed on Monday and Tuesday, the city was not as hard hit as Shore areas in New Jersey and New York.

DeLooper led a workshop on "Plasma 101" for middle school teachers on Oct. 30 for Science Teachers Day, a day of workshops for middle school and high school science teachers about fusion energy and plasma science. The program "is designed to really give the information to teachers so they can introduce plasma as well as fusion into their lesson plans," DeLooper said. The event went on as scheduled on Tuesday but only 17 teachers attended due to the storm while the event usually attracts up to 100 teachers.

Exploring plasma science

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Technology, presented a major review of the subject to a plenary session. Invited speakers on the topic of plasma-wall and impurity physics included PPPL scientists Filippo Scotti and Dick Majeski, principal investigator for the Laboratory's Lithium Tokamak Experiment (LTX). PPPL physicists Michael Jaworski and Igor Kaganovich participated in a session on plasma-wall interactions, with Jaworski serving as chair and Kaganovich giving the first invited talk in the session.

The importance of boundary physics has been recognized in innovations like the so-called snowflake divertor, which limits the heat on tokamaks' inner walls. The divertor, developed by researchers at PPPL and the DOE's Lawrence Livermore and Oak Ridge national laboratories, won an R&D 100 Award in June from R&D Magazine. The device "reduces both the power flux on plasma-facing components and the influx of impurities into the core plasma," said PPPL physicist Robert Kaita, the head of diagnostics and physics operations for the NSTX-U, and co-principal investigator for the LTX.

Considerable interest also was shown for inertial confinement fusion experiments at the National Ignition Facility (NIF) at the DOE's Lawrence Livermore National Laboratory. Speakers noted that producing fusion by heating a capsule producing energy with high-powered lasers was proving more difficult than expected. NIF scientists now seek to develop a more detailed understanding of the physics of this process in order to achieve ignition.

These press releases were prepared by the APS with the assistance of the scientists quoted as well as writers in the PPPL Office of Communications including Kitta MacPherson, John Greenwald and Jeanne Jackson DeVoe.

What a cup of coffee tells scientists about solar storms

A new theory asserts that a key astrophysical process parallels what happens at the breakfast table

Magnetic fields lines in a highly conducting gas called plasma can be an explosive mix. Solar storms, which involve rapid intermixing of magnetic field lines from different parts of the outer plasma layers of the sun, have disrupted power systems on Earth and interrupted satellite communications. The sudden intermixing of the lines from different sources of magnetic field, which is called magnetic reconnection, has been recognized as a central element in many astrophysical phenomena for more than 60 years.

Solar storm

Cream in coffee

"Existing models of magnetic reconnection can be misleading," says Allen Boozer, a Columbia University professor and long-term visitor at PPPL. Such models view space as if it had only two dimensions, or focus on too little of the region where reconnection takes place, as he states in a paper published in the September issue of Physics of Plasmas.

When magnetic field lines from different sources are pushed together, such as lines from the sun and the Earth, electric currents naturally arise around the contour—or boundary— that separates the two sets of lines. These currents prevent the lines from intermixing but allow large amounts of energy to be stored, which is released if the field lines ever do intermix.

As these currents act to prevent intermixing, they also cause the contour between the magnetic field lines to become contorted and exponentially longer—even billions of times longer—than the width of the region in which the current flows. This happens in three dimensions but not in two. Even reconnection experts are surprised by this enormous increase in the contour length, Boozer says. In a paper that has been accepted for publication in the Physics of Plasmas, he explains why this extreme contour lengthening occurs in realistic three-dimensional space but is missed by two-dimensional models.

Boozer compares magnetic reconnection to what happens with cream in coffee. There is little interdiffusion—or intermixing—of the coffee and cream at first. But even a gentle stirring makes the contour between the coffee and cream grow longer and longer. Soon the length of the contour multiplied by the small distance over which coffee and cream interdiffuse equals the area across the cup—and the coffee and cream completely mix.

As in the cream in coffee example, Boozer notes, the field lines in plasmas of high electrical conductivity can interdiffuse only a small distance across the contour that separates them. Nevertheless, a sudden reconnection of the lines takes place when the product of this small interdiffusion distance times the exponentially increasing length of the contour becomes comparable to the area of the region in which the electric currents flow.

The primary difference between these two mixing examples is that the contour between cream and coffee lengthens as time advances. But for magnetic reconnection, the contour lengthens as the field lines are followed, at any instant of time, through the region in which the electric currents are flowing.

Boozer says, gently stir your coffee and understand magnetic reconnection.

Paper author: A. Boozer

Halo-current effects in tokamak reactors: hardly heavenly

Physicists at PPPL decipher the shape and movement of reactor-squeezing ropes of current

Plasma physicists and fusion reactor engineers call them "halo currents," but they are hardly angelic.

These powerful currents occur under certain rare fault conditions known as "disruptions." If unchecked, they can damage components located inside reactor vacuum vessels. But their shape and form are not well known. Do they form thick ropes or are they more like wide ribbons? How fast do they fly around the tokamaks used to confine hot ionized gases known as plasmas?

While reliable methods have been developed to reduce these currents to acceptable levels, scientists want to learn more about the halo currents to improve the design of tokamak fusion reactors.

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Now, physicists at PPPL, using a ring of specially designed detectors on the National Spherical Torus Experiment, are closing in on some answers. Experiments show that halo currents flow in concentrated bands and move quickly, rotating as many as eight times around the vacuum vessel's inner chamber.

"Improving the understanding of these currents can have important implications for reactor designs," said Stefan Gerhardt, who led the effort to install the sensors that measured the currents. "Engineers will be able to design better experiments if they understand the shape of the currents and the forces they exert on the vacuum vessel."

Doughnut-shaped fusion devices, known as tokamaks, use strong electrical currents to generate the magnetic fields used to confine the plasma. When key components fail or tokamak operators push against known limits, the heat and current in the plasma can suddenly dissipate, a phenomenon known as a "disruption." The resulting halo currents flowing in the hot ionized gases can strike the wall of the vessel, possibly causing local damage. If the halo currents flow around the chamber wall many times, and at a rate similar to the natural vibration frequencies of the chamber, they can distort the vessel.

"Fortunately, we have observed that the instances with the strongest currents are often those with the smallest motion of the currents," Gerhardt said. "This trend, along with the observations from other tokamaks that these currents can be significantly reduced with strong gas puffing, should diminish the potential for 'resonance' damage to the fusion plant from these currents."

Evolution of the plasma during a disruption, as captured by a fast color camera. The plasma is centered in the left-hand frame, moves downward in the center frame, and lands on the floor of the vacuum chamber in the right frame. Large "halo currents" are observed in the indicated ring of detectors at this time.

Paper authors: S. P. Gerhardt, J. Breslau, E. Fredrickson, S. Jardin, R. Kaita, J. Manickam, J. Menard, S. Sabbagh, F. Scotti, H. Takahashi, A. H. Boozer

Scientists find a shortcut to map conditions for sustainable fusion

Results derived from a new computer code are the first to map the full range of conditions required to reliably and safely sustain fusion reactions by alpha particle heating, and could facilitate the development of fusion as a clean and abundant source of energy

Fusion takes place when the atomic nuclei—or ions—in hot, electrically-charged plasma fuse and release energy. The temperatures in these fusion plasmas can reach more than 100 million degrees, igniting the plasma and producing high-energy alpha particles so the plasma heats itself. One challenge for a fusion reactor is how to contain the alpha particles in the vessel long enough for them to efficiently heat the plasma. These fast particles can excite waves in the plasma and be lost, or transported, to the vessel wall rather quickly, much in the same way a surfer rides waves to the beach.

Scientists at PPPL have collaborated with colleagues from other leading U.S. research institutions to develop a method for rapidly distinguishing among various plasma conditions—forming a type of map that highlights regions where alpha particles will likely be well confined and fusion can safely and reliably take place. The new method could help pave the way to the design and construction of fusion devices that can produce a steady flow of fusion energy for generating electricity. Such devices include ITER, a huge international project that is being built in France to demonstrate the practicality of fusion power.

The new study illustrates for the first time the full range of plasma conditions needed to maintain a self-sustaining fusion reaction, and delineates the regions where fast ion driven waves can occur inside the plasma causing unacceptable alpha particle transport.

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"We have found a relatively simple way to quantify these requirements in terms of such easily accessible parameters as plasma pressure, temperature and density," said Nikolai Gorelenkov, an author of the paper that describes the method, which was published online in the journal Physics of Plasmas in August.

The researchers used a new computer code to calculate and plot the regions where fusion reactions can and cannot be easily maintained. The results demonstrate the correct combinations of temperature and a quantity called "beta"—the ratio of the pressure of the plasma to the pressure of the magnetic field that confines it—that are required to have good control of the alpha particles and keep the fusion reaction going.

"The importance of identifying the regions where fusion can take place cannot be overstated when building new devices," said Gorelenkov.

In the past, however, a single point on that figure would have taken the largest supercomputers in the world to calculate self- consistently. Now, with this simplified model, the entire "map" can be produced on a personal computer.

Note: Collaborative work on this paper came from the Institute for Fusion Studies at The University of Texas at Austin; the DIII-D research project at General Atomics in San Diego; and the University of California, Irvine.

Paper authors: K. Ghantous, N. N. Gorelenkov H. L. Berk, W. W. Heidbrink, M. A. Van Zeeland

Fusion plasma works best just where you least expect it

Scientists measure a surprising increase in fusion plasma stability at high performance

A key challenge for fusion researchers has been to maintain the stability of the magnetically confined plasma gas that fuels fusion reactions as scientists elevate the plasma pressure to generate very large fusion power. Now scientists at PPPL have measured an increase in plasma stability where it is least expected—at the high pressure that produces high fusion plasma performance.

This work challenges past scientific thought that efficient, high fusion power performance needs to be sacrificed to sustain continuous energy production.

"Up to this point, scientists have believed that fusion power production needed to be reduced to sustain the energy output," said Steven Sabbagh of Columbia University, who is on long-term appointment at PPPL's National Spherical Torus Experiment (NSTX). "This result shows that you can indeed have both. The present result is somewhat like finding just the right way to stir a cooking pot to keep it hot, but prevent it from boiling over."

Fusion powers the sun and stars. The process takes place when the atomic nuclei—or ions—in the plasma fuse and release energy. Scientists seek to reproduce this process on Earth by creating and controlling plasma inside powerful magnetic fields in fusion devices called tokamaks. Harnessing fusion in this way could produce a virtually limitless supply of clean energy for generating electricity.

Sabbagh and John Berkery of Columbia University, who also is on long-term appointment at PPPL, demonstrated their surprising result with the assistance of co-workers, and now are studying the process theoretically. The researchers performed their experiments on the NSTX before the facility was closed last year for an upgrade that is scheduled for completion in 2014.

The experiments turned up the plasma performance to a very high level that had been thought to be less stable. By using a special stability measurement technique, the scientists surprisingly found that these high performance plasmas in fact became more stable. Present analysis shows that a specific way the plasma rotates inside the machine creates the improved stability.

PPPL Director Stewart Prager remarked, "An historic challenge has been to elevate the plasma pressure to generate very large fusion power and keep the plasma stable. We are encouraged by this fascinating new physics regime in which the pressure is very high, but the plasma stability increases."

The result is especially good news, as it may have uncovered a new way to design devices with both high fusion performance and high stability. "Understanding this result may allow us to create similar rotation conditions in new machine designs that may finally produce more energy than they use," Sabbagh said. "Fusion devices have been significantly limited by stability, and creating the conditions needed to produce this enhanced stability may allow these devices to run more economically."

Paper authors: S.A. Sabbagh, J. W. Berkery

Elements duke it out to penetrate hot plasma

Scientists get a better understanding of why some atoms get into the core of their magnetic fusion experiments more easily than do others

Scientists at PPPL used fast cameras that take up to 100,000 frames per second and computer codes to understand how impurities are produced and can penetrate the core of the hot ionized gas known as plasma during magnetic fusion experiments in the National Spherical Torus Experiment (NSTX).

Impurities can cool the plasma so their accumulation has to be avoided in order to heat the plasma to at least 100 million degrees Celsius. These temperatures are needed in order for the fuel ions to collide into each other at a high speed and fuse together to create magnetic fusion. To understand the sources of impurities, scientists placed high-speed cameras viewing the interior of NSTX during fusion experiments, along with spectrometers that capture the unique light wave produced by the atoms. They were then able to trace what happens when plasma hits the walls of the vessel that holds the plasma inside a magnetic field. In NSTX in particular, the walls of the tokamak are made of graphite and are sprayed with a coating of lithium before each plasma experiment. When the plasma hits the walls of the tokamak, it causes lithium and carbon atoms to bounce off the walls and potentially penetrate the core plasma.

"The idea was to start looking at all the processes that cause impurities to be released at the wall and eventually penetrate the plasma," explained Filippo Scotti, a scientist on the project.

The researchers found there were numerous carbon atoms in the plasma core but very few lithium atoms, despite the layer of lithium on top of the graphite. The lithium erodes fairly quickly from the tokamak walls, exposing the graphite beneath it, but travels only a short distance before bouncing back to the tokamak floor (called a divertor). The lithium ions are then "trapped" more efficiently than carbon in the divertor region. The carbon atoms can escape more easily,

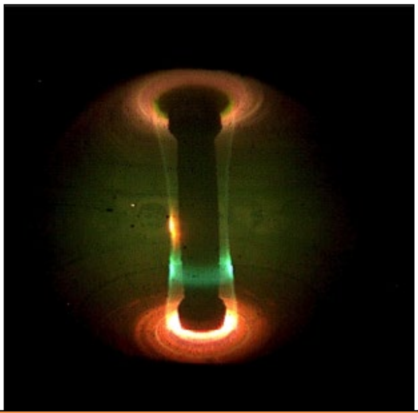

Photo of the interior of the NSTX fusion experiment showing light emitted by the hydrogen, carbon, and lithium atoms in the cooler edge regions of the plasma near where it contacts interior surfaces.

travel along the magnetic lines that contain the plasma and then penetrate the plasma core.

Scientists not only used a fast camera and spectrometers, they also used computer codes to explain how these processes work, leading to the identification of other processes which limit the penetration of lithium ions in the core. In particular, the few lithium ions that make it to the core are dispersed by collisions of carbon ions, which have a higher charge, thereby leading to lower accumulation.

Understanding the processes that generate and transport impurities into the plasma could help scientists find ways to further improve plasma performance. They could investigate using other materials to replace the graphite used in the tokamak, for example, or they could investigate other plasma configurations that would reduce the number of atoms that hit the tokamak walls and floor. In particular this work also highlights the potential of lithium as a material for a reactor first wall thanks to the very low core penetration of lithium ions.

Paper authors: F. Scotti, V. A. Soukhanovskii, R. Kaita

Shedding light on the explosive process behind space plasmas and solar flares

Experiments show the impact of a key magnetic-field component on the speed of magnetic reconnection—the process that triggers solar outbursts

PPPL scientists have shown quantitatively for the first time in a laboratory plasma how the presence of an external guide field affects the rate of magnetic reconnection—one of the most common but least understood phenomena in the universe, and one that gives rise to such events as auroras, solar flares and geomagnetic storms.

Magnetic reconnection takes place when the magnetic field lines in electrically charged gas called plasma snap apart and reconnect with violent force. To date, laboratory experiments have reproduced this process by focusing on field lines that merge in an anti-parallel manner as shown below. But actual reconnection takes place in most cases when the merging field lines come together at distinct angles rather than in an anti-parallel way.

The PPPL researchers set out to explore the impact of guide fields on the speed of reconnection by

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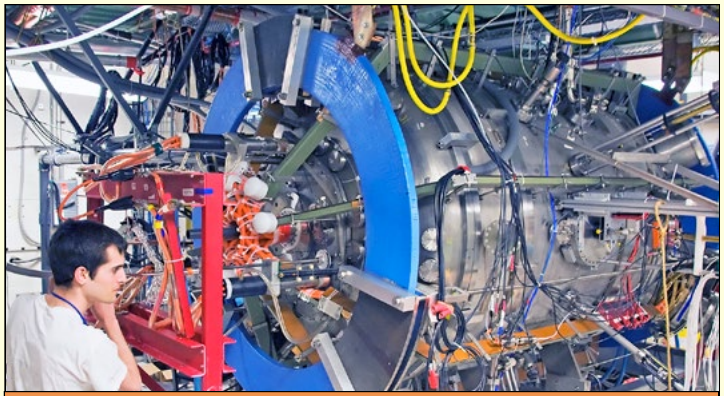
introducing them into the Magnetic Reconnection Experiment (MRX), which recreates reconnection in the laboratory. The studies found that guide fields can sharply reduce the reconnection rate in plasmas. This finding helps to explain the fact that reconnection in the plasma in the Earth's magnetosphere—a magnetic region above the Earth where strong field guides are present—takes place far more slowly than in anti-parallel reconnection. The results also shed light on solar and astrophysical plasmas and could lead to better predictions of disruptive solar flares and geomagnetic storms.

The researchers tested different strengths of guide fields by systematically altering the angle at which they intersected the reconnecting field lines. Strengthening the guide fields led to smaller merging angles and significantly slowed the rate at which reconnection took place. The results can be quantitatively compared with 2-D numerical simulations in the future. "Lots of theories have been developed for zero guide-field reconnection," said PPPL physicist Masaaki Yamada, the principal researcher for the MRX and coauthor of a paper on the experiment that has been accepted for publication by Physical Review Letters. "But here for the first time we have systematically added the guide field and studied its effects quantitatively. In nature reconnection always has some component of the guide field, so this makes the experiment more realistic."



The MRX experiment at PPPL produces magnetic field-line reconnection similar to what happens in solar flares and in the Earth's magnetosphere.

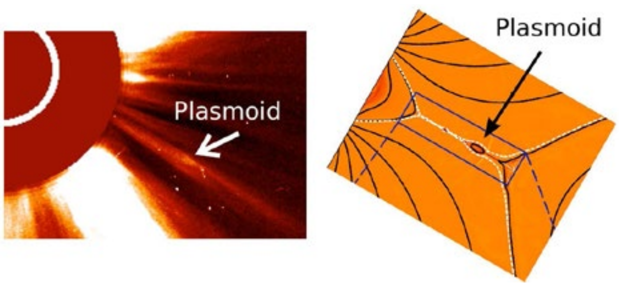
Magnetic reconnection seen in MRX: Oppositely directed field lines (measured) merge and reconnect.

Paper authors: T. Tharp, M. Yamada, H. Ji, E. Lawrence, S. Dorfman, C. Myers and J. Yoo

Here comes the sun: how solar flares happen faster than forecast

Simulations show that magnetic reconnection can take place in dense plasmas more quickly than the conventional wisdom holds

Scientists have struggled to predict how quickly solar flares can detach from the sun and launch the coronal mass ejections that create spectacular auroras and can disrupt communication systems and the nationwide electrical power grid. New computer simulations performed by scientists at the University of New Hampshire (UNH) and PPPL suggest that conventional theory misses an important effect that drastically speeds up the process.



At left, a plasmoid observed as a bright moving blob in the current sheet formed after a coronal mass ejection event, or massive release of plasma from the sun. At right, a computer simulation of plasmoid formation in a similar coronal mass ejection.

Solar flares detach from the sun through a process called magnetic reconnection, a common occurrence in space plasmas. The process takes place when the magnetic field lines in the electrically charged plasma of solar flares are stretched, break apart, and reconnect—leaving the plasma to fly off into space.

"Conventional wisdom asserts that reconnection happens slowly when the plasma density is high," said Yi-Min Huang, a UNH research scientist and principal author of the paper. "What our computer simulation tells us is that slow reconnection basically doesn't exist."

The new calculations reveal that the region in space where the reconnection takes place is much less stable than conventional theory predicts. The numerical simulations show the formation of a chain of plasmoids, or separate cylinders of plasma, during the reconnection process (see figure). Though such plasmoids have been seen in images of solar flares, according to Huang their possible role in speeding up reconnection had not been recognized.

Paper authors: A. Bhattacharjee, Lijia Guo, Y-M Huang and B. P. Sullivan

PPPL's Environmental Management System Audit Nov. 12 to 16

By Robert Sheneman

From Nov. 12 to 16, independent auditors from UL-DQS will visit the Laboratory to conduct the annual surveillance audit of PPPL's Environmental Management System (EMS). The annual audit is required in order to maintain ISO 14001 registration of our EMS. You may be interviewed by the auditors during their visit. Please review the following important information about PPPL's environmental management system in order to prepare for the audit.

Click here for the October 2012 ESH&S newsletter.

HR Happenings

Open enrollment period extended due to Hurricane Sandy

Due to the impact of Hurricane Sandy on the University and the surrounding communities, the end date of the annual benefits open enrollment period is being extended from Friday, Nov. 16 to Wednesday, Nov. 28.

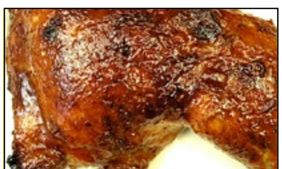
The new contribution maximums for the Retirement Savings Plan for 2013 are as follows:

- **Under age 50: $17,500**
- **Over age 50: $23,000**

You may elect these new maximums during the open enrollment period.

PPPL Café Menu

BREAKFAST .... 7 a.m. • 10 a.m.
CONTINENTAL BREAKFAST...... 10 a.m. • 11:30 a.m.
LUNCH .... 11:30 a.m. • 1:30 p.m.
SNACK SERVICE .... until 2:30 p.m.

	MONDAY NOV. 12	TUESDAY NOV. 13	WEDNESDAY NOV. 14	THURSDAY NOV. 15	FRIDAY NOV. 16
					
COMMAND PERFORMANCE CHEF'S FEATURE	LASAGNA WITH MEAT SAUCE & VEGETABLE	BBQ PORK LOIN WITH HERBED RICE	ROASTED CHICKEN BREAST	CHICKEN FETTUCCINI FLORENTINE	THANKSGIVING DINNER WITH ALL THE TRIMMINGS!!
EARLY RISER	Philly-style Steak, Egg and Cheese Wrap	The XL Roasted Vegetable Egg White Omelet with Potatoes	Cinnamon Raisin French Toast with Sausage	Mushroom, Potato, Onion, Pepper and Cheddar Frittata	Pork Roll, Egg, Cheese, Onion and Tomato on a Fresh Bagel
COUNTRY KETTLE	Beef Rice	Spicy Louisiana Seafood Chowder	Cream of Tomato Bisque	Tomato with Spinach & Lentils	Cream of Turkey with Vegetables
GRILLE SPECIAL	Mexican Style Crispy Chicken Sandwich with Fries	The BBQ Blue Turkey Burger with Onion Rings	California Chicken Cheese Steak with Fries	Black Bean, Roasted Corn, Pepper and Onion Quesadilla	Cajun Grilled Chicken Club with Spicy Mayo and Fries
DELI SPECIAL	Toasted Ham and Swiss Hoagie	Salami, Ham, Pepperoni and Provolone Toasted Hoagie	Savory Seafood Salad on a Multigrain Roll	Turkey Club Wrap	Pesto Chicken Salad on a Multigrain Roll
PANINI	Turkey, Swiss, Bacon and Tomato Griller on a Fresh Pita	Grilled Chicken, Spinach, Black Olives and a Feta Spread	Chicken Parmesan	Roasted Vegetables with Hummus and Provolone	Caribbean Ham, Swiss, Tomato and a Spicy Pineapple BBQ Sauce

MENU SUBJECT TO CHANGE WITHOUT NOTICE

CLICK HERE FOR A PRINTABLE WEEKLY MENU

WEEKLY

Editor: **Jeanne Jackson DeVoe** ◆ Graphic Design: **Gregory Czechowicz**
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Comments: commteam@pppl.gov ◆ **PPPL WEEKLY** is archived on the web at: http://www.pppl.gov/ppplweekly.cfm