FOR IMMEDIATE RELEASE
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New Insights into the Physics behind Stormy Space Weather that can Create Havoc on Earth

Earthly experiments are helping scientists probe the physics of plasma in space.

NEW ORLEANS—Each second, the sun hurls millions of tons of hot, charged plasma into space. This volatile "solar wind" buffets the magnetosphere, the magnetic field that surrounds the Earth, and can whip up geomagnetic storms that disrupt cell phone service, damage satellites and blackout power grids. Precise predictions of such outbursts could prompt measures to cope with them, just as forecasts here on Earth warn of approaching hurricanes and thunderstorms.

Researchers throughout the United States are using laboratory experiments to uncover important physics behind this space weather. Their latest results will be presented at the annual meeting of the American Physical Society's Division of Plasma Physics in New Orleans. Among their findings:

- Experiments at Princeton Plasma Physics Lab show in detail how magnetic reconnection, an explosive phenomenon that occurs in solar flares near the sun, accelerates solar wind particles to high energy and how the resulting solar wind interacts with the magnetic field that shields the earth (page 3 of this release).
- Using a plasma "wind tunnel" at Swarthmore College, professor Michael Brown and post doc David Schaffner are now able to simulate the key signatures of magnetic turbulence seen in the solar wind and also expected to play a role in astrophysical jets driven by exploding stars (page 6 of this release).
- A team of scientists conducting experiments in the Large Plasma Device (LAPD) at UCLA for the first time has observed interactions between the same type of plasma magnetic waves in their laboratory which are known to ripple throughout our Sun-Earth system. Theory and satellite measurements suggest the laboratory data may help explain the satellite data (page 5 of this release).
- Columbia University graduate student Thomas Roberts and his advisor, using a chamber filled with plasma and magnetic fields simulating the earth's magnetosphere, have discovered a possible connection between ionospheric currents and local space weather near the earth (page 7 of this release).

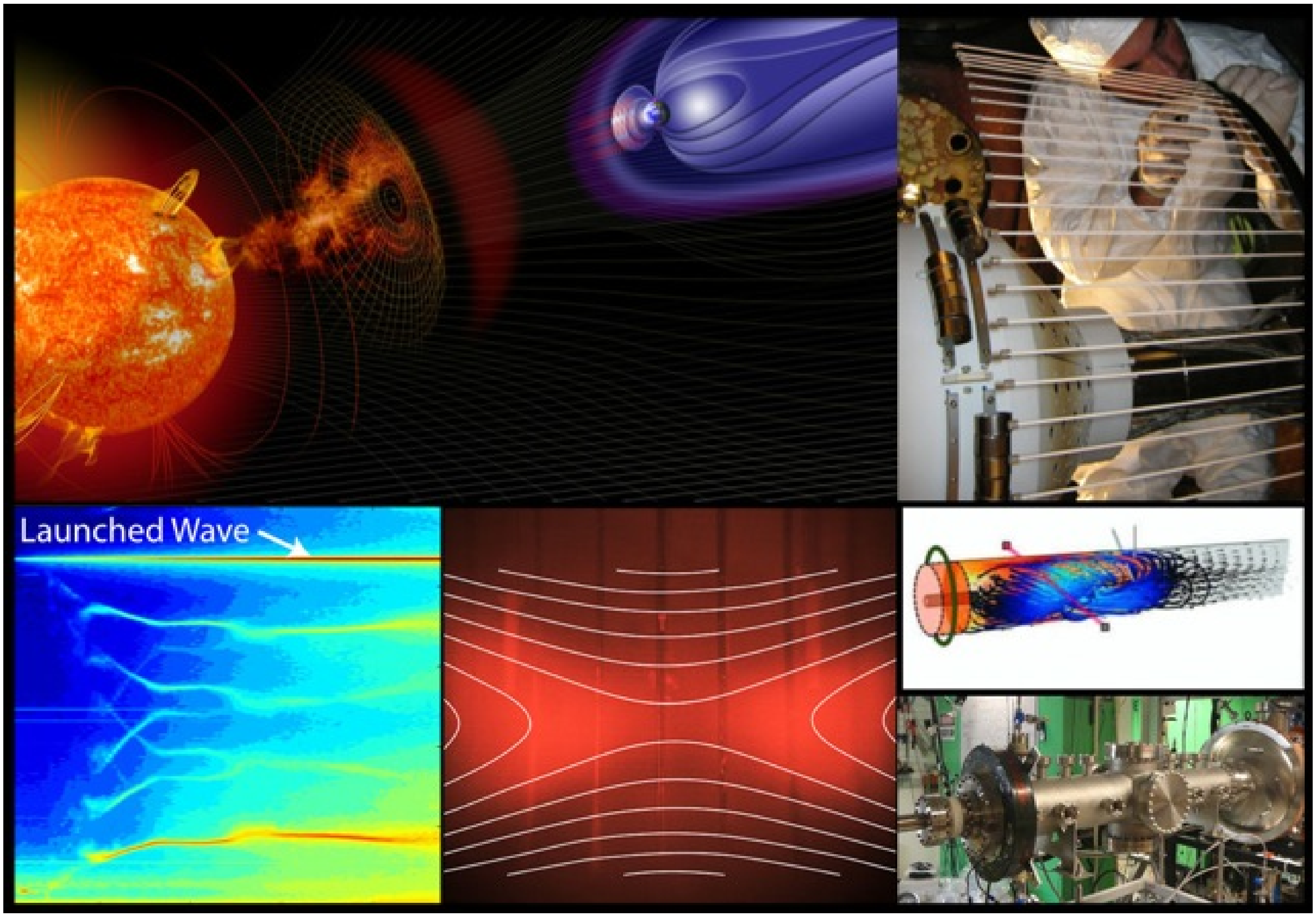

Figure 1: Clockwise from upper left: computer simulation of the solar wind in contact with the Earth's magnetosphere, magnetosphere simulation experiment at Columbia University, computer visualization of turbulent plasma currents in Swarthmore plasma wind tunnel (experiment at bottom right), magnetic surfaces overlaid on merging plasma with reconnection, and spectrogram showing interaction of magnetic waves in the UCLA Large Plasma Device.

Following are key results of five leading studies of physical processes that researchers have conducted in the laboratory to understand what happens in space, where the ability to make measurements is far more limited.

How Magnetic Reconnection Goes "Boom!"

Magnetic reconnection, in which the magnetic field lines in plasma snap apart and violently reconnect, creates massive eruptions of plasma from the sun. But how reconnection transforms magnetic energy into explosive particle energy has been a major mystery.

Now scientists at the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) have taken a key step toward solving the mystery. In research conducted on the Magnetic Reconnection Experiment (MRX) at PPPL, the scientists not only identified how the transformation takes place, but measured experimentally the amount of magnetic energy that turns into particle energy. This work was supported by the DOE Office of Science.

The investigation showed that reconnection in a prototypical reconnection layer converts about 50 percent of the magnetic energy, with one-third of the conversion heating the electrons and two-thirds accelerating the ions—or atomic nuclei—in the plasma. In large bodies like the sun, such converted energy can equal the power of millions of tons of TNT.

"This is a major milestone for our research," said Masaaki Yamada, the principal investigator for the MRX. "We can now see the entire picture of how much of the energy goes to the electrons and how much to the ions in a prototypical reconnection layer."

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Abstracts:

BI2.00005 Experimental study of energy conversion in the magnetic reconnection layer

11:30 AM–12:00 PM, Monday, October 27, 2014

Room: Bissonet

Session BI2: Space, Astro, and Lab Astro

9:30 AM–12:30 PM, Monday, October 27, 2014

Room: Bissonet

JM10.00008 Energetics of the magnetic reconnection in laboratory and space plasmas

4:40 PM–5:00 PM, Tuesday, October 28, 2014

Room: Bissonet

Session JM10: Mini-Conference: The Magnetic Universe -- A Mini-Conference in Honor of Stirling Colgate III

2:00 PM–5:00 PM, Tuesday, October 28, 2014

Room: Salon FGH

What a Difference a Magnetic Field Makes

Spacecraft observing magnetic reconnection have noted a fundamental gap between most theoretical studies of the phenomenon and what happens in space. While the studies assume that the converging plasmas share symmetrical characteristics such as temperature, density and magnetic strength, observations have shown that this is hardly the case.

PPPL researchers have now found the disparity in plasma density in experiments conducted on the MRX. The work, done in collaboration with the Space Science Center at the University of New Hampshire, marks the first laboratory confirmation of the disparity and deepens understanding of the mechanisms involved.

The research replicated at small scale the convergence of the plasma in solar wind and the plasma-filled magnetosphere, the magnetic field that surrounds the Earth. Before convergence, the density of the solar wind-like plasma was found to be from 10 times to 100 times greater than the density of the plasma that represented the magnetosphere.

Data from the MRX findings could help to inform a four-satellite mission—the Magnetospheric Multiscale Mission, or MMS—that NASA plans to launch next year to study reconnection in the magnetosphere. The probes could produce a better understanding of geomagnetic storms and lead to advanced warning of the disturbances and an improved ability to cope with them.

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Abstracts:

PP8.00106 Studies of electron energization during magnetic reconnection in a laboratory plasma

2:00 PM–2:00 PM, Wednesday, October 29, 2014

Session PP8: Poster Session VI: MST and Other Reversed Field Pinches; NSTX and Other Spherical Tori; Magnetic Reconnection
2:00 PM–2:00 PM, Wednesday, October 29, 2014
Room: Preservation Hall

Bringing Waves in Space Plasmas Down to Earth

To make forecasts of space weather a reality, scientists must first understand the plasma processes that occur on the sun's surface and between the Earth and the sun. In particular, understanding the interaction between waves that course through the plasma may play a key role in explaining how the overall sun-Earth system behaves.

Scientists at the Large Plasma Device (LAPD) at UCLA have made the first laboratory observations of two potentially important wave-wave interaction processes. Both involve the most fundamental wave that exists in plasma with a magnetic field. These waves, known as Alfvén waves, can be thought of as if the magnetic field were plucked like a string. The new LAPD observations enhance our understanding of fundamental physical processes that may play a key role in explaining how plasma behaves in space.

The wave-wave interactions observed have been predicted by theory and suggested by satellite observation, but have never before been seen in the laboratory.

UCLA scientists contributing to this work include: Seth Dorfman, Troy Carter, Stephen Vincena, Patrick Pribyl, Danny Guice, and Giovanni Rossi. Collaborators from other institutions include: Richard Sydora at University of Alberta, Yu Lin at Auburn University, and Kristopher Klein at the University of New Hampshire.

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Abstract:

DI2.00002 Laboratory Studies of Nonlinear Interactions Relevant to Alfvén Wave Decay Instabilities
3:30 PM–4:00 PM, Monday, October 27, 2014

Session DI2: Waves in Plasmas
3:00 PM–5:00 PM, Monday, October 27, 2014
Room: Bissonet

Capturing a Piece of the Solar Wind

The turbulence in solar wind twists and tangles magnetic field lines and can give rise to magnetic reconnection and stormy space weather. At Swarthmore College, the Swarthmore Spheromak Experiment (SSX) serves as the world's first plasma wind tunnel and recreates conditions similar to those found in the solar wind.

Research conducted under Prof. Michael Brown creates one-million-degree plasmas that sweep through the SSX at more than 60 miles per second. Working with post-doctoral fellow David Schaffner, the scientists have explored the mysteries of magnetohydrodynamic (MHD)—or magnetic fluid—turbulence. Their findings have enhanced understanding of the solar wind turbulence that can affect satellites and influence the environment of space near the Earth.

Combining all the measures of turbulence that the laboratory has developed could lead to a framework that captures the characteristics of all plasma turbulence—whether in fusion devices, laboratory MHD plasmas or the plasmas in space.

Contact:

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Abstracts:

PT2.00001	Magnetohydrodynamic Turbulence: Observation and Experiment 2:00 PM–3:00 PM, Wednesday, October 29
Session	PT2: Tutorial: Magnetohydrodynamic Turbulence: Observation and Experiment 2:00 PM–3:00 PM, Wednesday, October 29, 2014 Room: Bissonet
TP8.00067	MHD turbulence analyses in the plasma wind-tunnel of the Swarthmore Spheromak Experiment 9:30 AM–9:30 AM, Thursday, October 30, 2014
Session	TP8: Poster Session VII: C-MOD Tokamak; Divertors; Boundary/Edge Physics; Heating and Current Drive; Turbulence, Transport and Astrophysical Plasmas 9:30 AM–9:30 AM, Thursday, October 30, 2014 Room: Preservation Hall
JP8.00017	Permutation entropy analysis of dynamical turbulence in the SSX MHD wind tunnel and the solar wind 2:00 PM–2:00 PM, Tuesday, October 28, 2014

Session JP8: Poster Session IV: Education and Outreach; Undergraduate/High School Research; Fundamental Theory and Computation; Magnetic ICF & HEDP; Z-Pinch, X-Pinch, Exploding Wire Plasma and Dense Plasma Focus

2:00 PM–2:00 PM, Tuesday, October 28, 2014

Room: Preservation Hall

Taming Turbulent Space Weather in a Laboratory Magnetosphere

Like lightning bolts from storms clouds, powerful currents flow toward Earth from the motion of plasma inside the magnetosphere. Now students and scientists at Columbia University have conducted the first controlled experiments that regulate currents extracted from fast-moving laboratory plasma contained by a magnetic field shaped like the field in the Earth's magnetosphere.

This research gives students a new tool to test space-weather models, and provides clues to controlling the turbulence that causes heat and particles to escape from magnetic confinement in fusion facilities.

To reduce turbulence in the laboratory plasma, the students used an electrode to extract current from the plasma. Reversing the process by injecting current amplified the turbulence.

The experiments paralleled the process that takes place in space when the current that flows from magnetospheric plasma through the Earth's ionosphere slows the motion of space plasma. Adjusting the current thus acts like turning a knob to regulate the turbulence—a finding that could enhance the performance of future fusion facilities.

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Abstracts:

NI2.00001 Local Regulation of Interchange Turbulence in a Dipole-Confined Plasma Torus using Current-Collection Feedback

9:30 AM–10:00 PM, Wednesday, October 29, 2014

Session NI2: Basic Plasma Physics

9:30 AM–12:30 PM, Wednesday, October 29, 2014

Room: Bissonet