INFORMATION BULLETIN

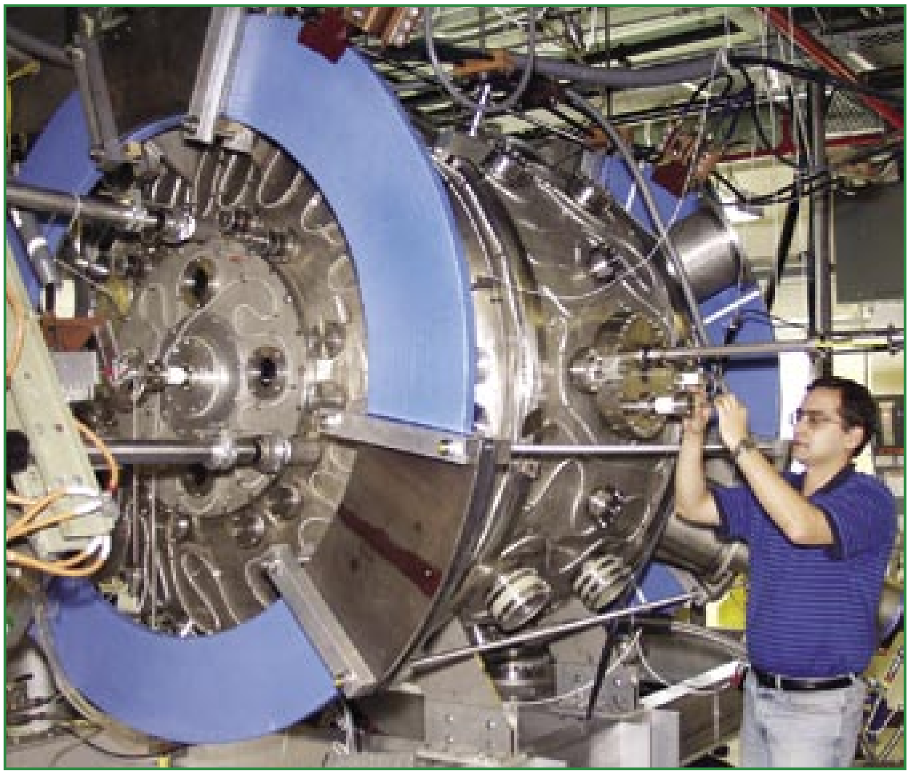
Office of Science
U.S. DEPARTMENT OF ENERGY

U.S. DEPARTMENT OF ENERGY'S
PRINCETON PLASMA PHYSICS LABORATORY
JAMES FORRESTAL CAMPUS, P.O. BOX 451
PRINCETON, NEW JERSEY 08543

MRX

The Magnetic Reconnection Experiment

The Princeton Plasma Physics Laboratory (PPPL) Magnetic Reconnection Experiment (MRX) was built to study a fundamental plasma process in a controlled laboratory environment. A plasma is a hot, ionized gas that can be confined using a magnetic field. Plasmas are often considered to be the fourth state of matter after solids, liquids, and gases, and account for more than 99 percent of the visible universe.



The Magnetic Reconnection Experiment.

Magnetic reconnection is the topological change of a magnetic configuration through the breaking and rejoining of magnetic field lines. During reconnection, magnetic energy is rapidly converted to kinetic and thermal energy, often significantly increasing the plasma temperature, or accelerating plasma particles. PPPL scientists hope to discern the governing principles of this important plasma physics process and gain a basic understanding of how it affects plasma characteristics.

Reconnection occurs in virtually all magnetized plasmas, both in nature and in the laboratory. It was first suggested more than 50 years ago to explain activities associated with observed solar flares. Long and quiet periods (days to months) exist before a sudden explosion of a solar flare, which lasts minutes or hours. In recent years, the solar satellite TRACE has provided the best evidence that reconnection is involved in rapid solar flare energy release. However, the rate of energy release is not well resolved by the present understanding of reconnection physics. The observed "fast reconnection" has made magnetic reconnection a very active area of research.

Magnetic reconnection also plays an important role in the formation of stars, in the heating of the Sun's corona, and in the dynamics of the Earth's space environment, or magnetosphere. The Sun's super heated corona is the source of the solar wind. Fluctuating magnetic fields carried by the solar wind reach the Earth and interact with the magnetosphere. Reconnection induced at the dayside magnetopause (see page 2) is thought to be a trigger of such events as auroral substorms and geomagnetic storms. High-energy particles created during magnetic reconnection ionize upper atmosphere gases producing the aurora borealis, or "northern lights," observed on Earth. The ionized gases release X-rays that are swept into the ionosphere and can damage satellites and disrupt communications and navigation systems. A better understanding of magnetic reconnection would help predict solar eruptions and the stormy behavior of the magnetosphere.

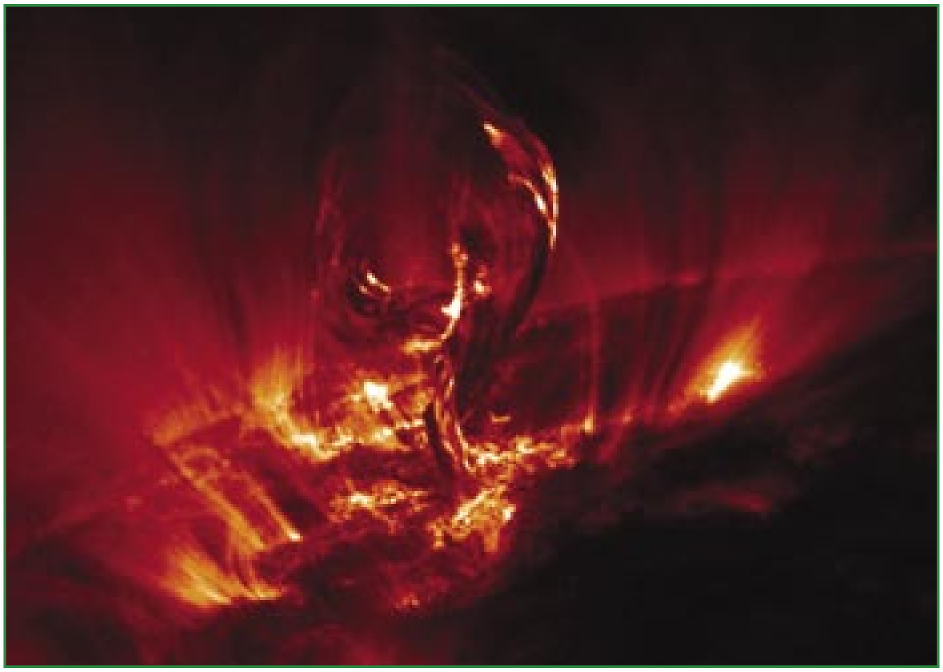


Image of the sun taken by the Transition Region and Coronal Explorer (TRACE) satellite. TRACE is a mission of the Stanford-Lockheed Institute for Space Research and part of the NASA Small Explorer Program.

of magnetic reconnection to understand important physics processes such as plasma heating and acceleration. This data provides information for comparisons with theory.

Magnetic reconnection in the solar corona and in MRX proceeds much faster than predicted by the conventional theories. Recent MRX experiments showed that the enhanced reconnection rate could be caused by an additional unknown source of electrical resistance in the plasma. By studying the structure of the MRX reconnection region, researchers have identified high frequency plasma fluctuations considered to be responsible for this unexpected resistance. Based on this experimental data, modifications to theory are being made which are resulting in better correlation between theory and experiment.

In laboratory fusion plasmas, reconnection manifests itself as "sawtooth" oscillations in electron temperature, affecting plasma confinement. Improved knowledge of magnetic reconnection would allow researchers to stabilize the plasma more efficiently, allowing fusion reactions to proceed.

MRX Experiments

An MRX experiment lasts only about a millisecond. Two donut-shaped plasmas are created with identical electric currents flowing within them. The plasmas are forced to merge together, which triggers magnetic reconnection. This process is well monitored by an extensive set of diagnostics allowing simultaneous measurements of such parameters as the magnetic field and the plasma's density and temperature. During each experiment, PPPL scientists also investigate the precise structure

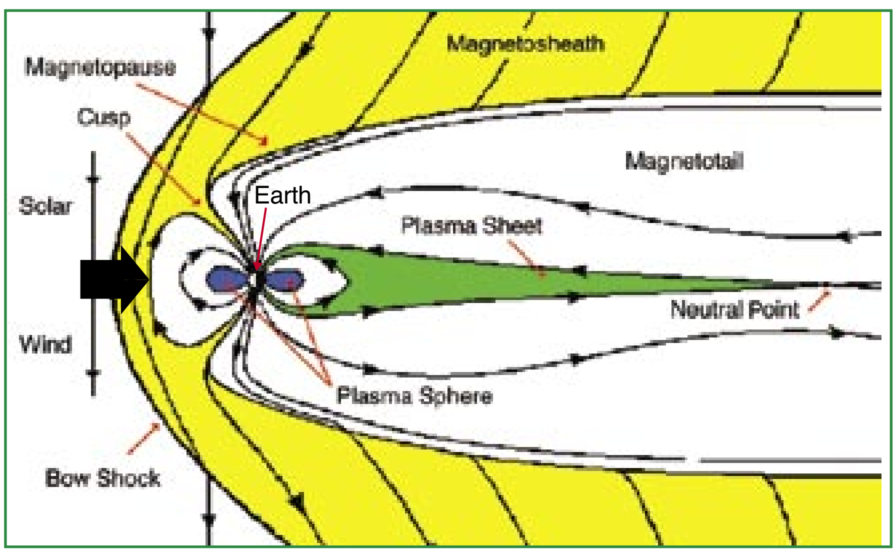


Illustration of magnetospheric reconnection at the dayside of the magnetopause (when the incoming magnetic field of the solar wind is southward).

The Princeton Plasma Physics Laboratory is operated by Princeton University under contract to the United States Department of Energy. For additional information, please contact: Information Services, Princeton Plasma Physics Laboratory, P.O. Box 451, Princeton, NJ 08543. Tel. (609)-243-2750, e-mail: pppl_info@pppl.gov, or visit our web site at: http://www.pppl.gov .