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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.

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PROVIDENCE—Scientists at the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) 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 in Figure 1. 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 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.

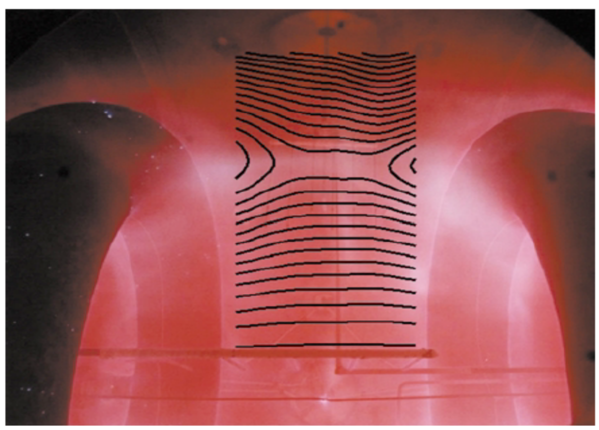

Figure 1. Magnetic reconnection seen in MRX: Oppositely directed field lines (measured) merge and reconnect.

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."

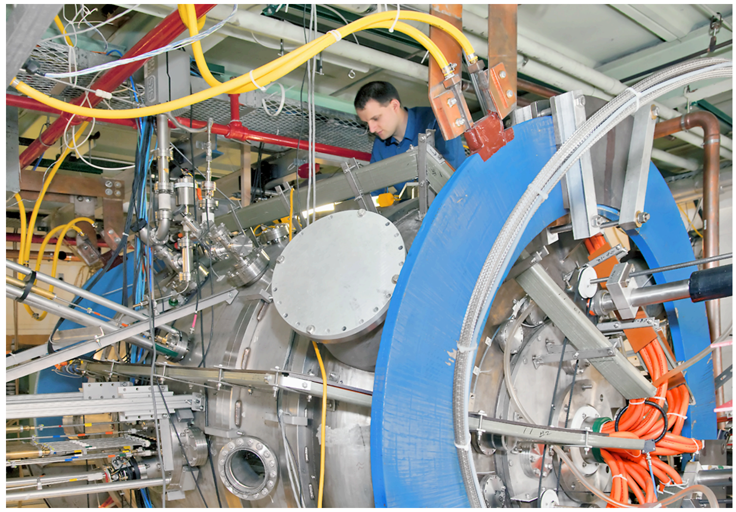

Figure 2. The MRX experiment at Princeton Plasma Physics Laboratory produces magnetic field-line reconnection similar to what happens in solar flares and in the earth's magnetosphere.

The work is part of research being presented by MRX staff at the 54th Annual Meeting of the American Physical Society Division of Plasma Physics in Providence, Rhode Island from Oct. 29 to Nov. 2.

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Abstracts:

TI2.00006	**Guide Field Effects on Hall Reconnection in a Laboratory Plasma**
Session	**TI2: Fundamental Plasma Physics II**,
	Ballroom DE, Thursday, November 1, 2012, 9:30AM–12:30AM