

Scientists take key step toward solving a major astrophysical mystery

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Magnetic reconnection can trigger geomagnetic storms that disrupt cell phone service, damage satellites and black out power grids. But how reconnection, in which the magnetic field lines in plasma snap apart and violently reconnect, transforms magnetic energy into explosive particle energy remains a major unsolved problem in plasma astrophysics. Magnetic field lines represent the direction, and indicate the shape, of magnetic fields.

Now scientists at the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) have taken a key step toward a solution, as described in a paper published this week in the journal *Nature Communications*. In research conducted on the Magnetic Reconnection Experiment (MRX) at PPPL, the scientists not only identified how the mysterious 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 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 and first author of the *Nature Communications* paper. "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."

The findings also suggested the process by which the energy conversion occurs. Reconnection first propels and energizes the electrons, according to the researchers, and this creates an electrically charged field that "becomes the primary energy source for the ions," said Jongsoo Yoo, a postdoctoral fellow at PPPL and coauthor of the paper. Also contributing to the paper were physicists Hantao Ji and Russell Kulsrud, and doctoral candidates Jonathan Jara-Almonte and Clayton Myers.

If confirmed by data from space explorations, the PPPL results could help resolve decades-long questions and create practical benefits. These could include a better understanding of [geomagnetic storms](#) that could lead to advanced warning of the disturbances and an improved ability to cope with them. Researchers could shut down sensitive instruments on communications satellites, for example, to protect the instruments from harm.

The PPPL team will eagerly watch a four-satellite mission that NASA plans to launch next year to study reconnection in the magnetosphere—the magnetic field that surrounds the Earth. The team plans to collaborate with the venture, called the Magnetospheric Multiscale (MMS) Mission, by providing MRX data to it. The MMS probes could help to confirm the Laboratory's findings.

Provided by Princeton Plasma Physics Laboratory

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