A 3-D way to release magnetic energy... fast!

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Experiments discover a 3-D process by which magnetic reconnection can release energyfaster than expected by classical theories.

Scientists at the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) have discovered a new process at work in a mysterious magnetic phenomenon that occurs both in the earth's atmosphere and in space, playing a role in events such as the aurora borealis and solar flares.

In a series of experiments on a device known as the Magnetic Reconnection Experiment (MRX), which replicates magnetic reconnection in the laboratory, a team of researchers found that many important plasma quantities are found to have strong variations in three dimensions very early in the process. This variation may aid in the formation of regions of high electric current with characteristics similar to what have been called "flux ropes."

Experiments show that when the reconnection rate spikes in this 3-D configuration, the high current ropes are ejected out of the reconnection region, leading to a sudden decrease in the current density. The researchers have termed this process a "current layer disruption."

"What makes this observation new and surprising is that the disruption process takes place in a truly 3-D way," said Seth Dorfman, a graduate student at PPPL who was part of the group conducting the experiments. "In many previous studies, the transition to fast reconnection is a 2-D process in which there are no variations along the reconnection current direction. By contrast, the 3-D current ropes ejected during a disruption are highly localized in the third dimension."

These processes may be important for natural plasmas in space and astrophysics, Dorfman noted, where key plasma properties vary in all three directions. For example, current disruptions are also observed in plasmas in the magnetosphere, where the reconnection process is thought to trigger the aurora borealis. Efforts are ongoing to relate the new result to these observations, he said.

More information: The work is part of research being presented by Dorfman and colleagues at the 53rd Annual Meeting of the American Physical Society Division of Plasma Physics, being held Nov. 14 – 18, in Salt Lake City, Utah.

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