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Connecting the Dots on Magnetic Reconnection

Experiments give indications of why explosive bursts of energy from plasma happen quickly.

MILWAUKEE, Wis.—Whether in outer space or in a laboratory, plasma can be volatile. The magnetic field lines that extend through plasma can detach suddenly and snap together again in new orientations, releasing enormous amounts of energy. This process, called magnetic reconnection, happens rapidly and causes eruptions of planet-sized flares from the surface of the sun that can interfere with cell phone service and electric power grids on Earth. Reconnection can also cause disruptions that degrade plasma confinement within doughnut-shaped magnetically confined plasmas like tokamak fusion reactors.

New experiments by physicists at the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) have confirmed theoretical models of electron pressure that have long been used to understand reconnection. Specifically, PPPL researchers confirmed that the motion of electrons in plasma creates a pressure that balances the force produced in plasma by parallel electric fields (Figure 1). This balance allows strong electric fields to be sustained, which in turn significantly increases the speed at which reconnection occurs. "These results show how well-controlled and diagnosed laboratory experiments can provide insights into the behavior of plasmas in astrophysics or fusion plasmas, where it is much harder to make such comprehensive measurements," said PPPL physicist Will Fox, who led the experiments.

These findings will enable improved understanding of the explosive events in stars and galaxies, where magnetic reconnection is prevalent, and could enable scientists to more confidently design tokamaks to minimize disruptions created by magnetic reconnection.

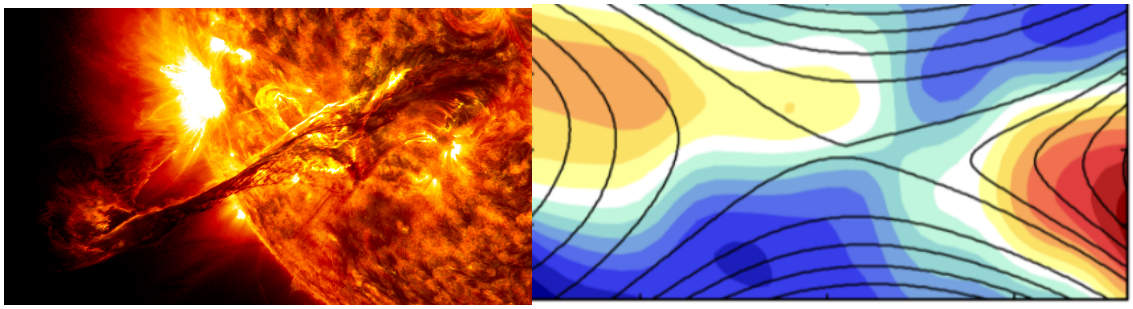

Figure 1: Left: A high-resolution image captured by NASA's Solar Dynamics Observatory shows a long filament of plasma erupting on the solar surface, initiating magnetic reconnection prior to breaking from the sun's surface and being ejected into space. Right: High (red) and low (blue) pressure structures forming in a region of laboratory plasma undergoing magnetic reconnection.

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Abstract

NI2.00005 Experimental verification of the role of electron pressure in fast magnetic reconnection with a guide field

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