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# Turbulent magnetic reconnection initiated by kinetic instabilities in colliding laser-produced plasmas

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Magnetic reconnection enables the explosive conversion of magnetic field energy to plasma kinetic energy plasmas ranging from laboratory to astrophysical environments. However, a challenge has been to understand how reconnection proceeds rapidly and efficiently, especially in large systems with low dissipation. The rate of magnetic reconnection can be greatly increased by the action of secondary instabilities, such as the tearing instability, breaking a long current sheet into a hierarchy of shorter reconnection layers, and the contraction and interaction of multiple flux ropes thus produced are efficient accelerators of particles. The instabilities also generate magnetic islands (also called "flux-ropes," or "plasmoids") which have further interest, as the relaxation and merg- ing dynamics of these structures may provide a Fermi mechanism to energize particles. Here we show experiments[1] with colliding magnetized laser-produced plasmas obtaining long extended current sheets ($L/d_i \sim 100$) and low dissipation (high Lundquist number $S = \mu_0 L V_A/\eta \sim 1000$, where $V_A$ is the Alfven speed). The current sheet breaks up into a chain of a large number of magnetic islands. Proton radiography and optical shadowgraphy directly observe the size and temporal growth of island structures, which merge into larger structures over the course of the interaction. We propose that this process also leads to rapid reconnection in a broad range of natural plasmas with collisionless, compressible flows, including the interac- tion of the solar-wind with planetary magnetospheres, at the heliopause, and in high-Mach-number collisionless shocks. The secondary instability leads to a turbulent magnetic reconnection, verifying processes recently proposed to drive particle acceleration in high-Mach number magnetized shocks[4]. We discuss the possibility of observing particle energization relevant to heliospheric and astrophysical plasmas using this experimental platform.

References:

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