Frontiers for Laboratory Study of Magnetic Reconnection Relevant to Heliophysics and Astrophysics

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Abstract

Frontiers of magnetic reconnection research will be discussed by highlighting a few recent achievements primarily from laboratory experiments but also from theory and numerical simulations. Of particular importance among these achievements is the development of a reconnection "phase diagram", in which different coupling mechanisms from the global system scale to the local dissipation scale are classified into different reconnection phases [H. Ji & W. Daughton, Phys. Plasmas 18, 111207 (2011)]. This progress motivated the major next-step laboratory device, called the Facility for Laboratory Reconnection Experiments or FLARE (flare.pppl.gov), which is currently under construction at Princeton. The goal of the FLARE project is to access reconnection regimes directly relevant to heliophysical and astrophysical plasmas. The currently existing small-scale experiments have been focusing on the single X-line reconnection process in plasmas either with small effective sizes or at low Lundquist numbers, both of which are typically very large in natural plasmas. The new regimes involve multiple X-lines are illustrated in the reconnection phase diagram. The design of the FLARE device is based on the existing Magnetic Reconnection Experiment (MRX) (mrx.pppl.gov). After a brief summary of recent laboratory results on the topic of magnetic reconnection, the motivating major physics questions, the construction status, and the planned collaborative research especially with heliophysics and astrophysical communities will be discussed.