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Phase Diagram for Magnetic Reconnection in Heliophysical, Astrophysical and Laboratory Plasmas and Opportunities for A Next Generation Magnetic Reconnection Experiment H. JI, M. YAMADA, S. PRAGER, PPPL, W. DAUGHTON, V. ROYTERSHTEYN, LANL — Recent progress in understanding the physics of magnetic reconnection is conveniently summarized in terms of a phase diagram[1] which organizes the essential dynamics for a wide variety of applications in heliophysics, laboratory and astrophysics. The two key dimensionless parameters are the Lundquist number and the macrosopic system size in units of the ion sound gyroradius. In addition to the conventional single X-line collisional and collisionless phases, multiple X-line reconnection phases arise due to the presence of the plasmoid instabilities in both collisional and collisionless current sheets. In particular, there exists a unique phase termed "multiple X-line hybrid phase" where a hierarchy of collisional islands or plasmoids is terminated by a collisionless current sheet, resulting in a rapid coupling between the macroscopic and kinetic scales and a mixture of collisional and collisionless dynamics. The new phases involving multiple X-lines and collisionless physics may be important for the emerging applications of magnetic reconnection to accelerate charged particles beyond their thermal speeds. A large number of heliophysical and astrophysical plasmas are surveyed and grouped in the phase diagram. Scientific opportunities for a next generation reconnection experiment to explore these new phases, guided by large-scale computation, are discussed in detail.

[1]H. Ji & W. Daughton, submitted to Phys. Plasmas (2011).

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