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Nonlinear forced magnetic reconnection and onset of plasmoid instability

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We discuss the process of magnetic reconnection which is triggered within an MHD stable magnetic configuration in response to some external perturbation (hence, forced reconnection). Although such a process is of significant interest itself as a mechanism of internal magnetic relaxation [1], here the emphasis is on the associated onset of the secondary tearing (plasmoid) instability. The latter as a pre-requisite to the regime of fast reconnection is presently a hot topic in the magnetic reconnection research [2-4].

A model under consideration is the force-free modification of the well-known Taylor's problem [5]. As shown in [6], if external boundary perturbation is strong enough, nonlinearity in the current sheet evolution becomes important before resistive effects come into play. This terminates the current sheet shrinking that takes place at the linear stage [5], and brings about its nonlinear equilibrium with a finite thickness. Then, in the conventional theory, this equilibrium is destroyed by a finite plasma resistivity during the skin-time, and further reconnection would proceed in the Rutherford regime. However, realization of such a scenario is unlikely because of the plasmoid instability, which is fast enough to develop before transition to the Rutherford phase occurs. This conclusion is in excellent agreement with numerical simulations of nonlinear forced reconnection.

However, in many applications the Lundquist number is so large that the current sheet width becomes comparable to the ion inertial length. In such a case flows of electron and ions become separated, which makes the standard single-fluid MHD description invalid. This flow separation manifests itself as Hall effect, and the Hall-MHD theory of forced reconnection [7] is discussed in the second part of the talk. Thus, we start with the linear theory of the Hall-mediated forced reconnection, and then use these results to demonstrate when and how the plasmoid instability can develop in the course of this process.

References

[1] G. Vekstein and R. Jain, Phys. Plasmas **5**, 1506 (1998).

[2] A. Bhattacharjee, Y. M. Huang, and B. Rogers, Phys. Plasmas, **16**, 112102 (2009).

[3] D. Uzdensky, N. Loureiro, and A. Schekochihin, Phys. Rev. Lett., **105**, 235002 (2010).

[4] T. Shibayama, K. Kusano, T. Mioyshi, T. Nakanobu, and G. Vekstein, Phys. Plasmas **22**, 100706 (2015).

[5] T. S. Hahm and R. Kulsrud, Phys. Fluids, **28**, 2412 (1985).

[6] G. Vekstein and K. Kusano, Phys. Plasmas, **22**, 090707 (2015).

[7] G. Vekstein and K. Kusano, Phys. Plasmas, submitted (2017).