A Kinetic Model for Laboratory and Space Observation of Fast Collisionless Magnetic Reconnection

J. Egedal[1], W. Fox[1], A. Fasoli[2] and M. Porkolab[1]

[1]MIT, PSFC, Cambridge, Massachusetts 02139, USA
[2]CRPP-EPFL, CH-1015, Lausanne, Switzerland

Magnetic reconnection in the collisionless regime is studied on the Versatile Toroidal Facility (VTF). The detailed evolution of the profiles of plasma density, current density, and electrostatic potential at the onset of driven reconnection is reconstructed experimentally. Despite a constant, externally imposed reconnection drive, we show that the reconnection does not proceed in a steady-state manner. The formation and decay of the current is shown to be related to the evolution of the electrostatic potential and the associated ion polarization currents. The size of the diffusion region is inferred from the detailed knowledge of the electrostatic potential, and is shown to scale with the drift orbit width of the electrons insensitive to the ion mass and plasma density [1]. This scaling is consistent with the drift kinetic approach in Ref. [2].

In addition to the prediction of the size of the VTF diffusion region, the drift kinetic approach [2] also appears to be relevant to the interpretation of resent satellite observations: The model predicts that effects due to trapped electron will cause the distribution of electrons to be anisotropic close to the X-line. The predicted anisotropy is in close agreement with observations by the Wind satellite in the Earth magnetotail [3]. The symmetry in the distribution function, imposed by the trapped electron motion, implies a high neoclassical resistivity consistent with the high rates of reconnection observed. We present calculated electron distribution functions and compare our theoretical results with the Wind observations.

We also present preliminary results from a new closed magnetic configuration, which will be applied in future experiment on VTF. The new configuration is relevant for experimental bench marking of numerical simulations, such as the GEM magnetic reconnection challenge [4] and similar scenarios including a guide magnetic field [5].

[1] Egedal J, Fasoli A and Nazemi J, (2003) *Phys. Rev. Lett.* **90**, 135003.
[2] Egedal J, (2002) *Phys. Plasmas,* **9**, 1095.
[3] Øieroset M, Lin RP, Phan TD, Larson DE, and Bale SD, (2002) *Phys. Rev. Lett.* **89**, 195001.
[4] Birn J et al, J. Geophys. Res., (2001) **106**, 3715.
[5] Hesse M, Schindler K, Birn J and Raytheon MK, (1999) *Phys. Plasmas,* **6**, 1781.