Abstract for an Invited Paper
for the DPP08 Meeting of
The American Physical Society

Marshall N. Rosenbluth Dissertation Award Talk: Identification of the Electron Diffusion Region during Magnetic Reconnection in a Laboratory Plasma

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Magnetic reconnection is a process which converts magnetic energy to plasma kinetic and thermal energy. One of the important goals in magnetic reconnection research is to explain the fast reconnection rate observed in natural phenomena. Recent breakthroughs show that the Hall effect facilitates reconnection in the collisionless regime [1], by decoupling the ions and electrons on the ion skin depth scale, forming ion and electron diffusion regions. The width of the electron diffusion region is on the order of the electron skin depth, while the ion diffusion region is much wider, allowing the ions to flow out efficiently. The electron diffusion region is identified by observing an out-of-plane quadrupole magnetic field during the reconnection process in the Magnetic Reconnection Experiment (MRX) [2,3,4]. The width of the electron diffusion region scales with the electron skin depth ($\sim 5.5 - 7.5 c/\omega_{pe}$), and the peak electron outflow velocity scales with the electron Alfven velocity ($\sim 0.12 - 0.16 V_{eA}$), independent of the ion mass. The measured width of the electron diffusion region is much wider and the observed electron outflow is much slower than those obtained in 2D numerical simulations. Comparisons of these measurements with state-of-art, two- dimensional Particle-In-Cell simulations using boundary conditions similar to MRX will be also presented. In collaboration with M. Yamada, H. Ji, S. P. Gerhardt, R. Kulsrud, S. Dorfman and W. Daughton. This work is supported by DoE, NSF and NASA.

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