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Study of Two-Fluid MHD Physics and the Effects of Boundary Conditions on Magnetic Reconnection in MRX

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Magnetic reconnection is an important physical process which leads to topology change and magnetic field evolution in many laboratory and astrophysical plasmas. In general, the reconnection process is determined by local plasma dynamics in the diffusion region as well as by global boundary conditions. In this talk we report recent experimental results on both aspects of reconnection physics from the Magnetic Reconnection eXperiment (MRX) [1]. Globally, the effects of boundary conditions have been studied by varying the distance between the two "flux-cores" which are used to drive reconnection in MRX. It is found that, despite large changes in both the current sheet length and the outflow speed, the observed reconnection rate can be understood in the framework of a generalized Sweet-Parker using the local plasma parameters and an effective local resistivity [2]. There are two leading theories to explain the local physics of fast reconnection: one involves anomalous resistivity due to wave-particle interactions, and the second is based on two-fluid MHD effects arising from the decoupling of electron and ion motions in the diffusion region [3]. The hallmark of the latter is a quadrupole out-of-plane magnetic field, which has never previously been observed in a laboratory experiment. Using an array of magnetic pickup coils with a spatial resolution comparable to the electron skin depth, we have successfully detected the quadrupole out-of-plane field [4], strikingly similar to that predicted by theory. Detailed physical analysis based on these new experimental results, including comparisons with the space and astrophysical observations [5], will also be presented. This work is supported by DOE, NASA and NSF. In collaboration with Y. Ren, S. Gerhardt, H. Ji, R. Kulsrud, and M. Yamada.

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