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Highly localized, fully 3-D disruptions of the reconnection layer in the Magnetic Reconnection Experiment

SETH DORFMAN, CMSO, PPPL

Magnetic reconnection is a fundamental process in plasmas which converts magnetic energy to plasma kinetic and thermal energy through topological changes. One of the important goals in magnetic reconnection research is to explain the fast reconnection rate observed in real three-dimensional laboratory and astrophysical systems. In the Magnetic Reconnection Experiment (MRX), an enhancement of the reconnection electric field is often associated with a wholesale disruption of the reconnection current layer, an intrinsically 3-D phenomena observed in the presence of out-of-plane gradients of local quantities such as reconnection layer current and density. During a disruption, the out-of-plane current decreases as current carrying electrons are redirected in the outflow direction. Observed "O-point" signatures and density striations suggest that this redirection often occurs though the ejection of 3-D flux rope structures. Large fluctuations in the lower hybrid frequency range are also routinely seen, but the ratio of the phase speed to the diamagnetic drift speed does not match what is predicted by 3-D kinetic simulations without disruptions. A 2-D Hall MHD analysis of the out-of-plane gradients is consistent with the buildup of magnetic energy leading to the event [1], but variation in all three spacial dimensions is required in order to obtain results in agreement with the disruptive behavior observed. Analysis and comparison with 3-D simulations is ongoing to determine if the fluctuations and/or disruptive behavior are responsible for the corresponding discrepancies in the layer structure between the experiments and 2-D kinetic simulations [2,3,4]. Supported by DOE, NASA, and NSF.

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