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Guide Field Effects on Hall Reconnection in a Laboratory Plasma[1]

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Guide field effects are a major outstanding research issue for magnetic reconnection. Recent results from simulation and observation indicate that guide field can strongly impact reconnection dynamics in collisionless two-fluid regimes such as the earth's magnetosphere and magnetotail. In particular, simulations agree that the addition of guide field can produce effects such as a tilting of the current sheet, reduction or destruction of the quadrupole field, and a reduced reconnection rate. In the present work, the effect of guide field on magnetic reconnection has been quantitatively studied in the two-fluid regime by systematically varying an externally applied guide field in the Magnetic Reconnection Experiment (MRX). The quadrupole field, a signature of two-fluid reconnection, is significantly altered by the presence of guide field. The structure of the layer is twisted in the plane by $J \times B$ forces, and the resulting modified Hall fields are very similar to those observed in simulation. Additionally, the in-plane Hall currents are reduced by an amount consistent with the scaling $E_{rec} \approx \frac{J \times B}{ne}$, indicating that two-fluid physics is critical to the local reconnection dynamics. The reconnection rate, E_{rec}, is strongly reduced with increasing guide field. This dependence is explained by the advection and compression of guide field, which produces an increased magnetic pressure both within and downstream of the reconnection region. These observations indicate that a dynamic guide field is capable of influencing reconnection through both the local physics of two-fluid reconnection and the global physics of pressure balance.

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