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Extended MHD Effects in High Energy Density Experiments¹

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The MHD model is the workhorse for computational modeling of HEDP experiments. Plasma models are inheritably limited in scope, but MHD is expected to be a very good model for studying plasmas at the high densities attained in HEDP experiments. There are, however, important ways in which MHD fails to adequately describe the results, most notably due to the omission of the Hall term in the Ohm's law (a form of extended MHD or XMHD). This talk will discuss these failings by directly comparing simulations of MHD and XMHD for particularly relevant cases. The methodology is to simulate HEDP experiments using a Hall-MHD (HMHD) code based on a highly accurate and robust Discontinuous Galerkin method, and by comparison of HMHD to MHD draw conclusions about the impact of the Hall term. We focus on simulating two experimental pulsed power machines under various scenarios. We examine the MagLIF experiment on the Z-machine at Sandia National Laboratories and liner experiments on the COBRA machine at Cornell. For the MagLIF experiment we find that power flow in the feed leads to low density plasma ablation into the region surrounding the liner. The inflow of this plasma compresses axial magnetic flux onto the liner. In MHD this axial flux tends to resistively decay, whereas in HMHD a force-free current layer sustains the axial flux on the liner leading to a larger ratio of axial to azimuthal flux. During the liner compression the magneto-Rayleigh-Taylor instability leads to helical perturbations due to minimization of field line bending. Simulations of a cylindrical liner using the COBRA machine parameters can under certain conditions exhibit amplification of an axial field due to a force-free low-density current layer separated by some distance from the liner. This results in a configuration in which there is predominately axial field on the liner inside the current layer and azimuthal field outside the layer. We are currently attempting to experimentally verify the simulation results.

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