Coulomb Force Effects in Multimaterial Continuum Plasmas

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Magnetohydrodynamics (MHD) models have historically been a significant mainstay in the computational analysis of high energy density pulsed power physics. Recent evidence in the pulsed power community suggests that low density regions can significantly affect the dynamics of high density target physics. However, many of the fundamental assumptions of MHD do not hold in low density regimes and MHD codes must find ways to work around the limitations of the model equations.

This opens the door to a hierarchy of increasingly complex extended MHD models. We consider an incremental improvement of MHD, namely no longer neglecting electric displacements. We call the model Full Maxwell Hydrodynamics (FMHD). FMHD offers several advantages over MHD in low density regimes. First characteristic speeds do not become arbitrarily fast in the limit of low densities. Second it allows for the relaxation of charge quasi-neutrality assumed by MHD. This opens the door to Coulomb force effects in addition to Lorentz forces.

In this talk we discuss the discretization of FMHD in an indirect Arbitrary Lagrangian Eulerian (ALE) framework. We will discuss the Lagrangian discretization of the FMHD system using compatible finite elements and IMEX time integration and a compatible remap which discretizes the Lie derivative. We remap magnetic fields with a strong 2-form Lie derivative and electric fields with a weak 2-form Lie derivative. This guarantees that the divergence of magnetic fields is zero to machine precision and that the weak charge conservation guaranteed by the Lagrangian step is preserved during remap.