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Benchmarking Multi-Fluid Plasma Electromagnetic Models for Pulsed Power Applications

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The dynamical behavior of plasmas is strongly dependent on frequency. At the lowest frequency the plasma is in the regime of magnetohydrodynamics (MHD) and has been the focus of extensive research in fluid plasma modeling in the past few decades. At somewhat higher frequencies, the electrons and ions can move relative to each other, behaving like two charge separated, interpenetrating fluids. This is the regime of high-frequency, non-neutral two-fluid physics and is relevant to high-density, fast MHD phenomena encountered in pulsed-power devices like dense plasma focus, Z-pinches and field-reversed configurations. Here we present fully implicit schemes for solving the two fluid equations based on a combination of physics-based preconditioning and Jacobian-Free Newton Krylov solvers. We apply this approach to a range of problems, including shock physics, ambipolar expansion and shear flow. Results obtained from our approach will be compared to analytic theory and, where appropriate, magnetohydrodynamic and kinetic simulations.

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