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Nested Iteration First-Order Least Squares on Incompressible Resistive Magnetohydrodynamics

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Magnetohydrodynamics (MHD) is a single-fluid theory that describes Plasma Physics. MHD treats the plasma as one fluid of charged particles. Hence, the equations that describe the plasma form a nonlinear system that couples Navier-Stokes with Maxwell's equations. To solve this system, a nested-iteration-Newton-FOSLS-AMG approach is taken. The goal is to determine the most efficient algorithm in this context. One would like to do as much work as possible on the coarse grid including most of the linearization. Ideally, it would be good to show that at most one Newton step and a few V-cycles are all that is needed on the finest grid. This talk will develop theory that supports this argument, as well as show experiments to confirm that the algorithm can be efficient for MHD problems. Currently, a reduced 2D time-dependent formulation is studied. These equations can simulate a "large aspect-ratio" tokamak, with non-circular cross-sections. Here, the problem was reformulated in a way that is suitable for FOSLS and FOSPACK. This talk will discuss two test problems from this formulation: the Tearing Mode instability and the Island Coalescence Instability.