

Nested Iteration First-Order System Least Squares on Incompressible Resistive Magnetohydrodynamics

James H. Adler,* Tom Manteuffel,* Steve McCormick,* and John Ruge*

Magnetohydrodynamics (MHD) is a fluid theory that describes Plasma Physics by treating the plasma as a 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. Most of the work is done on the coarse grid, including most of the linearizations. We show that at most one Newton step and a few V-cycles are all that is needed on the finest grid. Here, we describe how the FOSLS method can be applied to incompressible resistive MHD and how it can be used to solve these MHD problems efficiently in a full multigrid approach. A 3D steady state and a reduced 2D time-dependent test problem are studied. The latter equations can simulate a “large aspect-ratio” tokamak. The goal is to resolve as much physics from the test problems with the least amount of computational work. We show that this is achieved in a few dozen work units (A work unit equals a fine grid residual evaluation).

*Department of Applied Mathematics, University of Colorado at Boulder, Boulder, CO 80309. Research supported by DOE OASCR under grant no: DE-FG02-03ER25574