James Adler

Nested Iteration FOSLS-AMG for Resistive Magnetohydrodynamics

2075 Goss St 11
Boulder
CO 80302
james.adler@colorado.edu

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 system is linearized on a coarse grid using a Newton step and is then discretized in a FOSLS functional upon which several AMG V-cycles are performed. If necessary, another Newton step is taken and more V-cycles are done. When the linear functional has converged "enough," the approximation is interpolated to a finer grid where it is again linearized, FOSLized, and solved for. 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, two test problems have been studied, both with the use of FOSPACK: a 3D steady state MHD test problem with a manufactured solution, and, for a more realistic problem, a reduced 2D time-dependent formulation. The latter 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 stopping criteria. First, on each refinement level, when should one stop solving the linear system and re-linearize the problem. Secondly, how does one choose whether to do another Newton step or move to a finer grid. In addition, different types of h and p refinement will be tested, as well as adaptive mesh refinement. The goal is to resolve as much physics from the test problem with the least amount of work.