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Investigations of Multgrid implementiaton of precondition within the extended MHD NIMROD code.

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Considerable effort has been put forth in efforts to simulate Edge Localized Modes (ELMs) with nonlinear extended magnetohydrodynamic codes in order to understand the effects of ELMs on plasma confinement properties. These simulations have led to new numerical challenges. The disparate time scales demand implicit treatment, but the required operators for the two-fluid physics leads to non-symmetric matrices. The broad linear spectrum means greater resolution is required, further increasing the condition number of the matrices. Thus, an effective preconditioner is necessary. SuperLU, a direct linear solver, has proven to be an effective preconditioner for NIMROD's three-dimensional matrices by application to only the decoupled two-dimensional matrices. Because the majority of the simulation time is spent in matrix solves, effective use of computational resources requires effective linear solves. Multigrid methods, while more than 30 years old, are currently regarded as the most efficient solvers for a wide variety of problems. For elliptic problems, they have been shown to be the fastest algorithms. Multigrid methods are *scalable* (or *optimal)* because they can solve a linear system with N unknowns with $O(N)$ operations. In addition to this favorable scaling, the fundamental idea of operating at different scales can also be exploited to minimize the computations and work well for parallel computing. We currently implement the multgrid linear solver *hypre* via an interface to the PETSc numerical suite, which also can interface Super LU. We will present processor scaling results comparing SuperLU and *hypre* as preconditioners for the $(2, 1)$ tearing mode benchmark case and recent ELM milestone case. Also, we will present the extended MHD system from which the preconditioned matrices are derived from so as to illicit further insight for preconditioning techniques.