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Block Preconditioning and a Monolithic AMG Method for Magnetic Confinement Fusion Relevant Resistive MHD Simulations

Peter Ohm[1], Jesus Bonilla[2], Jonathan J. Hu[3], John N. Shadid[3], Raymond S. Tuminaro[3]

[1] Sandia National Laboratories, PO Box 5800, MS 1320, Albuquerque, NM, 87185-1320, pohm@sandia.gov

[2] Los Alamos National Laboratory, jbonilla@lanl.gov

[3] Sandia National Laboratories, {jhu, jnshadi, rstumin}@sandia.gov

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The mathematical basis for the continuum fluid modeling of resistive magnetohydrodynamic of multifluid plasma physics systems is the solution of the governing partial differential equations (PDEs) describing conservation of mass, momentum, and thermal energy, along with various reduced forms of Maxwell's equations for the electromagnetic fields. The resulting systems are characterized by strong nonlinear and nonsymmetric coupling of fluid and electromagnetic phenomena, as well as the significant range of time- and length-scales that these interactions produce. These characteristics make scalable and efficient iterative solution, of the resulting poorly-conditioned discrete systems, extremely difficult. In this talk we consider the use of both block preconditioners and an algebraic monolithic multigrid approach for solving the coupled physics block systems [1,2].

Monolithic multigrid methods can also benefit from this block linear structure. In this context we present a framework for the construction of an algebraic monolithic multigrid utilizing the natural block linear structure arising from coupled multiphysics problems [3]. Multigrid components are constructed first on matrix subblocks corresponding to individual physics. The resulting AMG sub-components are then composed together to define a monolithic AMG preconditioner.

We demonstrate this approach through an implementation in MueLu [2,3] for various Resistive MHD problems that that are relevant to magnetic confinement fusion applications and compare the performance with alternative preconditioning methods.

REFERENCES

[1] E. C. Cyr, J. N. Shadid, and R. S. Tuminaro, Teko an abstract block preconditioning capability with concrete example applications to Navier-Stokes and resistive MHD, SIAM SISC Vol. 38, No. 5, pp. S307–S331, 2016

[2] Luc Berger-Vergiat, Christian A. Glusa, Jonathan J. Hu, Matthias Mayr, Andrey Prokopenko, Christopher M. Siefert, Raymond S. Tuminaro and Tobias A. Wiesner, *MueLu multigrid framework*, http://trilinos.org/packages/muelu, 2019.

[3] Peter Ohm, Tobias A. Wiesner, Eric C. Cyr, Jonathan J. Hu, John N. Shadid and Raymond S. Tuminaro, A monolithic algebraic multigrid framework for multiphysics applications with examples from resistive MHD, Submitted.