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On the Development of a Scalable Implicit Stabilized Finite-Element Resistive MHD Solver L. CHACÓN, ORNL, J.N. SHADID, R.P. PAWLOWSKI, SNL — We explore the development of a massively parallel, scalable fully-implicit stabilized unstructured finite element (FE) capability for low-Mach-number resistive MHD. We focus on the development of the stabilized FE formulation and the underlying fully-coupled preconditioned Newton-Krylov nonlinear iterative solver. To enable robust, scalable and efficient solution of the large-scale sparse linear systems generated by the Newton linearization, fully-coupled algebraic multilevel preconditioners are employed. These preconditioning methods are based on a variable-overlap additive one- level Schwarz preconditioner and a relatively new algebraic multilevel technique that employs a graph-based aggressive-coarsening aggregation method applied to the nonzero block structure of the Jacobian matrix. We will present verification results that demonstrate the expected order-of-accuracy, including prototype problems such as an MHD Faraday conduction pump, the hydromagnetic Rayleigh-Bernard instability, the magnetic island coalescence problem, and 3D tokamak calculations using Solove'ev equilibria. We will discuss initial encouraging results that explore the scaling of the solution methods on up to 4096 processors for problems with up to 64M unknowns on a CrayXT3/4, and will demonstrate a successful large-scale proof-of-capability calculation for 1 billion unknowns for the MHD Faraday pump problem on 24,000 cores.

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