STREAMFUNCTION FINITE ELEMENT METHOD FOR MAGNETOHYDRODYNAMICS

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ABSTRACT. We apply the finite element method to two-dimensional, incompressible MHD, using a streamfunction approach to enforce the divergence-free conditions on the magnetic and velocity fields. This problem was considered by Strauss and Longcope. In this paper, we solve the problems with magnetic and velocity fields instead of the velocity stream function, magnetic flux, and their derivatives. Considering the multiscale nature of the tilt instability, we study the effect of domain resolution in the tilt instability problem. We use a finite element discretization on unstructured meshes and an implicit scheme. We use the PETSc library with index sets for parallelization. To solve the nonlinear MHD problem, we compare two nonlinear Gauss-Seidel type methods and Newton's method with several time step sizes. We use GMRES in PETSc with multigrid preconditioning to solve the linear subproblems within the nonlinear solvers. We also study the scalability of this program on a cluster.

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