A Monolithic Approach for the Incompressible Magnetohydrodynamic Equations

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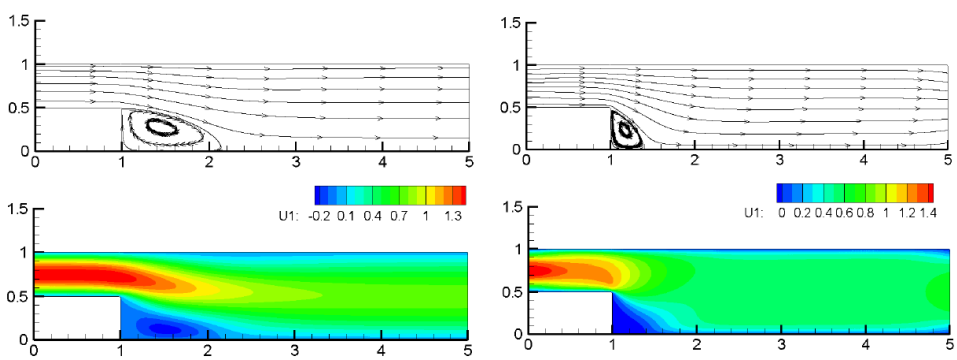
ABSTRACT

A numerical algorithm has been developed to solve the incompressible magnetohydrodynamics (MHD) equations in a fully coupled form. The numerical approach is based on the side centered finite volume approximation [1] where the velocity and magnetic filed vector components are defined at the center of edges/faces, meanwhile the pressure term is defined at the element centroid. In order to enforce a divergence free magnetic field, a magnetic pressure is introduced to the induction equation. The resulting large-scale algebraic linear equations are solved using a one-level restricted additive Schwarz preconditioner with a block-incomplete factorization within each partitioned sub-domains. The parallel implementation of the present fully coupled unstructured MHD solver is based on the PETSc library for improving the efficiency of the parallel algorithm. The numerical algorithm is validated for 2D and 3D lid-driven cavity flows and backward step problems for both conducting and insulating walls.



(a) (b)

Figure 1: Streamlines and $x-$velocity contours of MHD flow over a backward step with uniform magnetic field $B(0,1)$ and conducting walls at $Re = 100$, $Ha = 0$ (a) and $Re = 100$, $Ha = 20$ (b).

REFERENCES

[1] Erzincanli, B. and Sahin, S. An arbitrary LagrangianEulerian formulation for solving moving boundary problems with large displacements and rotations. *J. Comp. Phys.* (2013) **255**:660–679.