6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

A High-Order Solver for Simulations of Magnetohydrodynamics Flows

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Keywords: *High Order, Local time stepping, Magnetohydrodynamics, Adaptive Mesh Refinement*

In this paper, we present a high-order parallel solver for numerical simulations of magnetohydrodynamics (MHD) flows. The flux reconstruction (FR) method[1] is employed in our solver due to its various advantages,e.g. simple and efficient implementation, compact stencil for easy parallelization,etc. We also introduce adaptive mesh refinement(AMR) technique to our solver. Together with AMR a local time stepping method based on FR is utilized to further enhance computational efficiency. For MHD flows with discontinuities, e.g. shock waves, contact discontinuity and magnetic discontinuity, we introduce localized artificial diffusivity and resistivity to alleviate spurious oscillation near discontinuities.

When it comes to simulations of MHD flows, the magnetic divergence-free constraint should be satisfied or at least the divergence error should be under control. Unlike constraint transport (CT) method, FR is inherently unable to guarantee discrete divergence free. To this end, a novel sub-iterative divergence cleaning technique is introduced. Numerical tests show that divergence cleaning with multiple iterations performs more effectively than its counterpart.

In our solver, we successfully applied FR scheme to magnetohydrodynamics. Coupled with other technique, e.g. AMR, Local time stepping and sub-iterative cleaning, our FR-based solver shows very efficient and robust performance for simulations of MHD flows with both smooth and discontinuous features.

REFERENCES

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