Sixteenth International Conference Zaragoza-Pau on Mathematics and its Applications
Jaca, September 7–9th 2022

High-Order Spectral Difference Methods for Magnetohydrodynamics

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SUMMARY

A high-order spectral difference method (SDM) for solving the magnetohydrodynamics equations is presented. Because of the presence of shocks in astrophysical scenarios, the numerical framework consists of a hybrid scheme, where for smooth parts of the flow, the SDM is used, and those regions with strong shocks are evolved with a robust finite volume (FV) method with WENO3 reconstruction. In this approach, we interpret the nodal SDM values in the troubled element as FV subcell values for their further time evolution. The generalized Lagrange multiplier method is employed to enforce the solenoidal constraint on the magnetic field. For the time discretization, an explicit fourth-order strong stability-preserving Runge–Kutta method is employed. Numerical results with very high polynomial degree include the Orszag–Tang vortex, the spherical blast wave problem and the Kelvin–Helmholtz instability. Finally, we also compare this scheme with high-order finite difference, finite volume, and discontinuous Galerkin schemes, analyzing their robustness and performance.

Keywords: Spectral difference methods, magnetohydrodynamics, shock capturing

AMS Classification: 65M70, 76M22, 76W05

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