Higher-order weighted compact nonlinear scheme for magnetohydrodynamics

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Complex interactions between a magnetohydrodynamic (MHD) shock and turbulence play an important role in various space and astrophysical plasmas. For the last several decades, a number of approximate Riemann solvers for MHD have been developed. The HLLD approximate Riemann solver proposed by Miyoshi and Kusano [1] is adopted as a standard solver in many MHD software packages. In addition, the Riemann solver which is first-order accurate must be extended to higher-order in order to numerically solve the turbulence. A higher-order finite-volume method in which the numerical fluxes are evaluated using a nonlinear variable interpolation method such as MUSCL, WENO, or MP5 is often constructed as a higher-order MHD method [2,3,4]. However, it is difficult in general to construct higher-order finite-volume method in multidimensions and realize higher-order for multidimensional physics simulations.

In this study, we construct a higher-order MHD scheme by applying a finite-difference method which can simply be extended to multidimensions. Particularly, a shock capturing finite-difference method, so-called weighted compact nonlinear scheme (WCNS) [5,6], is adopted. The WCNS is composed of higher-order numerical fluxes evaluating from a weighted variable interpolation method and higher-order central finite-difference method. Combinations of 5th-order numerical fluxes and 4th or 6th-order central finite-difference method are applied for and comparatively investigated. We also discuss a divergence-free WCNS for multidimensinoal MHD in this report.

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