Higher-order weighted compact nonlinear scheme for magnetohydrodynamics

*Takahiro Miyoshi[1], Takashi Minoshima[2], Yosuke Matsumoto[3]

1.Graduate School of Science, Hiroshima University, 2.Department of Mathematical Science and Advanced Technology, Japan Agency for Marine-Earth Science and Technology, 3.Graduate School of Science, Chiba University

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.
[1] T. Miyoshi, K. Kusano, J. Comput. Phys., 208, 315, 2005.
[2] A. G. Kritsuk, et al., Astrophys. J., 737:13, 2011.
[3] T. Minoshima, et al., Astrophys. J., 808:54, 2015.
[4] http://www.astro.phys.s.chiba-u.ac.jp/cans/
[5] X. G. Deng, H. Zhang, J. Comput. Phys., 165, 22, 2000.
[6] T. Nonomura, K. Fujii, Comput. Fluids, 85, 8 , 2013.

Keywords: MHD, WCNS, approximate Riemann solver

