A comparative study of divergence cleaning methods for magnetohydrodynamics

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Unphysical divergence of the magnetic field is numerically produced by upwind-type numerical schemes for magnetohydrodynamics (MHD) such as approximate Riemann solvers. Since MHD simulations are abnormally terminated by the unphysical Lorentz force due to the unphysical magnetic monopole, the development of divergence cleaning methods is one of the most important task for the study of numerical schemes for MHD. Therefore, in this paper, several divergence cleaning methods are studied comparatively based on the HLLD approximate Riemann solver, which now becomes widely used as a standard solver for MHD. Particularly, a new constrained transport-like (CT-like) method that can be applied into unstructured grid systems is developed and discussed in the viewpoint of consistency within the integral of the induction equation.