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A new divergence-free-preserving high-order scheme for magnetohydrodynamics[1] SOSHI KAWAI, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency — We present a new strategy that is very simple, divergence-free, high-order accurate, yet has an effective discontinuous-capturing capability for simulating magnetohydrodynamics (MHD) with shock waves. The new strategy is to construct artificial diffusion terms in a physically-consistent manner, and to be built into the induction equations in a conservation law form at a partial-differential-equation level. The physically-consistent manner means that the artificial terms act as a diffusion term only in the curl of magnetic field to capture numerical discontinuities in the magnetic field while not affecting the divergence field (thus maintaining divergence-free constraint). The proposed method is inherently divergence-free both ideal and resistive MHD, with and without shock waves, and also both inviscid and viscous flows. The method is based on finite difference method with co-located variable arrangement, and any linear finite difference scheme in an arbitrary order (i.e., any desirable high-order) of accuracy can be used to discretize the modified governing equations to ensures the divergence-free constraint numerically at the discretization level. Two-dimensional smooth and non-smooth ideal MHD problems are considered to show a superior performance of the proposed method.

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