A high-order divergence-free weighted finite difference scheme for the two-fluid plasma equations

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Recent development of numerical techniques for magnetohydrodynamics (MHD) enables us to simultaneously simulate fine structures created by shock-vortex interactions and a large-scale MHD structure. On the other hand, the scales of the fine structures can become so small that the MHD approximation breaks down. Thus, a new macroscopic plasma simulation model beyond MHD is strongly required. In particular, the full two-fluid plasma model including local charge separation is considered in this study. According to the growth of computing power, the full two-fluid plasma simulation model will be scope of a standard model in the near future.

Since the full two-fluid plasma equations are hyperbolic conservation laws with stiff source terms, i.e., hyperbolic balance laws, state-of-the-art numerical techniques for the neutral fluid and MHD models can be applied. Recently, Minoshima et al. [1] developed high-order, non-oscillatory, and divergence-free finite difference schemes for MHD. In their schemes, the magnetic fields are defined on staggered grids, and the induction equation is discretized using high-order centered finite differences of the electric fields that correspond to numerical fluxes for the induction equation weightedly interpolated to the vertices of the grids. We apply this approach such that the Maxwell equations are discretized on the staggered grids using high-order centered finite differences of the electric and magnetic fields interpolated to the grid vertices and construct a high-order non-oscillatory divergence-free scheme for the full two-fluid plasma equations. A comparative study with other schemes is presented in this talk. We also discuss the time integration method.

[1] T. Minoshima, T. Miyoshi, Y. Matsumoto, submitted to Astrophys. J. Suppl.

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