

Multidimensional divergence-constrained relativistic two-fluid simulation code

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Relativistic plasmas are known to exist around compact astrophysical objects such as neutron stars and/or black holes. Ideal relativistic magnetohydrodynamics (RMHD) approximation has commonly been used to investigate the dynamics of high-energy plasmas. There has been growing interest in incorporating resistive effect into the model to take into account dissipation of magnetic field energy, which often dominates the total energy of the system. In contrast to the classical counterpart, however, resistive RMHD is not so commonly adopted because implementation of Ohm's law is much more involved.

On the other hand, the relativistic two-fluid model has rarely been considered as a macroscopic model, mainly because it contains small-scale physics that appears to be unimportant in large-scale phenomena. We here explore the possibility of the relativistic two-fluid model being used as an alternative model to RMHD, in particular, with the effect of resistivity. Since the resistive effect in the two-fluid can easily be taken into account as a friction term between the fluids, we think that it may offer a numerically more convenient model. We have developed a second-order three-dimensional simulation code for the two-fluid equations. The code employs the HLL (Harten-Lax-van Leer) approximate Riemann solver and the UCT (Upwind Constrained Transport) scheme originally proposed for MHD. By carefully designing discretization of the electromagnetic field, we show that the divergence constraints for both the magnetic and electric fields are simultaneously satisfied up to machine precision. Finite difference approach for extension to higher orders will also be discussed.