Development of a MHD simulation code automatically satisfying solenoidal condition of the magnetic field using R-CIP algorithm

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Because of the week intrinsic magnetic field, the Mercury's magnetosphere is small in comparison with the Earth. Thus the kinetic aspect of ions is considered not negligible. Recent simulation studies of electron and ion dynamics in the Mercury's magnetosphere used analytical electric and magnetic field models that are obtained by rescaling the Earth's magnetosphere [e.g., Delcourt et al. 2003; 2006]. The resultant properties of ion and electron dynamics largely depend on the analytical models used in the simulation. In order to verify the rescaling magnetospheric models, investigation of ion and electron dynamics in a self-consistent electric and magnetic field configuration such as obtained from MHD simulations is needed. In order to study particle dynamics, the global simulation, which provides self-consistent fields, is required to precisely fulfill the solenoidal condition for the magnetic field (divB=0) to avoid artificial acceleration/deceleration. In this study, we develop a new MHD simulation code which automatically satisfies the solenoidal condition for B.

To implement the condition, we use vector-potential (A) substitute for magnetic field itself (B) in MHD equation. Aiming at accurate simulation of high Reynolds number magnetofluid (low numerical viscosity), we adopted R-CIP algoerithm [Yabe et al., 1991; Xiao et al., 1996] to solve the advection term in the simulation code. Time evolution of their first derivatives as well as physical quantities is solved in the CIP method. The non-advection terms are solved by 3rd order Adams-Moulton predictor-corrector method. As a first step of the code development, we conducted several test runs for the one-dimensional MHD code and compare the results with previous simulations or analytical solutions so as to assess the energy and mass conservation, description of MHD discontinuities, and Alfven wave propagations. A remarkable feature of the new 1-D code with A is that it can simulate the Alfven wave propagation quite precisely than the code with B. In the presentation, the status of ongoing 3-D code development will be also presented in addition to the 1-D case.

References:
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