イオ-木星系のためのセミディスクリート中心スキームを用いた電磁多流体コードの開発

松田 和也 [1]; 寺田 直樹 [2]; 加藤 雄人 [3]; 三澤 浩昭 [4]; 齋 和人 [3]
[1] 東北大・理・地物; [2] 東北大・理・地物; [3] 東北大・理・地球物理; [4] 東北大・理・惑星プラズマ大気研究センター

Development of a new multi-fluid code for the Io-Jupiter system based on semi-discrete central schemes

Kazuya Matsuda[1]; Naoki Terada[2]; Yuto Katoh[3]; Hiroaki Misawa[4]; Kazuhito Sai[3]
[1] Geophysics, Tohoku Univ.; [2] Dept. Geophys., Grad. Sch. Sci., Tohoku Univ.; [3] Dept. Geophys., Grad. Sch. Sci., Tohoku Univ.; [4] PPARC, Tohoku Univ.

Subcorotation of Iogenic plasma in the Io plasma torus has been understood as electric drift by a perpendicular electric field with respect to the Jovian magnetic field. A part of the radially integrated potential has been considered to be imposed in the direction parallel to the magnetic field in some regions on the field lines. To describe parallel acceleration of electrons in a fluid simulation, it is important to treat at least two ion components, one of which is shut out and the other of which is accelerated by the electric field. We are developing a multi-fluid simulation code based on semi-discrete central schemes so as to clarify the actual structure of the electric fields and current density in the Io-Jupiter system.

Central schemes do not have to differ between left-going and right-going waves in contrast to upwind schemes such as MUSCL and WENO. They need no characteristic decompositions based on (approximate) Riemann solvers in their constructions. Semi-discrete central schemes can avoid large numerical viscosity of these central schemes. As far as we know, there has been only one application of the semi-discrete central schemes to Hall MHD equations [Qian et al., 2009], and no example applying them to general two-fluid or multi-fluid equations. We therefore have tried to confirm that the schemes are capable of simulating these sets of equations.

We first performed MHD, Hall MHD, and two-fluid simulations. The equations consist of mass conservation law, equation of motion, energy equation (or pressure equation), Faraday's law, and Ohm's law. The numerical diffusion for advection of Alfven wave was found to be similar to that of the MOCCT method [Matsumoto and Seki, 2008]. Phase errors of slow, Alfven, and fast modes turned out to be negligible for all wave numbers. In the cases of Hall MHD simulations, whistler mode dispersion similar to previous studies [Huba, 2003; Qian et al., 2009] was obtained.

We then performed three-fluid simulations. Following Winglee [1998], we was assumed that the perpendicular velocities of ions relative to magnetic field are identical to avoid resolving the cyclotron motions of ions, which requires an impractically small time step. We found that since direction perpendicular to magnetic field changed in time, the accuracy of dispersion for short-wavelength Alfven wave became worse. However, our code enjoys the simplicity of being independent of the eigenstructure of the problem which is an advantage of the scheme.

We have been developing general two-fluid and three-fluid simulation codes. We will also show their initial results.