地球磁気圏グローバルMHDシミュレーションモデルの比較研究

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Comparative studies of global MHD simulations of the terrestrial magnetosphere with different numerical schemes

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A global MHD simulation of the terrestrial magnetosphere numerically solves an interaction of the magnetosphere with the supersonic solar wind plasma. The first attempt was examined in the 2-D meridian plane by *Leboeuf et al.* [1978] more than 30 years ago. Bow shock formation and magnetic reconnection at the day side magnetopause and in the tail region were successfully shown for the first time in a time-dependent model. Further challenges in 3D models were examined without [*Wu et al.*, 1981] and with [*Ogino*, 1986] the interplanetary magnetic field (IMF) in the early 1980's.

Rapid growth of computational capabilities in the last 30 years enables us to simulate more realistic situations of an interaction of transient phenomena of the sun, such as Coronal Mass Ejections (CMEs), with the magnetosphere and resultant ionospheric responses as auroral brightening. Nowadays, the global MHD simulation is a powerful tool for predicting the geospace environment in response to the solar activities, that is, the space weather forecast. Although numerous models based on different numerical schemes have been developed, they have been tested independently, and occasionally reach different conclusions even under similar conditions. For example, *Raeder* [1999] reported with his model solved by the semi-conservative scheme that the magnetotail does not get closed with low electrical resistivity under a northward IMF condition. Later, *Gombosi et al.* [2000] showed similar simulations with their model solved by the fully conservative scheme and indicated that the closed magnetosphere is an universal feature under the northward IMF regardless of the strengh of the numerical resistivity. Though some comparative studies have been examined, there has been no direct comparison of different global MHD simulation models under the same solar wind and numerical (e.g., spatial resolutions) conditions.

We compare recent global MHD simulation models of the terrestrial magnetosphere based on different numerical schemes. The schemes include the finite difference method based on the modified leapfrog (MLF) scheme, and the semi-Lagrangian scheme based on the CIP algorithm. With the two models, we examined the simulation under a northward IMF condition. As results, we found that the two simulation models give consistent results on the magnetopause locations at the subsolar point and the terminator, and overall structures of the cusp in the meridian plane. However, discrepancies are also found in the location and jump conditions of the bow shock. The MLF model showed higher thermal pressure value and weaker magnetic field strength in the downstream than those in the CIP model. The difference in the jump condition across the shock is also reflected in difference in the length of the magnetotail in the two models. The magnetotail is shorter in the CIP model than in the MLF model. We conclude that further comparative studies with finite volume methods are necessary to verify the solution of the bow shock formation and the location of the last closed field line under northward IMF conditions.

Reference:
Matsumoto et al., *IEEE Trans. Plasma Sci.*, in press.