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Global MHD simulation of the magnetosphere: Implementation of the CIP algorithm

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The mean free path of plasmas surrounding the magnetosphere is about 1 AU and thus it is usually referred to as a super-high Reynolds flow or collision-less plasma. Actually, it was reported that the Reynolds and the magnetic Reynolds numbers are order of 10^{11-13} based on the coulomb collision rate [Borovsky, 1997]. The actual situation is therefore much more turbulent than we expect from global MHD simulations of the magnetosphere interacting with the solar wind. For example, the Kelvin-Helmholtz instability (KHI) has been considered to responsible for formation of the LLBL via its turbulent evolution [Matsumoto and Hoshino, 2004, 2006] for a northward IMF. Despite its importance, the role of the KHI for a northward IMF has been poorly understood in a global MHD model, while the KHI is recently reproduced by the high-resolution global MHD simulation for the southward IMF case in the context of the ULF pulsation [Claudepierre et al., 2008].

To show importance of turbulence in the context of energy and mass transports at the magnetopause and an acceleration of plasmas in the plasma sheet, we have developed a new global MHD simulation model of the magnetosphere. The model implements the CIP algorithm [Yabe et al., 2001] which enables us to solve the advection equation stably with a low numerical dissipation. The MHD equations are based on the Elsasser variables [Elsasser, 1950] to solve the advection and the Alfven wave propagation by the CIP algorithm [Matsumoto and Seki, 2008]. The compressive terms are remained as non-advective terms which are descretized on a staggered Cartesian grid system and solved by the 3rd order Adams-Moulton predictor-corrector method. Since the present scheme is not specially designed for capturing shock formation, a shock capturing artificial viscosity [Ogata and Yabe, 1999] is introduced to solve the fast shock formed ahead of the magnetosphere. The inner boundary conditions are applied at the surface at r=6R_E where the physical quantities are fixed at the initial values. The ionospheric boundary condition is therefore not implemented in the present model at this moment. In this talk, we present details of our newly developed global MHD simulation model and an interaction of the solar wind with the magnetosphere for a northward IMF case.