

## The realization of magnetospheric MHD processes: An idea based on the eigenmode decomposition in global MHD simulations

# Aoi Nakamizo[1]; Akimasa Yoshikawa[1]

[1] Earth and Planetary Sci., Kyushu Univ.

In magnetospheric physics, MHD has been used as the primary theory. However, do we understand the mechanics and the magnetosphere-ionosphere (M-I) coupling process of magnetosphere phenomena completely in the context of MHD? In the linear theory, any MHD processes are described as the superposition of the MHD eigenmodes (intermediate, fast, and slow mode) that are independent of each other and its related physics, such as the force balance and the balance between electromagnetic energy and plasma energy, is clear. However, in the actual magnetosphere, due to the complexity and inhomogeneity of the background magnetic field and plasma, it is extremely difficult to understand the physical processes of phenomena occurring there. Then numerical simulations are very useful for capturing the complex actual phenomena.

Formally, the source of FACs on the magnetospheric side is identified as the center of rotational convection and the inhomogeneity of the background field and the requirements explicitly imposed by the M-I coupling are only the equality of electric potential and the current closure (continuity of FACs and divergence of ionosphere current) between magnetosphere and ionosphere. Then, it seems that we understand the M-I coupling if we can deduce the one-to-one correspondence of magnetosphere rotational field and ionosphere convection connected via FACs. Here the problem is that the above formalism only states the quasi-steady state but say nothing about the physics of non-steady processes. The following are at least necessary for the consideration of non-steady processes.

(1) The excitation of FACs on the magnetosphere side: The magnetospheric convection is basically composed of rotational motion (incompressible, quasi-steady, potential electric field, intermediate mode, FAC) and divergent motion (compressible, non-steady, inductive electric field, fast or slow mode, perpendicular current) and FACs are always connected to magnetospheric perpendicular currents. The excitation of FACs is inextricably linked with the growth and decay of perpendicular currents. Therefore, the stress and energy balance associated with divergent field and how they are related to that of rotational field should be clarified.

(2) The description of the magnetosphere-ionosphere coupling process: It is necessary to describe the interaction of intermediate mode and weakly-ionized plasmas consistently in order to clear up the relationship between the inflow/outflow of electromagnetic energy and stresses transferred by FACs and the joule dissipation and momentum change of weakly-ionized plasmas in the ionosphere.

Existing magnetosphere MHD simulations do not provide with the viewpoints of the decomposition of magnetospheric convection into divergent and rotational part and the interaction process through intermediate mode in the magnetosphere-ionosphere coupled system. In this paper, as the first step, we propose an idea for the realization of the rotational field and divergent field in a global MHD simulation and discuss about our expectation.