非ダンジェー対流駆動機構ー磁気圏物理学の新しいパラダイム

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Generation mechanism of the non-Dungey convection - A new paradigm of the magnetospheric physics

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The magnetosphere-ionosphere coupling convection is a core process from which all global magnetospheric phenomena like substorms, storms, steady magnetospheric convections, sawteeth events, sudden commencements, and theta auroras develop. However, only the schematic model proposed by Dungey (1961) has been accepted as a standard model of the convection. This fact is surprising compared with other precise researches of the magnetospheric physics like the reconnection. At the same time, this fact indicates backwardness of the magnetospheric physics compared with other Earth and planetary sciences like the atmospheric physics in which the physical process of the global circulation is well understood.

Tanaka (2003) proposed physical processes of the magnetosphere-ionosphere coupling convection based on precise global MHD simulation results. Although he established the physical processes inside the magnetosphere, there is still a missing link about transport of mass, momentum and energy from the solar wind to the magnetosphere in order to understand a driving mechanism of the magnetosphere-ionosphere coupling convection. After elucidating the transport mechanism, the magnetospheric physics becomes a precise science like the atmospheric physics. In order to investigate the driving mechanism of the convection - namely a driving mechanism of a dynamo for the Region 1 field-aligned current -, we pursue both transport of energy from the solar wind to the lobe via the cusp-mantle region and generation of a dynamo of the Region 1 field-aligned current in the context of conversion of energy in the cusp-mantle region based on a global MHD simulation. We first identify stream lines of the plasmas bulk flow pass from the solar wind to the lobe. The thermal energy in the magnetosheath is enhanced mainly by the solar-wind dynamic pressure. The electromagnetic energy from the cusp-mantle region also contributes to the enhancement. This enhanced thermal energy is converted to the field-aligned plasma bulk flows. This field-aligned bulk flow turns to be a perpendicular one due to the centrifugal force of a field-aligned flow on a curved magnetic field in the boundary between the magnetosheath and the lower-latitude side of the cusp. In the cusp-mantle region, decrease in the thermal energy due to plasma escape along field lines into the lobe induces a dynamo (the slow mode expansion). It is concluded that magnetic field merging (reconnection) in the dayside magnetopause does not play a direct role in driving the magnetosphere-ionosphere coupling convection. We also identify the magnetospheric energy convection in which the mechanical energy flux from the solar wind to the cusp-mantle region is partly converted to the Poynting flux returning to the dayside magnetopause.

References

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