磁気圏対流生成機構

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Generation mechanism of the plasma convection in magnetosphere-ionosphere compound system

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The magnetosphere-ionosphere convection has been regarded to be driven by the dayside reconnection proposed in the famous paper by Dungey [1961]. The Dungey convection model is now accepted as a standard model. Although not stated definitely by him, the Dungey model insists the magnetic tension force associated with bending field lines derived from the reconnection as the driver of the plasma convection flow.

Recent realistic MHD simulations [Tanaka, 2003] cast doubts about this Dungey convection model because acceleration/deceleration of plasmas in the magnetosphere due to the magnetic tension force does not appear in the simulation results. Tanaka [2003] proposed a new convection model called by the magnetosphere-ionosphere compound system in which the plasma population, the magnetospheric and ionospheric currents and the magnetospheric and ionospheric convections keep the self-consistent quasi-stationary relation.

Although the magnetosphere-ionosphere compound system is an epoch-making and break-through idea about the convection system, we point out here a defect of this idea; the momentum transfer from the solar wind into the magnetosphere is not clear in this model. In addition, we also point out omission of the null-separator structure in the real solar wind-magnetosphere configuration. It is the time when we propose the new model of the plasma convection in the magnetosphere-ionosphere compound system.

Let us explain the new convection model. We are focused on the southward IMF condition. When IMFBy is westward, the null points in the northern and southern hemispheres are located in the morning side and in the evening side, respectively. In the magnetosheath-magnetopause region in the northern hemisphere, the open magnetic field line merged with the IMF at the null point in the northern hemisphere invokes the magnetic tension force in the morning side. This force eventually is consumed to confine the high-pressure plasmas in the cusp region. Thus, this tension force does not affect directly the plasma motion in the magnetosphere. On the other hand, merging of the field lines at the null point in the afternoon side of the southern hemisphere drives magnetic field erosion from the closed magnetic field lines in the dayside magnetosphere to the open one in the nightside lobe region. The simulation reveals that the magnetic tension force does not play any significant role in this case. Instead, the plasmas are accelerated along the magnetic field lines due to the field-aligned pressure gradient in the dayside magnetopause region. This pressure gradient is generated by transport of the solar wind into deep magnetosheath in the equatorial plane. Then, the accelerated field-aligned plasma flow changes the convection flow (the flow perpendicular to the field line) due to the centrifugal force invoked by the curved field line. This is the mechanism that the momentum in the solar wind is transported into the magnetosphere. It should be noted that the reconnection does not play a role in generation of the convection except that it triggers configuration change of the magnetic field lines.

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