Geotailによるリコネクションの検証

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Evidence for magnetic reconnection with Geotail observations

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(1) Microphysics in the ion diffusion region

Close to the X-line, electrons are strongly accelerated and heated, and their speed exceeds the Alfven velocity. In the outflow region, since electrons are frozen-in to the magnetic field, they carry the magnetic field. Initially, ions are not frozen-in to the magnetic field and are less accelerated because of their large inertia. The ambipolar electric field forms with charge separation. Hence, ions are accelerated with this electric field, while electrons are decelerated. The final velocity of ions and that of electrons become the Alfven velocity. On January 27, 1996, Geotail observed fast ion tailward convection flows with a speed of 2300 km/s. We can estimate that the average tailward flow speed of electrons is 4000 km/s on the basis of electron distributions, when the Afven velocity is 2925 km/s.

(2) Hall currents

In the inflow region, electrons approach to the X-line with a distance of electron inertial length, while ions approach to the X-line only with a distance of ion inertial length. A relative motion of electrons and ions results in the Hall current system near the X-line, in which the currents flow outward in the separatrix region . Geotail observes escape of high-energy electrons from the reconnection region. In the outermost region, there are electrons flowing toward the reconnection region. These electrons are signatures of the Hall current system.

(3) "Slow shock"-like structure

Electrons are thought to be accelerated and heated near the X-line. Ions are thought to be accelerated in the "slow mode shock" situated in the separatrix region as well as the X-line. Geotail observes two Hall current layers in the separatrix region: the outer Hall current layer consisting of low energy (< 1 keV) inflowing electrons and the inner Hall current layer consisting of medium energy (1-5 keV) inflowing electrons. In the outer Hall current layer, ions move toward the neutral sheet and these ions are cold. In the inner Hall current layer, ions are strongly heated and their convection speed becomes high. Furthermore, ions move dawnward as well as toward the neutral sheet.
This indicates that the ions move with the ExB drift with the negative (positive) Ez in the northern (southern) hemisphere. Hence, the "slow shock"-like structure exists in the Hall current region, and ions are accelerated and heated.