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Estimate of the orientation and current density in the plasma sheet: Application of the energetic ion sounding technique

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Energetic ion observations have been used to sound the boundaries with density gradients such as the magnetopause. The present study applies the energetic ion sounding technique to the plasma sheet boundary, which can be sounded by ion observations in the low-density regions above or below the plasma sheet. We estimate the normal direction of the boundary and the distance from the spacecraft to the boundary. Successive estimates of the distance allow us to calculate velocity of the boundary motion. Utilizing multi-spacecraft observations of Cluster, we attempt to estimate the current density in the plasma sheet.

The method can provide the current density perpendicular to the magnetic field in the plasma sheet, under the following conditions; (1) One of the spacecraft (#A) makes successive observations of non-gyrotropic ion distribution in the plane perpendicular to the magnetic field, (2) the X-component of the magnetic field is dominant at the position of spacecraft #A, and (3) another spacecraft (#B) close to spacecraft #A is inside the plasma sheet. We estimate the velocity of the plasma sheet from spacecraft #A and the change in the magnetic field X-component from spacecraft #B. Assuming the same velocity of the plasma sheet at both spacecraft positions, we can estimate the current density in the plasma sheet with the use of the Ampere's law (i.e., $j \sim (dBx/dz)/\mu_0$).

The CIS instruments onboard Cluster 1 and 4 observed non-gyrotropic distributions

of 13 keV proton at X_{GSM} = -19.5 R_E on 29 August 2001. The estimated normal direction is consistent with that derived from the minimum variance analysis (shown in Runov et al., 2003, GRL). The current density is estimated to change from a few to 10 nA/m^2.

The present study also examines the 25 September 2002 event in which non-gyrotropic distributions are observed successively for more than 30 min. We discuss motion of the plasma sheet and current structures in the plasma sheet.