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Identification of slow shocks with the effect of temperature anisotropy

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Hot and high speed plasmas are often observed in the magnetotail, and it is believed that those hot and high speed plasmas are produced by slow shock waves formed in the boundary between the lobe and the plasma sheet. In fact, the existence of the slow mode shock has been carefully analyzed by using a full set of plasma observation data of the GEOTAIL spacecraft [e.g., Saito et al., 1995]. In the previous slow shock analyses, for simplicity, an isotropic temperature has been assumed, but it is known that the plasma often shows an anisotropic temperature in magnetotail, and the parallel temperature is often larger than the temperature perpendicular to the magnetic field. The plasma anisotropy contains an important memory of the plasma dynamics in magnetoail, and the formation of the anisotropy and its relaxation process are the long-standing unsolved issue in space plasma.

In this presentation, we investigate the slow shock structure with the effect of temperature anisotropy by using GEOTAIL data. First, we estimated the temperature anisotropy by bi-Maxwellian fitting to the observed velocity distribution functions. Next we reexamined the Rankine-Hugoniot relations by taking into account temperature anisotropy. Due to the anisotropic effect where the parallel is larger than the perpendicular temperature, the shock downstream magnetic field increases, while the plasma density, velocity and total temperature decrease compared with the isotropic Rankine-Hugoniot relations. We found that this behavior can help to explain the observed slow shock downstream state more accurately than an isotropic case. We also found that the anisotropy of the slow shock downstream is gradually relaxed as moving from the boundary toward the central plasma sheet. We conclude that we can identify slow shocks accurately by using Rankine Hugoniot relations with the effect of temperature anisotropy, and the anisotropy in shock downstream is an important agent for understanding the plasma sheet dynamics.