Dumbbell-type ion distributions observed in the cold dense plasma sheet: Revisit of March 24, 1995 event

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The authors presented performance of a new computer program to display 3-D distribution function of ions observed by Geotail spacecraft at the 210th SGEPSS Meeting [2006]. This paper reports the first results of event analyses on the basis of this useful tool.

Geotail crossed the magnetopause at X ˜- 15 RE on March 24, 1995. The spacecraft took 320 minutes from 0450 UT to 0910 UT to pass the boundary layer between the magnetosheath and the plasma sheet. Inspecting a B-C plane diagram at 0804 UT, Fujimoto et al. [1998] showed that the PSDs (Phase Space Density) of low-energy ions are more intense at directions near magnetic field lines than those at other directions. In this paper we examine this significant feature of the ion distribution function in more detail.

We introduce new indices to characterize shapes of the distribution function. The index DP (or DA) denotes the ratio of the average PSD in the area within 30 degrees (or in the area between 150 and 180 degrees) to that in the area between 75 and 105 degrees from the direction parallel to magnetic field lines. Both DP and DA values are greater than unity, when ions have a field-aligned anisotropy. Both are less than unity, when the distribution function has a so-called pan-cake anisotropy. In this paper we identify that ions have a dumbbell-type distribution when both DP and DA values are greater than two. We treat only data with the magnetic-field elevation angle greater than 60 degrees in GSM coordinates to examine the ion distributions in the equatorial region of the magnetotail.

We have examined the distribution function of ions with average energy of 1.08 keV, since a dumbbell anisotropy is most clearly seen at this energy range in the March 24, 1995 event. Geotail observed 287 data points between 0800 and 0900 UT. Inspecting the temperature and the energy spectrum of ions, it is inferred that among them, 275 data points were obtained in the magnetosphere. The plasma speed Vx was less than -100 km/s in 100 data points, indicating the LLBL. The rest of them, 175 data points, were obtained in the region of stagnant plasma (Vx greater than -100 km/s). Including the data analyzed by Fujimoto et al., only twelve data, have the dumbbell anisotropies in the 1.08 keV ion distribution in the LLBL, while 83 data have the dumbbell anisotropies in the stagnant region. In other words, 85.5 % of the data with a dumbbell-type ion distribution were observed in the stagnant region. In addition, data with a dumbbell-type ion distribution were observed continuously after 0910 UT, at which Geotail finally penetrated into the sunward convection region of the plasma sheet in this event.

The results of the present study suggest that the dumbbell-type distribution of ions occurs in the region near the convection boundary and the sunward plasma-flow region adjacent to the convection boundary region. The positions of Geotail in this event can be mapped onto the ionosphere near 70 GML at ˜18 MLT, using a model geomagnetic field. This mapping is roughly consistent with the convection boundary identified from observations on the ground and at low-altitudes. In the March 24, 1995 event, electrons show the dumbbell-type distributions from just inside the magnetopause [Fujimoto et al., 1998]. This observation supports the hypothesis that magnetic field reconnection at high latitudes causes such electron anisotropies. Since the ion anisotropies are seen in the vicinity and inside of the convection boundary, these must be accounted for by another mechanism. The present findings provide us with useful information on the ionosphere/magnetosphere coupling issues.