Generation mechanism of energetic ions' hard spectra observed in the plasma sheet

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Generation of energetic particles is a longstanding unsolved problem in the Earth's magnetosphere. Magnetic reconnection has been discussed as one of the strong candidates for the generation of energetic particles. Plasma turbulence is also known to play an important role for the stochastic acceleration of particles. However, the understanding of its role in the Earth's magnetosphere is still poor.

We have investigated the energy spectra of ions in the plasma sheet obtained by GEOATIL LEP (32eV-43keV) and EPIC/ICS (67keV-1367keV). We showed that there is a dawn-dusk asymmetry in the flux of energetic particles in the plasma sheet that is consistent with the past studies [Sarafopoulos et al., 2001, Imada et al., 2005]. A positive correlation was found between the temperature of thermal ions and the power-law index of nonthermal ions. When the thermal component is cold, the hard spectrum (1.5-3) is observed while the flux of energetic particles is low. On the other hand, we observed the soft spectrum (4-6) when the thermal component is hot. We found that the flux of high-energy ions (over 539 keV) does not depend on the power-law index, though the flux of middle-energy ions (over 67 keV) increase when the spectrum becomes soft. These results suggest that the particles with the medium energy are generated in association with the heating process of the thermal component, and the large phase space density at the highest energy range (about 1 MeV) is somehow kept in the course of the cooling process resulting in the hard spectrum. We have investigated the physical process operating to make this hard spectrum.

We observed soft spectra in association with the fast bulk flow, which suggests that the hard spectrum is not directly generated by magnetic reconnection. Plasma turbulence may be another candidate for the generation of hard spectrum in the plasma sheet, especially in the distant magnetotail where the effect of the solar wind flow overcome the contribution of the Earth's dipole magnetic field and the turbulence can be easily developed. However, we found no correlation between the total wave power (defined as the root-mean-square deviation obtained when we decompress the observed 16 Hz magnetic field to the 3 second data) and the power-law index of energetic ions, which suggest that the wave spectrum analysis is necessary to reveal the ongoing acceleration process. We will represent the relationship between the low-frequency wave power and the power-law index of energetic particles and discuss the generation mechanism of hard spectra in the plasma sheet.