Statistical properties of low-frequency waves and ion beams in the plasma sheet boundary layer: Geotail observations

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Statistical properties of low-frequency (0.01-0.1 Hz) electromagnetic waves and their relations to ion distribution functions in the plasma sheet boundary layer (PSBL) are investigated based on 5-year data of the Geotail spacecraft observations in Xgsm = [-31,-15] and where |Ygsm| is smaller than 5 RE. It is shown that the amplitude of the magnetic field fluctuations increases with increasing plasma beta (the ratio of the plasma thermal pressure to the magnetic pressure), while the electric field amplitude decreases in high-beta regions. These tendencies are consistent with a decrease of the local Alfvén velocity (VA) in the PSBL with increasing beta. The statistical results also indicate that the low-frequency wave power has clear correlation with the energy flux of local ion beams in the PSBL. If 10% of the beam energy are converted to the wave power, the ion beams could be the source of free energy of the large-amplitude electromagnetic waves. The estimated Poynting flux of the waves is distributed in the range from 5.0x10-6 to 1.6x10-2 mW/m2. The maximum Poynting flux is the same order of the pointing flux of Alfvén waves observed by the Polar spacecraft at altitudes of 4-7 RE, when mapped along converging magnetic field lines to the ionosphere at an altitude of 100 km. The good agreement of the Poynting fluxes is consistent with the idea that the low-frequency electromagnetic waves in the tail PSBL are the source of Alfvén waves in the high-latitude auroral regions. In order to investigate the generation mechanism of the large-amplitude waves, the ion distribution function in the enhanced wave events is investigated in detail, and the linear dispersion relation is solved numerically using the observed distributions. The results show that in most of the events, the relative drift-speed between cold-core and hot-beam ion components is below 2VA, the density ratio of the cold-core to the hot-beam is typically a few tens of %, and the beam component has a strong temperature anisotropy of Tpara/ Tperp~0.44. Comparison with the linear theory suggests the importance of the ion cyclotron anisotropy instability modified by the existence of cold-core ions for the generation of low-frequency large-amplitude electromagnetic waves in the PSBL.