

Electromagnetic ion cyclotron waves related to minor ion composition in the inner magnetosphere observed by Akebono

Shoya Matsuda^{1*}, Yoshiya Kasahara¹, Yoshitaka Goto¹

¹Kanazawa University

According to observations by GEOS1 and GEOS2, it was reported that ELF waves, which were assumed to be ElectroMagnetic Ion Cyclotron (EMIC) waves, were observed below the proton cyclotron frequency near the geomagnetic equator in the magnetosphere. In the recent study, it is pointed out that EMIC waves are deeply related to loss mechanism of relativistic electrons of radiation belt. As representative classical studies of the EMIC waves around the equatorial region, it was suggested that EMIC wave has a close relation to heavy ions (e.g., He⁺, O⁺), and that polarization reversal of EMIC is caused by these ions at the crossover frequency. It was also pointed out that EMIC wave has a lower cut-off at so-called lower-hybrid frequency. It is important to note that these characteristic frequencies change depending on the ion constituents in plasma. This fact suggests that we can estimate the ion constituents measuring these characteristic frequencies of EMIC.

The Akebono satellite has been successfully operated for the purpose of observation of the auroral region and inner magnetosphere for more than 23 years since its launch in 1989. The ELF receiver, which is a sub-system of the VLF instruments onboard Akebono, measures waveforms below 50 Hz for one component of electric field and three components of magnetic field, or waveforms below 100 Hz for one component of electric and magnetic field, respectively. It was reported that ion cyclotron waves were observed near magnetic equator by the receiver.

In this paper, we introduce EMIC waves which have characteristic cut-off frequency observed in the vicinity of geomagnetic equator by the Akebono satellite along its trajectory during a magnetic storm on 1989. These waves repeatedly observed within a half days after sudden decreases of Dst, but they disappeared when the Dst index recovered nearly to 0. This fact suggests that the generation of the wave was closely correlated with fresh energetic particle injection. The cut-off frequencies of each event are stable on approximately equal to half of cyclotron frequency of proton in spite of disturbance of inner magnetosphere represented by sudden Dst decrease and electron density fluctuation. We study dispersion relation of EMIC under the condition of multiple species of ions and demonstrate that there exists a few percent of alpha particle (He⁺⁺) or deuteron (D⁺) which causes the lower cut-off of EMIC in the inner magnetosphere.

Keywords: electromagnetic ion cyclotron wave, Akebono satellite, inner magnetosphere, heavy ion