GEOTAIL OBSERVATIONS OF ELECTROMAGNETIC WAVES IN THE MAGNETOSPHERE

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ABSTRACT

Measurements of the detailed spectral structures as well as waveforms of the ELF/VLF electromagnetic waves by GEOTAIL spacecraft have given the valuable information to investigate their generation and propagation mechanisms in geospace. In this study, we analyze the two kinds of ELF/VLF electromagnetic wave phenomena observed by GEOTAIL in the magnetosphere: the chorus emissions and the related wave-particle interaction in the dayside outer magnetosphere, and the generation and propagation of the lobe-trapped continuum radiation in the geomagnetic tail region.

INTRODUCTION

The GEOTAIL spacecraft has been observing a wide variety of natural plasma waves in geospace. The waveform measurements by the Wave Form Capture (WFC) of the Plasma Wave Instrument (PWI) have made it possible to analyze quantitatively the temporal evolution of wave electromagnetic fields as well as their detailed frequency structures. The WFC captures five electromagnetic components (2E and 3B) in the frequency range between 10 Hz and 4 kHz over 8.7 seconds every 5 minutes. This gives quite valuable information on the characteristics of ELF/VLF electromagnetic waves in geospace, such as polarization, k-vector direction, refractive index, and Poynting flux.

In this study, on the basis of the WFC observations, we analyze propagation and generation mechanisms of the two kinds of ELF/VLF electromagnetic waves observed by GEOTAIL: the chorus emissions in the dayside outer magnetosphere, and the lobe-trapped continuum radiation in the geomagnetic tail region.

CHORUS EMISSIONS IN THE DAYSIDE MAGNETOSPHERE

A number of ELF chorus emissions have been observed around the equatorial plane in the dayside outer magnetosphere. Analysis of the wave normal and Poynting vectors for each element (rising, falling, hook, etc.) of the emissions has shown that they are generated in the geomagnetic equator and propagate to higher latitudes in a non-ducted whistler mode [1]. Along with the chorus observations, on the other hand, the pitch angle anisotropy of the cyclotron resonant electrons has been measured by the Low Energy Particle (LEP) and the Comprehensive Plasma Instrument (CPI). The observed anisotropy, however, is too small to generate simultaneously observed chorus emissions via linear cyclotron resonance. This is possibly caused by the pitch angle diffusion of cyclotron resonant electrons by the generated chorus emissions [2]. On the basis of theoretical analysis and particle simulation we evaluate the temporal and spatial evolution of resonant electrons interacting with the generated chorus emissions.

LOBE TRAPPED CONTINUUM RADIATION IN THE MAGNETOTAIL

The "lobe-trapped continuum radiation" (LTCR) is observed at VLF frequencies (several kHz) in the distant geomagnetic tail region. The LTCR is possibly generated near the tail plasma sheet boundary layer (PSBL) and then trapped inside the low-density "lobe" region [3]. With the detailed examination of the spectral structures and the wave forms of the LTCR we have made a direction-finding analysis, which is combined with a ray-tracing analysis to show the the LTCR source region to be located in the PSBL off the nominal tail axis or the low latitude boundary layer (LLBL) [4].

On the other hand, we have found a couple of events demonstrating the existence of a Z mode wave in the generation region of the LTCR. The Z mode wave plays an important role in generating the LTCR because it appears in the linear mode conversion from an electrostatic wave near the upper hybrid resonance (UHR) frequency to an L-O mode LTCR through the "radio window." With full wave calculation and particle simulation we examine the generation mechanisms of continuum radiation from the Z mode wave in the PSBL and LLBL.

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