Particle simulaton of cyclotron interaction of chorus in a nonuniform magnetic field

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INTRODUCTION

The GEOTAIL spacecraft has been observing many chorus emissions in the outer geomagnetosphere with the Plasma Wave Instrument (PWI) [1]. It is generally considered that the chorus emissions are generated via nonlinear wave-particle interaction between electrons and whistler mode waves which move (or propagate) in the opposite directions to each other along the geomagnetic field. With the well-known linear growth rate of a parallel-propagating whistler mode wave, pitch-angle anisotropy and its critical value are an important factor in determining whether a whistler mode waves will grow though cyclotron resonance with resonant electrons or not [2]. In this study, we analyze the wave-particle interaction involved in the generation and propagation of the chorus emissions by using electromagnetic particle simulation [3].

PARTICLE SIMULATION OF WHISTLER MODE GENERATION

In the simulation, we inject the whistler mode wave parallel to the magnetic field into hot electrons with pitch-angle anisotropy in a one-dimensional model. From this reslult, only the wavefront (several wavelength) of the injected whistler mode wave grows, and the wave propagating behind the amplified portion does not grow. This suggests that the resonant electrons with large pitch-angle anisotropy are pitch-angle diffused by the cyclotron resonance between the whistler mode wavefront and the resonant electrons. As a result, the initially unstable pitch-angle anisotropy is lost, and such electrons can no longer grow the wave behind the wavefront. We also evaluate pitch-angle anisotropies and linear growth rates from the electron velocity distributions with the cyclotron interaction. By the cyclotron interaction, the initially unstable resonant electrons with the velocity corresponding to the wave resonent frequency are diffused. Then the anisotropy decreases down to the stable anisotropy, and the linear growth rate is reduced to 0.

Next, to simulate generation and propagation process of chorus emissions around the equatorial plane in the magnetosphere, we tentatively set up an inhomogeneous magnetic field as the Earth's dipole magnetic field in the simulation, and simulate a process that whistler mode waves triggered from a thermal noise existing in space are generated and propagate. From the simulation result, waves are generated and propagate from the region where the intensity of the magnetic field is weak. This is consistent with the theory of chorus generation and chorus observation around the equatorial plane.

CONCLUSION

We have analyzed by using electromagnetic particle simulation the generation and propagation of the whistler mode waves via nonlinear wave-particle interaction in the dayside outer magnetosphere. The simulation results have shown that the electrons with resonant velocity corresponding to the frequency of whistler mode wave growth are diffused toward stable pitch-angle anisotropy. In the future, we will examine the evolution of the resonant electrons and the frequency shift of the chorus emissions in the inhomogeneous magnetic field.

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