A Simulation Study of the Propagation of Whistler-Mode Chorus in the Earth's Inner Magnetosphere

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Abstract

Whistler-mode chorus emissions are generated in the region close to the magnetic equator outside the plasmapause during geomagnetically disturbed periods. Spacecraft observations near the magnetic equator have revealed that chorus appear in the frequency range from 0.2 to 0.8 Ω_{e0}, where Ω_{e0} is the electron gyrofrequency at the magnetic equator, while the frequency range of chorus is classified into the lower-band (0.2 to 0.5 Ω_{e0}) and upper-band chorus (0.5 to 0.8 Ω_{e0}) by a distinct gap at 0.5 Ω_{e0} [1]. Observations have revealed that chorus typically propagate along a magnetic field line in its source region and become oblique during their propagation away from the equator. Propagation properties of chorus have been studied for a half of century (e.g., [2,3]). Theoretical estimations and results of ray-tracing studies have been compared with observations of chorus in space and at high-latitude ground stations.

In the present study, we study the propagation of whistler-mode chorus in the magnetosphere by a spatially two-dimensional simulation code in the dipole coordinates [4]. We set the simulation system so as to assume the outside of the plasmapause, corresponding to the radial distance from 3.9 to 4.1 R_E in the equatorial plane and the latitudinal range from -15 to +15 degrees, where R_E is the Earth's radius. We assume a model chorus element propagating northward from the magnetic equator of the field line at L=4 with a rising tone from 0.2 to 0.7 Ω_{e0} in the time scale of 5000 Ω_{e0}^{-1}. For the initial density distribution of cold electrons, we assume three types of initial conditions in the outside of the plasmapause: without duct (Run 1), a density enhancement duct (Run 2), and a density decrease duct (Run 3). In Run 1, the simulation result reveals that whistler-mode waves of different wave frequency propagate in the different ray-path in the region away from the magnetic equator. In Runs 2 and 3, the model chorus element propagates inside the assumed duct with changing the wave normal angle. The simulation results show the different propagation properties of the chorus element in Run 2 and Run 3, and reveal that resultant wave spectra observed along the field line are different between the density enhancement and the density decrease duct cases. The spectral modification of chorus by the propagation effect should play a significant role in the precipitation of energetic electrons related to pulsating aurora through the interaction with chorus in the magnetosphere, particularly in the region away from the equator. The present study clarifies that the variation of propagation properties of chorus should be taken into account for the thorough understanding of resonant interactions of chorus with energetic electrons in the inner magnetosphere.

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References

1. O. Santolik, D. A. Gurnett, J. S. Pickett, "Spatio-temporal structure of storm-time chorus", *J. Geophys. Res.*, **108**, 2003, pp. 1–14.
2. R. L. Smith, R. A. Helliwell, I. W. Yabroff, "A theory of trapping of whistlers in field-aligned columns of enhanced ionization", *J. Geophys. Res.*, **65**, 1960, pp. 815-823.
3. T. F. Bell, U. S. Inan, N. Haque, J. S. Pickett, "Source regions of banded chorus", *Geophys. Res. Lett.*, **36**, 2009, L11101.
4. Y. Katoh, "A simulation study of the propagation of whistler-mode chorus in a dipole magnetic field", *Earth Planets Space*, 2014, submitted.