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Duct propagation of whistler-mode chorus emissions under the presence of ULF waves

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Whistler-mode chorus wave is a coherent electromagnetic plasma wave. Accordance with previous studies, chorus emissions perform important roles; the acceleration of relativistic electrons in the radiation belt and the pitch angle scattering of keV electrons inducing diffuse/pulsating aurora. Recent research suggests that the high latitude propagation by the duct propagation of chorus leads to the precipitation of relativistic electrons. In the present study, we investigate the effect of ULF waves on the duct propagation of whistler-mode waves. We analyze the Arase satellite data. During the time interval from 21:30 UT to 22:00 UT, the Arase satellite observed chorus emissions and ULF waves simultaneously. The Arase satellite was located at L~6.3-6.1, 04:00-04:12MLT, and from -12.7 to -7.4 degrees MLAT. During this event, chorus was shown to propagate parallel to the magnetic field lines up to a magnetic latitude exceeding 10 degrees, suggesting the possibility of duct propagation. We examine the effects of ULF waves on the duct propagation of chorus emissions and propose a model of the duct propagation of whistler-mode waves due to the contribution of the compressional component of ULF waves.

At first, we evaluate how effective the magnetic variation changes refractive index. Based on the dispersive relation of whistler mode wave, the refractive index depends on not only the density but also magnetic field intensity [1]. Setting the amplification factor x and y for the magnetic field intensity and electron density, respectively, we obtain a dependence of the refractive index on the variation of either the magnetic field or number density; a decrease in the magnetic field intensity leads to a refractive index change corresponding to an increase in the electron density. Where the range of the variation is less than 10% of the background level, both of effects to the refractive index are comparable.

Next, we examine whether the magnetic field fluctuations observed in the event resulted in significant refractive index changes. Here we assume that the number density of the background plasma is constant during the event. The observation result shows that chorus emissions propagating parallel to the background magnetic field appear at timings corresponding to the decrease of the total magnetic field due to the compressional component of ULF waves. The observed property can be explained by the model we propose. In addition, we discuss the frequency dependency of duct width.

We also consider the density variation during the event with MHD equation. We estimate that the phase relation between compressional component of ULF and cold electron density is anti-correlation in the case of $\beta > 1$, corresponding to the event we analyzed.

References

[1] Smith *et a*l., (1960) Journal of Geophysical Research (1896-1977)