Properties of the Generation Process of Whistler-Mode Chorus Emissions by Electron Hybrid Simulations

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Abstract

We investigate properties of the generation process of whistler-mode chorus emissions by a series of self-consistent electron hybrid code simulations. Whistler-mode chorus are narrowband electromagnetic emissions observed mostly on the dawn side of the Earth's magnetosphere as a group of coherent wave elements often consisting rising tones. Recent simulation studies revealed that chorus elements with rising tones are successively generated near the magnetic equator and undergo further nonlinear growth through their propagation away from the equator [1]. First, we study the amplitude dependence of frequency sweep-rates of rising-tone chorus elements by conducting numerical experiments with different initial number densities of energetic electrons at the magnetic equator [2]. The simulation results clarify a close relationship between frequency sweep-rates and wave amplitudes of chorus elements. The existence of an amplitude threshold in generating chorus is also quantitatively revealed. Next, we have carried out numerical experiments with different spatial inhomogeneities of the background magnetic field in the simulation system for the same initial condition of energetic electrons at the magnetic equator [3]. The simulation results reveal that the spectral characteristics of chorus significantly vary depending on the magnetic field inhomogeneity. While we have reproduced distinct chorus with rising tones in the simulation of the moderate inhomogeneity, we find that distinct chorus did not occur for large inhomogeneity cases and that the simulation of the smallest inhomogeneity reproduced excitation of broadband hiss-like emission whose amplitudes are comparable to discrete chorus elements. The broadband hiss-like emission consists of many wave elements with rising tones nonlinearly triggered in the region close to the magnetic equator. The small spatial inhomogeneity of the background magnetic field results in the small threshold amplitude for the nonlinear wave growth and allows the triggering process of rising tone elements to emerge easily in the equatorial region of the magnetosphere. We show that the simulation results obtained by the present study are consistent with estimations of both frequency sweep-rates and threshold amplitudes predicted by the nonlinear wave-growth theory [4-6] and that nonlinear wave-particle interactions play essential roles in the generation process of rising tone chorus emissions.

References

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