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Nonlinear Wave Growth Process of Whistler-mode Hiss and Chorus Emissions in the Magnetosphere

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We have conducted a series of electromagnetic particle simulations reproducing whistler-mode waves with rising-tone and falling-tone frequencies. In a plasma with a large plasma frequency much greater than the electron cyclotron frequency as in the plasmasphere, many wave packets with short time durations are generated even in a uniform magnetic field, and they grow through propagation forming emissions like plasmaspheric hiss [1]. The growth rates are much greater than linear growth rates, indicating that the growth process is due to coherent nonlinear wave-particle interaction. By checking the separability criterion of wave frequencies for no overlapping of nonlinear wave potentials in the velocity phase space, we have confirmed that the wave growth process is based on nonlinear trapping motion of resonant electrons interacting with a coherent wave packet. With a relatively small plasma frequency several times greater than the electron cyclotron frequency, on the other hand, relatively long wave packets with gradual increase or decrease of frequencies are generated, forming large amplitude emissions with rising-tone and falling-tone frequencies like discrete chorus emissions. By injecting a triggering wave at a fixed frequency, we find that both rising-tone and falling-tone emissions are triggered even in a uniform magnetic field [2]. The triggered emissions are formed in the upstream region from the triggering wave [3]. In a dipole magnetic field, on the other hand, the gradient of the magnetic field controls the spatial scale of the nonlinear interaction region and the threshold wave amplitude for effective wave growth through propagation away from the equator.

References

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