Computer Simulations of Wave-Particle Simulations in Space Plasmas

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We have clarified a long-standing issue on the generation process of whistler-mode chorus emissions in the Earth's magnetosphere by performing computer simulations based on particle models [1]. We develop a nonlinear wave growth theory of VLF chorus emissions [2], taking into account the spatial inhomogeneity of the static magnetic field and the plasma density variation along the magnetic field line. We derive theoretical expressions for the nonlinear growth rate and the amplitude threshold for the generation of self-sustaining chorus emissions. We assume that nonlinear growth of a whistler mode wave is initiated at the magnetic equator where the linear growth rate maximizes. Self-sustaining emissions become possible when the wave propagates away from the equator during which process the increasing gradients of the static magnetic field and electron density provide the conditions for nonlinear growth [3]. The amplitude threshold is tested against both observational data and self-consistent particle simulations of the chorus emissions. The self-sustaining mechanism can result in a rising tone emission covering the frequency range below the equatorial electron gyrofrequency.

The same nonlinear mechanism works for electromagnetic ion cyclotron (EMIC) waves with left-handed polarization. We recently found an observation of discrete rising tone emissions emerging from EMIC waves with a constant frequency. We have named them as EMIC triggered emissions [4], and reported its theoretical analysis [5], extending the theory developed for whistler-mode chorus emissions.

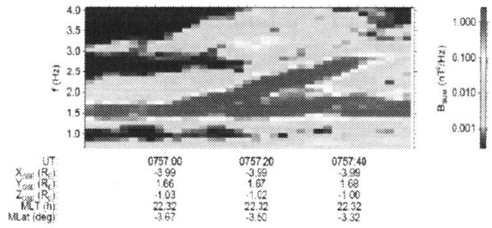

Figure 1. Dynamic spectrum of Pc1 waves observed by Cluster spacecraft.

References

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