Nonlinear Interactions Between Chorus Waves and Radiation Belt Electrons

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In the Earth's radiation belts, wave-particle interactions play an important role in changing energetic electron dynamics. In particular, chorus waves are suggested to play a critical role in accelerating electrons to several MeV, thus producing growing peaks in electron phase space density in the heart of the outer radiation belt. Although quasilinear interactions between chorus and electrons can explain the observed radiation belt electron acceleration in some electron acceleration events, there is growing support that nonlinear interactions are potentially important for the observed rapid electron acceleration. However, under which conditions the nonlinear effects, such as phase bunching and phase trapping, between chorus and energetic electrons become important is not well understood and is under active investigation.

In this study, we use a test particle simulation code to simulate interactions between energetic electrons and chorus waves. At first, we construct realistic chorus wave packets with varying wave amplitude and frequency based on the Van Allen Probes observation, and launch them from the equator towards higher latitudes. Then we evaluate how nonlinear effects of energetic electrons change for chorus waves with various properties (e.g., wave amplitude, discreteness, sweep rate, wave normal angle, etc.) through performing test particle simulations. For each chorus wave structure, we calculate transport coefficients of diffusive scattering, phase bunching and phase trapping of electrons at various energies and pitch angles. Our results provide quantitative understanding of the nonlinear interactions between chorus and energetic electrons, which is a key step towards incorporating nonlinear effects of chorus waves into global radiation belt modeling.