Chorus wave amplification in the Radiation Belts

Rualdo Soto Chávez
Princeton Plasma Physics Laboratory
U.S.A.

We address the major topic of whistler-mode chorus amplification. The topic -still is an outstanding problem in space plasma physics- has been a subject of great theoretical as well as observational interest, in part because it's been shown that chorus waves are one of the most energetic electromagnetic waves in the Earth's magnetosphere and responsible for plasma-sheet electron scattering leading to diffuse auroral precipitations as well as local particle energization in the Van Allen radiation belts. The energized particles can damage satellites and disrupt certain communications systems as well. Understanding chorus is one of the main focal points of the recently launched Van Allen Probes, a NASA mission. Here we present a new mechanism for chorus wave amplification. The model is based on the similarities between the physics of Free-electron laser and whistler-mode chorus. We present an analytically tractable formulation, which couples the relativistic single-particle equations with Maxwell's equations yielding the equations for the amplitude and phase of the field. We solve the coupled equations numerically in the nonlinear regime. In this regime our numerical results exhibit strong amplitude modulation and particle trapping, consistent with observations and numerical results previously obtained in the literature. Finally, we give an analytical expression of wave growth rate in terms of a few measurable plasma parameters that can be used by observers without further simplification.

Refs.

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