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On Resonant Interaction of Electrons with Falling-Tone Chorus Waves

Ilya Kuzichev[1] and Angel Rualdo Soto-Chavez[2]
[1]New Jersey Institute of Technology, The Center for Solar-Terrestrial Research, Newark, United States of America (marcuss@yandex.ru)
[2]Syntek Technologies, Inc, Fairfax, VA, United States of America

Whistler-mode chorus waves are one of the most intense wave phenomena in the Earth's inner magnetosphere. They are considered to be a major driver of the outer radiation belt dynamics, as they can efficiently scatter and energize electrons via resonant wave-particle interaction. These waves are observed as series of discrete coherent structures with rising or falling frequencies in the whistler frequency range (below local electron cyclotron frequency).

Such frequency variation results in a correction to the resonance Hamiltonian which describes particle dynamics in the given wave field. For a monochromatic wave, the effective potential in the resonance Hamiltonian consists of two terms. The first one corresponds to the nonlinear pendulum and describes the direct interaction of a particle with the wave. The second term accounts for plasma inhomogeneity, describing the effects of spatial gradients of plasma and wave parameters on the particle. Frequency chirping contributes to this effective inhomogeneity, producing a correction to this second term. The inhomogeneity term is of particular importance for the trapped particles that remain in resonance with the wave, this term defines their acceleration. And, as spatial inhomogeneity becomes zero at the equator (for dipole magnetic field), the wave frequency variation contribution might be the dominant one close to this region.

In this report, we present the results of test particle simulations of the electron dynamics in the field of a chirped wave. A general curvilinear relativistic code is developed to address the particle dynamics in the wave field, pre-determined from the simplified wave equations. We demonstrate that particle acceleration is affected by the competition between the effective inhomogeneity related to the wave frequency chirping and spatial inhomogeneity of the Earth's magnetic field.

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