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Simulations of chorus waves and acceleration of electrons to relativistic energies

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Whistler-mode chorus waves are generated in the equatorial region of the magnetosphere via a cyclotron instability driven by temperature anisotropy of energetic electrons of 30-300 keV injected into the inner magnetosphere. The generation region is confined to the equator as observed by recent spacecraft. Chorus emissions are discrete coherent emissions propagating away from the equator, and their frequencies increase from 0.1 to 0.5 fce of the chorus elements of a few hundred ms duration, which can interact effectively with relativistic electrons of 0.5-4.5 MeV. We present a self-consistent particle simulation reproducing chorus emissions in a dipole magnetic field [1], and we discuss the mechanism of the frequency increase based on formation of electromagnetic electron holes [2]. In the simulation, we also find that a fraction of energetic electrons are trapped by the chorus waves, and they are accelerated effectively. We have formulated a new theory of relativistic second-order resonance condition [3], and confirmed that a very efficient acceleration takes place in the presence of a coherent whistler-mode wave and the dipole magnetic field. We named the process as relativistic turning acceleration (RTA), because the resonant particles change the signs of their parallel velocities in interacting with the wave. The RTA process is an irreversible process contributing to formation of MeV electrons in the radiation belt.

[1] Katoh and Omura, Computer simulation of chorus wave generation in the Earth's inner magnetosphere, GRL, in press. [2] Omura and Summers, Dynamics of high-energy electrons interacting with whistler mode chorus emissions in the magnetosphere, JGR, 111, A09222, 2006. [3] Omura, Furuya, and Summers, Relativistic turning acceleration of resonant electrons by coherent whistler-mode waves in a dipole magnetic field, submitted to JGR.