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Dynamic variation of Earth's outer radiation belt due to nonlinear wave-particle interactions

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During space weather events, energetic particles are injected from the magnetotail to the inner magnetosphere, and various kinds of wave-particle interactions take place. Whistler-mode chorus emissions are one of the most important waves for the dynamics of relativistic electrons forming the outer radiation belt. Chorus emissions are excited via interaction with 10 – 100 keV electrons outside the plasmasphere [1], and they can accelerate a fraction of resonant electrons to MeV energy [2,3]. The time scale of acceleration is much shorter than that predicted by the quasi-linear theory. Effective acceleration of electrons through Landau resonance with obliquely propagating chorus emissions can also take place [4]. Another kind of waves important for the radiation belt dynamics is electromagnetic ion cyclotron (EMIC) rising-tone emissions excited by nonlinear interaction with energetic protons both inside and outside the plasmasphere [5]. The EMIC emissions can interact with relativistic electrons and scatter them to lower pitch angles efficiently by nonlinear wave trapping, resulting in significant precipitation of radiation belt electrons [6,7,8] as well as energetic protons [9]. In these nonlinear wave-particle interactions, the rising-tone frequencies of the emissions and the gradient of the magnetic field play essential roles. We review recent development of nonlinear theory and simulations that can describe dynamic nature of the radiation belts under intense space weather events.

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