Chorus Waves Modulation of Langmuir Waves in the Radiation Belts

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Using high-resolution waveform measured by the Van Allen Probes, we report a novel observation in the radiation belts. Namely, we show that multiband, discrete, rising-tone whistler-mode chorus emissions exhibit a one-to-one correlation with Langmuir wave bursts, and the modulated Langmuir waves can have even larger electric amplitude than the chorus waves. Moreover, the periodically modulated Langmuir wave bursts are generally observed at the phase location where the parallel electric component of the chorus wave is oriented opposite to its propagation direction. The electron measurements show a beam in phase space density at the particle velocity that matches the parallel phase velocity of the chorus waves. Based on this evidence, we conclude that the chorus waves accelerate the suprathermal electrons via Landau resonance, and generate a localized electron beam in phase space density distribution. Consequently, the Langmuir waves are excited locally and are modulated by the chorus wave phase.

In the case investigated in this study, the modulated Langmuir waves in association with the chorus waves were observed over 3 hours in MLT and 1 L-shell. The discovery of such new phenomenon shows that the chorus waves can transfer the electron perpendicular energy to their parallel direction, and meanwhile, the Langmuir waves also gain energy and grow. This mechanism can speed up the relaxation of the excess perpendicular energy in the injected electrons. The high temporal resolution electric and magnetic waveform measurements provide information about the microscopic wave-particle interaction, and can potentially assist in understanding a variety of related nonlinear interaction processes.