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Enerrgetic Electron Precipitation induced by lower-band chorus emissions

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Wave-particle interactions between whistler-mode chorus emissions and energetic electrons affect radiation belt dynamics and electron distribution in the Earth's inner magnetic field. Electrons can be scattered by whistler-mode chorus emissions and precipitate into the Earth's upper atmosphere. Significant mechanisms that cause rapid energetic electron precipitation are nonlinear resonances. This study aims to clarify precipitation processes via various n-th cyclotron resonances of lower-band chorus wave-particle interactions by numerical simulations. To clarify the contribution of wave normal angles and wave amplitudes, we apply 12 chorus wave models with 4 various wave normal angle sets (the maximum wave normal angles are 0, 20, 60, and 90% of resonance cone angles) and 3 wave amplitude sets (the maximum wave magnetic fields are 2.1 nT, 300 pT, and 50 pT) at L=4.5. We use Green's function method [1,2] to calculate the possibility of electrons being precipitated by the waves.

The simulation results show that the oblique chorus waves result in higher precipitation rates at energies below several hundred keV than the parallel chorus does. The very oblique chorus emissions contribute to the highest electron precipitation rates, especially at 50–100 keV. Checking the highest initial equatorial pitch angles of the precipitated electrons, we find that the very oblique chorus waves can precipitate electrons from > 45 degrees. In contrast, the other chorus waves can only precipitate electrons from < 30 degrees. Then, we derive the pitch angle scattering rates theoretically and verify the precipitation processes by n-th cyclotron resonances with oblique chorus emissions. The effective precipitation of oblique chorus emissions is due to active nonlinear trapping (n = 0 and n = -1 resonances) and nonlinear scattering (n = 2 resonance).

References
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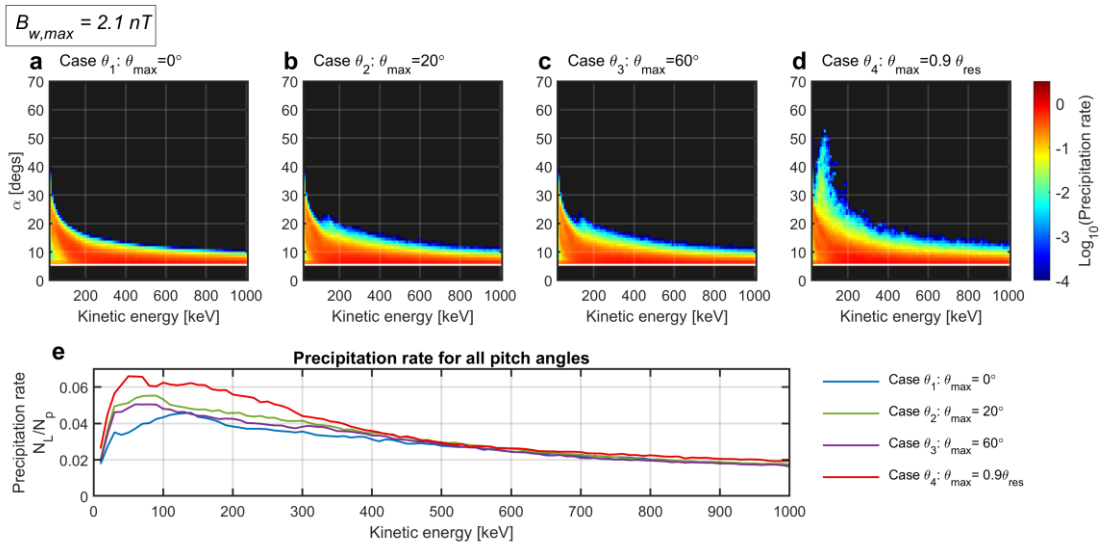

Figure 1. Precipitation rates for electrons interacting with a pair of chorus emissions with maximum wave amplitude 2.1 nT. (a–d) Electron precipitation rates as functions of initial kinetic energies and equatorial pitch angles with different wave normal angle settings. The white lines denote the loss cone angle 4.56°. No electron precipitates from the black region. (e) Precipitation rate for all pitch angles as functions of kinetic energy. The most oblique chorus case results in the highest precipitation rate. (Hsieh & Omura, 2023 [3])