

Nonlinear Interactions Between Chorus and ECH Waves in the Inner Magnetosphere

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Nonlinear wave-wave interactions critically influence magnetospheric dynamics via spectral broadening and energy transfer. This study examines coupled chorus and electron cyclotron harmonic (ECH) waves, evidenced by the ECH sidebands generation (Figure 1). Analysis of Van Allen Probes data (2012–2017) reveals 1,668 chorus-ECH interaction events concentrated near the magnetic equator ($|\text{MLAT}| < 5^\circ$), at $L=5.0-6.0$, and in night-to-dawn sectors (23–09 MLT), consistent with enhanced wave activity in the equatorial outside plasmasphere. Chorus-ECH interactions significantly increase during geomagnetically disturbed periods (1,255 cases, Figure 2b) versus quiet conditions (315 cases, Figure 2a). Disturbed periods also exhibit sideband expansion to lower $L=4.5$, attributed to compression of plasmasphere toward Earth. Amplitude analysis (Figure 3) shows ECH sidebands intensity ($E_{S\text{-RMS}}$) quasi-proportional to the geometric mean of parent chorus ($E_{C\text{-RMS}}$) and ECH ($E_{E\text{-RMS}}$) amplitudes. Considering that the ECH sidebands can extend the energy range of resonant electrons down to tens of eV, these findings advance our understanding of wave-wave interactions and wave-driven particle precipitation processes in the inner magnetosphere.

References

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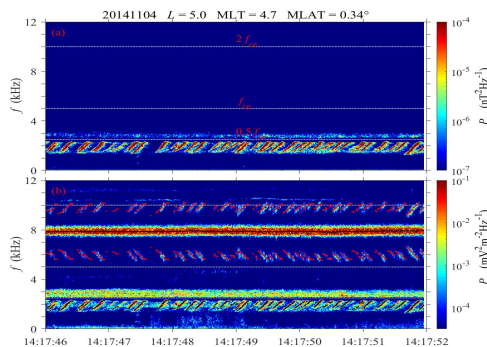


Figure 1. Nonlinear chorus-ECH interaction event on 04

November 2014. (a,b) magnetic (a) and electric (b) power spectral density P_B and P_E . The white dotted lines denote $0.5f_{ce}$, f_{ce} and $2f_{ce}$. Black dots, solid lines, and red dots indicate lower band chorus, typical ECH waves, and the ECH sidebands.

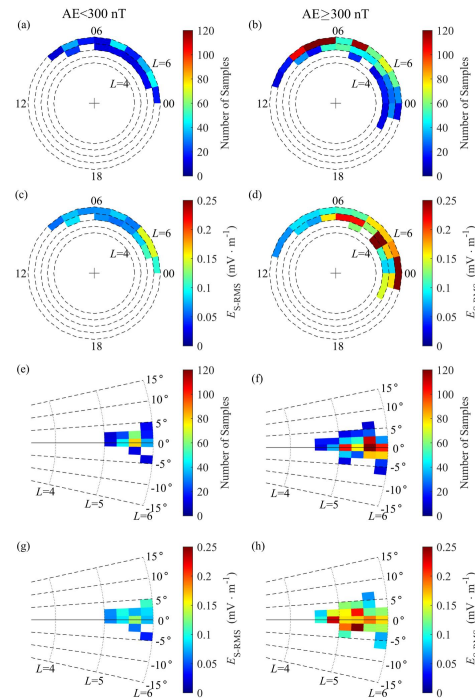


Figure 2 Global distribution of nonlinear chorus-ECH interaction samples (a-b, e-f) and root-mean-square electric field amplitude of ECH sidebands (c-d, g-h) under different AE index: AE<300 (left), AE≥300 (right).

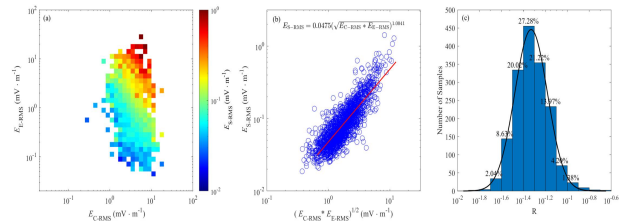


Figure 3. The relationship between $E_{S\text{-RMS}}$ and $E_{C\text{-RMS}}$, $E_{E\text{-RMS}}$. (a) $E_{S\text{-RMS}}$ as a function of $E_{C\text{-RMS}}$ and $E_{E\text{-RMS}}$. (b) The relationship between the $E_{S\text{-RMS}}$ and $(E_{C\text{-RMS}} * E_{E\text{-RMS}})^{1/2}$. The red solid line is the fitting result. (c) The number of samples in different ranges of ratio $R = E_{S\text{-RMS}} / (E_{C\text{-RMS}} * E_{E\text{-RMS}})^{1/2}$ with Gaussian fit (black curve).