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Gap formation around $0.5\Omega_e$ of whistler-mode waves excited by electron temperature anisotropy

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Whistler-mode waves are intense and coherent electromagnetic emissions that naturally occur in the Earth's inner magnetosphere. These waves are believed to play an important role in both scattering low-energy (0.1-30 keV) electrons into the upper atmosphere to produce diffuse aurora and accelerating energetic (~100 keV) electrons to relativistic energies (>1 MeV) in the heart of Van Allen radiation belt. One of the most remarkable properties of whistler-mode waves is the power gap around $0.5\Omega_e$ (where Ω_e represents the equatorial electron gyrofrequency), which can separate their spectrograms into a upper band (0.5-$0.8\Omega_e$) and lower band (0.1-$0.5\Omega_e$).

Although great efforts have been devoted to explain the formation of the power gap in the past several decades, there is still no consensus on this issue. It is naturally thought that the upper band and lower band of the whistler-mode waves are excited by two different anisotropic electron populations[1, 2]. However, the two different electron populations should be chosen carefully to make the power gap around $0.5\Omega_e$. The idea of nonlinear wave-wave interactions has also been introduced to explain such banded whistler-mode waves, where the harmonics of whistler-mode waves are produced due to the lower band cascade[3], and the 'multiband chorus' commonly observed in the magnetosphere is then formed. Whistler-mode waves are expected to experience enhanced nonlinear damping via the Landau resonance around $0.5\Omega_e$ as they propagate toward higher latitudes[4], suggesting that banded spectra of whistler-mode waves tend to appear off the equator. However, this is inconsistent with the source region near the magnetic equator.

With a 1-D PIC simulation model, we have investigated the generation mechanism of whistler-modes with a clear power gap around $0.5\Omega_e$, which have been ubiquitously observed in the inner magnetosphere. When the frequencies of excited waves in the linear stage cross $0.5\Omega_e$, or when they are slightly larger than but then drift to smaller than $0.5\Omega_e$, a pronounced plateau component at about $\pm 0.5V_{Ae}$ is formed due to the Landau resonance. Such a component causes severe damping around $0.5\Omega_e$ in the opposite propagating waves via the cyclotron resonance[5, 6]. The power gap forms eventually. Moreover, the position of plateau shape (V_D) plays an important role in determining the frequency of power gap, which will decrease as V_D increases.

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References

[1] K. J. Liu *et al,* Geophysical Research Letters. **38**, L14108 (2010)

[2] J. X. Li *et al,* Nature Communications, **10**, 4672 (2019)

[3] X. L. Gao *et al,* Geophysical Research Letters, **43**, 2343–2350 (2016)

[4] Y. Omura *et al,* Journal of Geophysical Research, **114**, A07217 (2019)

[5] H. Y. Chen *et al,* Journal of Geophysical Research: Space Physics, **126** (2021)

[6] H. Y. Chen *et al,* AIP Advances, **10**, 125010 (2020)

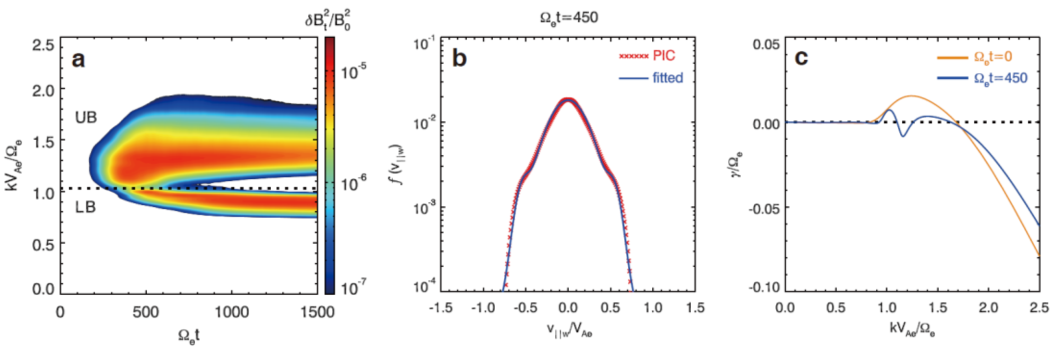

Figure 1. (a) The k-t spectrogram of transverse fluctuating magnetic fields, which is divided by a power gap around $0.5\Omega_e$ (black dotted line); (b) The fitted electron velocity distribution at $\Omega_e t$=450 (blue line) in the parallel direction and (c) the corresponding linear growth rate. In panel c, the growth rate at $\Omega_e t$=0 are over plotted by the orange line.