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Harmonic structure of lower hybrid and upper hybrid waves driven by energetic particles

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In the cold plasma approximation, X-mode waves do not exist above the lower hybrid resonance frequency until the dispersion curve reaches the upper hybrid wave. However, unknown harmonics of lower hybrid waves have recently been reported in space and fusion plasmas [1-3]. For example, they have been observed in the auroral and magnetotail regions of the Earth's magnetosphere. They are believed to be excited by energetic ions, but it has not been clarified. Motivated by these observations, we have recently worked on the non-linear development of lower hybrid wave instability driven by energetic ions. To investigate this, we have performed one-dimensional, electromagnetic, particle-in-cell (PIC) simulations with the PASTEL code [4].

Our first paper [5] has performed PIC simulations with realistic parameters, such as ion-to-electron mass ratio and ratio of electron plasma frequency to electron cyclotron frequency (ω_{pe}/Ω_e), similar to the observation at the auroral region. We have shown that energetic ions with a ring-like velocity distribution in velocity space perpendicular to the magnetic field can drive the harmonic structure of lower hybrid waves, in addition to lower hybrid waves. Here, the harmonic structure is characterized by a lattice-like spectrum in the wavenumber-frequency plane, $(mk_1, n\omega_1)$, where m and n are integers and(k_1, ω_1) is the wavenumber and frequency of the lower hybrid wave. The second paper [6] has shown that the harmonic structure of lower hybrid waves can be excited by non-linear wave-wave coupling of lower hybrid waves.

In this presentation, we will report our recent progress on the harmonic structure of lower hybrid waves driven by energetic ions. In order to examine the excitation condition of the harmonic structure of lower hybrid waves, we perform parametric simulations with paying attention to the two parameters of ω_{pe}/Ω_e and the velocity of energetic ions [7]. We will also show that the harmonic structure of upper hybrid waves can be driven by energetic electrons [8].

References

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