Simulation of mode conversion process from Upper-Hybrid wave to LO-mode wave with an oblique density gradient

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A large variety of waves can exist in plasmas depending on the condition of the medium. The refractive index for plasma wave is a function of plasma parameters such as ion or electron density and magnetic field strength. Therefore, in a case that these parameters are function of position in plasmas, the local value of the refractive index is also to be a function of position. The mode conversion occurs where a wave of one wave mode is linearly coupled to other propagation mode. There are various phenomena related to the mode conversion process: terrestrial continuum radiation, Auroral kilometric radiation, and Jovian decametric emissions. Stix (1965) investigated a theoretical basis for the conversion mechanism, while analytical methods have been proposed by using the full dispersion relation approximating as cold, warm and hot plasma conditions for the propagating plasma medium. Oya (1971) clarified the mode conversion from electrostatic to electromagnetic mode over a wide frequency range. A mechanism of double mode conversion of beam radiation was proposed by Oya(1974)for Jovian decametric radiation. However, we often find observational results related to the mode conversion process in the region where theoretical assumptions are not valid; e.g., electromagnetic radio emissions observed near the plasmapause during a geomagnetically disturbed period where WKB approximation might violated. To discuss these phenomena, we should evaluate the conversion process quantitatively by numerical experiments. For this purpose, we use Electron Hybrid code which is originally developed by Katoh (2003) to study resonant scattering process of energetic electrons. In this scheme hot electrons are treated as particles while cold electrons are treated as a fluid. We assume two-dimensional simulation system where the uniform magnetic field B_0 is assumed to be in x-y plane. The wave vector was introduced to be aligned the x-axis direction making an oblique propagating to the external magnetic field. The plasma density gradient was set perpendicular to external magnetic field B_0 within the present study. Several simulations with different wave normal angle have been performed, with the same conditions such as, plasma frequency, steepness of density gradient and angular frequency in order to looking for the most efficient wave normal angle for mode conversion. Frequencies are normalized by electron cyclotron frequency. The size of the simulation box used in the present study was determined depend on the wave normal angle. We generate plasma waves by oscillating E_x and E_z components in the generation region assumed in the simulation model. We assume damping regions at the both edges of the simulation system to suppress the reflection of outgoing waves. First, the verification of the developed simulation code is carried out. By considering a plane wave, we performed several tests for a case of homogeneous plasma for comparing dispersion relation and polarization in different wave modes. As for a next step, we consider an inhomogeneous case with a spatial density gradient perpendicular to the ambient magnetic field direction. We used the results of the homogeneous case as a reference. Based on the simulation results, we discussed how the wave coupling occurs in magnetized cold plasma by performing FFT analyses on wave electric field to examine spatial distribution of frequency/wave number spectra and by considering the polarization of wave modes propagating in the simulation system. Thus, the simulation results showed the generation of electromagnetic LO-mode wave through the mode conversion process s from Upper Hybrid wave into LO-mode wave quantitatively.we also evaluated the efficiency of mode conversion depending on the wave normal angle.