# Kinetic full wave analysis of OXB mode conversion in electron cyclotron heating and current drive in tokamak plasmas

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Wave heating and current drive in the range of electron cyclotron (EC) resonance frequency have been successfully applied to magnetized plasmas and considered to be promising for fusion plasmas due to the controllability of deposition and accessibility to high-density and high-temperature core plasma in tokamaks. In the case of low-field-side excitation in toroidal configuration, however, a narrow evanescent layer between O and X mode cutoffs may prevent the penetration of the EC waves. By introducing the integral form of dielectric tensor, Hansen et al. [1] have proposed to employ the OXB mode conversion with optimum injection angle for wave penetration into the high density region which makes the electron Bernstein wave penetrate the core.

In order to describe the wave tunneling across the evanescent layer and kinetic behavior of the electron Bernstein waves, the full wave code TASK/WF has been extended to use the integral form of the dielectric tensor. The effects of finite-Larmor-radius and inhomogeneous magnetic field are quantitatively considered. By using a more general approach based particle orbit theory and integral form of the dielectric tensor taking electron gyro motion fully into account, one-dimensional kinetic full wave model and code (TASK/W1) were developed [2]. The model utilizes the integro-differential equation for the wave electric field with frequency ω and successfully describes the OXB mode conversion, EC resonance heating and weak collisional effects in tokamak configuration.

Newly developed two-dimensional analysis of OXB mode conversion on horizontal plane and poloidal cross section shows various parameter dependences of the wave structure and power deposition profile. A typical two-dimensional analysis on horizontal plane in tokamak configuration is shown in Figure 1. The static magnetic field along the vertical axis is straight and uniform in z. Magnetic field strength and plasma density are increasing leftward. The O mode excited by a waveguide near the lower-right edge is converted to the X mode and reflected to the central region, reflected again near the upper hybrid resonance (UHR) position and mode converted to electron Bernstein wave, and ultimately absorbed near the electron cyclotron resonance located at plasma centre. When very small amount of collisions ($\nu/\omega \sim 10^{-5}$) is present, most of the power is absorbed near UHR which is consistent with the experimental observation [3]. Preliminary analysis of poloidal cross-section including the poloidal magnetic field will also be presented.

References

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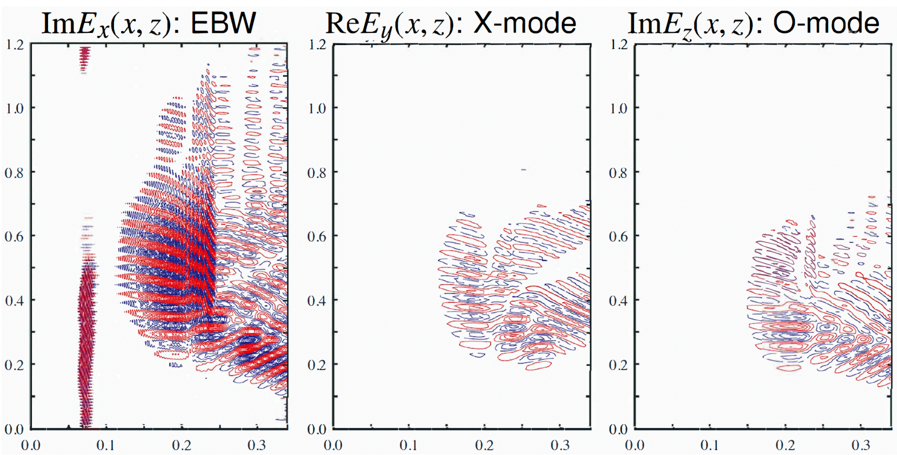


**Figure 1.** OXB mode conversion and wave electric field on horizontal plane of slab tokamak configuration where horizontal (vertical) axis shows the major radius (toroidal) direction. The imaginary part of $E_x$ (the electron Bernstein wave,) real part of $E_y$ (the X mode component), and imaginary part of $E_z$ (the O mode) are shown from the left respectively. The O mode is excited by the waveguide located near the lower-right edge, mode-converted to the X mode near the cutoff, reflected and mode-converted again to the Bernstein wave near the UHR and absorbed near the EC resonance