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内部導体装置Mini-RTにおけるECRF電磁場解析
Wave Analysis of ECRF in the Internal Coil Device Mini-RT

内島健一朗，河合智香，竹本卓斗，伊庭野健造，小川雄一
K. Uchijima, C. Kawai, T. Takemoto, K. Ibano, Y. Ogawa

東京大学新領域創成科学研究科
Graduate school of Frontier Sciences, the Univ. of Tokyo

The Mini-RT is an internal coil device, which was constructed to confine high beta plasma by a planetary magnetic field. In this device, so-called overdense plasmas have been observed[1], and Electron Bernstein Wave (EBW) heating is expected. EBWs have no cutoff density, so EBW heating is expected to be one of the most promising methods for generating and heating high density plasmas. Three schemes of Excitation of EBWs, which requires that X-mode microwaves reach the Upper Hybrid Resonance (UHR) layer are well known, i.e. FX-SX-B, SX-B and O-X-B. The mode conversion efficiency depends on the propagation characteristics of electromagnetic waves in Electron Cyclotron Range of Frequencies (ECRF) like as tunneling, cutoff, O-X mode bond.

The possibility of each mode conversion scenarios is investigated in the Mini-RT experiments. It is necessary to solve Maxwell's equations in order to describe the propagation of waves in the Mini-RT plasmas, in which typical scale length are of the order of the wavelength and in which the approximation of geometrical optics is no longer valid. So the aim of this work is to develop a full wave code in the Mini-RT with the Finite-Difference Time Domain (FDTD) method. This method is a popular technique to calculate the propagation of electromagnetic wave in inhomo--geneous media like as magnetized plasmas[2,3]. The finite-difference method enables us to visualize the spatial wave pattern in detail, and the time domain method does us to obtain time evolution of propagation and mode conversion processes.

The basic equations to be solved are

$$\frac{\partial \mathbf{B}}{\partial t} = -\nabla\times\mathbf{E}$$
$$\frac{\partial \mathbf{E}}{\partial t} = c^2\nabla\times\mathbf{B} - \frac{1}{\epsilon_0}\mathbf{J} \qquad (1)$$
$$\frac{\partial \mathbf{J}}{\partial t} = \epsilon_0\omega_{pe}^2\mathbf{E} - \frac{e}{m_e}\mathbf{J}\times\mathbf{B_0} - \nu\mathbf{J}$$

where ω_{pe} is the electron plasma frequency and ν is collisional frequency, respectively, and the $\nu\mathbf{J}$ term is responsible for collisional damping of the wave. In particular case where only the dominant first order term in the Larmor radius expansion and the perpendicular dispersion are considered in the plasma current, **J** is written as [4]

$$\frac{1}{4\pi\epsilon_0}\mathbf{J} = \nabla_\perp(\tilde{\chi}\nabla_\perp\cdot\mathbf{E}_\perp) - \nabla_\perp\times(\tilde{\chi}\nabla_\perp\times\mathbf{E}_\perp)$$
$$\tilde{\chi} = \frac{3\omega_{pe}^2\omega^2}{(\omega^2-\Omega_e^2)(\omega^2-4\Omega_e^2)}\left(\frac{v_{th}}{\sqrt{2}c}\right)^2. \qquad (2)$$

Results of these models in the Mini-RT device are as follows. Figure 1 (a) shows the cross sections of the device and snapshots of electric field of 1GHz X-wave injected from low field side, and (b) does the polarization of waves in the level of internal coil. The device has pure poloidal magnetic confinement torus plasma, so a wave having longitudinal polarization and short wavelength mode can be seen to grow up with time development.

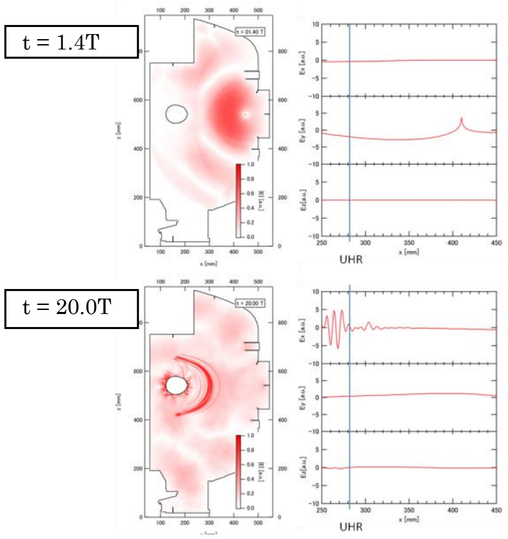

Fig.1 (a)Snapshots of |E| (b)Electric field components

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