§26. Experiments on the Excitation of an Electron Bernstein Wave in the Internal Coil Device

Ogawa, Y., Morikawa, J., Uchijima, K., Makino, W., Hosaka, Y. (Univ. Tokyo)

The Mini-RT is an internal coil device that was constructed to confine high beta plasma by a magnetic field similar to that of a planet. In this device, so-called overdense plasmas have been observed with levitation of an internal superconducting magnetic coil , and heating with Electron Bernstein Waves (EBWs) is expected. The direct measurement of waves excited in Mini-RT revealed wave characteristics of the Electron Cyclotron Range of Frequencies (ECRF) corresponding to EBW in FX-SX-B mode conversion in Mini-RT [1]. Here, to examine O-X-B mode conversion in Mini-RT experiments, we are attempting to investigate the propagation of waves in the ECRF in overdense plasmas, sifting the initial injection angle of diagnostic microwaves.

To excite EBWs in plasma, microwaves have to access to the Upper Hybrid Resonance (UHR) layer, and in the O-X-B conversion, there are two mode conversion processes i.e., the first transition from O-mode to slow X-mode and the second one from slow X-mode to EBW mode. The efficiency of the O-SX transition process in the two dimensions is given by Mjolhus [2],

$$T = \exp\left[-\pi k_0 L \sqrt{\frac{\Omega_e}{2\omega}}\left\{2\left(1+\frac{\Omega_e}{\omega}\right)\left(N_{/\!/}^2 - N_{/\!/,opt}^2\right)^2\right\}\right]$$

where $\vec{N} = \vec{k}c/\omega$, $\vec{k}$ is the wave number vector, ω is the wave angular frequency, k_0 is the wave number of the incident wave in vacuum and L is the characteristics density scale length at the UHR respectively.

In the Mini-RT device, waves at frequencies lower than 2.45 GHz are injected to diagnose wave propagation in overdense plasmas; the plasma produced by 2.45 GHz microwaves acts as an overdense plasma with respect to lower frequency diagnostic microwaves. In this study, diagnostic O-waves at 1GHz and 10W are injected from low field side, and the angle between wave number vector k and the external magnetic field can be altered by changing position and angle of element of excitation antenna.

To examine the mode conversion of waves in the internal coil device, electromagnetic and electrostatic components are measured with interferometry system by probing antennas inserted directly into plasmas. Probing antennas detect the injected diagnostic microwaves and send them to the mixer. They are modulated by IQ demodulators and output as sine and cosine components that contain information on the amplitude and phase of electromagnetic field.

Figure 1 shows the density profile measured by the triple probe. Cutoff density for 1 GHz microwaves is 1.24×10^{16} m^{-3}, so the region inside the major radius R<285mm is the overdense region for diagnostic microwaves, and this density profile and magnetic field configuration give optimum injection angle to be $\theta_{opt} = 64.7°$. In the radial electric field measurement, shown in Fig.2, a short wavelength mode (λ = 20 mm) is observed at only the initial injection angel $\theta = 66.5°$, while in other injection angle (ex. in Fig.2 $\theta = 71.0°$) this short wavelength mode waves are not observed. Figure 4 shows radial profiles of the phase in θ = 66.5° and 71.0°. The phase is function of the spatial position and length of the transmission lines; the gradient of the phase gives the wave number vector. The figure 3 confirms a reversal of the phase gradient around the UHR in θ = 66.5°. This suggests a change in the direction of the phase velocity.

[1] K. Uchijima *et al.*: Plasma and Fusion Res. **6** (2011) 401122.
[2] E. Mjolhus: Plasma Phys. **31** (1984) 7.

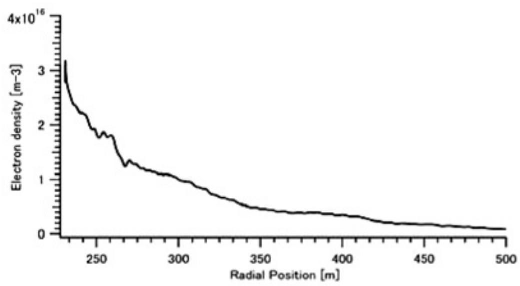

Fig.1 Electron density profile

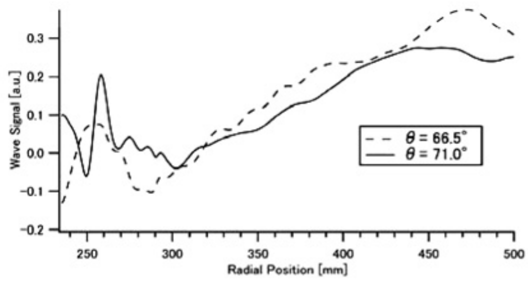

Fig.2 Longitudinal polarized wave amplitudes

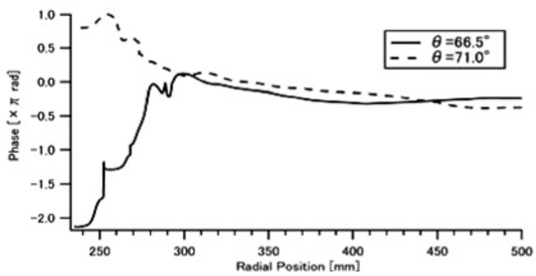

Fig.3 Phase profile