§7. Study on 2.45 GHz Electron Bernstein Wave Heating by a Ray-tracing Method

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Production and heating of over-dense plasmas by 2.45 GHz microwaves system under very low field condition was performed and demonstrated on CHS [1]. Power deposition profiles measured by power modulation method or power step up/down method indicated that the injected microwave power was absorbed in over-dense region where electron density exceeds the O-mode cutoff density [2]. These results suggest that injected electron cyclotron waves are converted into electron Bernstein waves (EBW). EBW can be excited in a plasma by mode conversion scenarios such as O-X-B, FX-B and SX-B. Two 2.45 GHz microwave systems, ECH#1 and ECH#2, were used in these experiments as shown in Fig. 1. However, the directivity of launched waves is poor and the polarization is not optimized because of long wave length (~ 12 cm). It is not clarified yet whether or not the abovementioned mode conversion scenario occurs effectively. Moreover, it is unclear how the incident waves are transmitted and absorbed. We have investigated wave trajectories, power deposition mechanism and mode conversion by using a ray-tracing method developed for LHD plasmas [3].

Figure 1 shows examples of ray trajectories injected from ECH#1 and ECH#2 at B_{ax} = 875, 613 and 437.5 G. These trajectories have been calculated as O-X-B scenario. It is assumed that the radial profiles of n_e and T_e are parabolic and the values of n_e and T_e at the plasma center are 3×10^{17} m^{-3} and 20 eV, respectively. Radial profiles of Ω_{ce}/ω, $N_\perp$, $N_{//}$, and power absorption rate are shown in Fig. 2. There is almost no difference by ECH#1 and ECH#2 in the mode conversion region. In two cases of 875 G and 437.5 G on the plasma center, mode converted EBW is absorbed at the fundamental electron cyclotron resonance (ECR) layer or 2^{nd} ECR layer. Power deposition through Doppler-shift ECR damping was not shown although large down shift of $N_{//}$ clearly occurs. On the other hand, the ray is transmitted to the inner helical coil side and the power is absorbed by Doppler-shifted ECR damping in an off-axis condition of 613G. Contour plots of O-X mode-conversion efficiency, $C_{o\text{-}sx}$, are shown in Fig. 3. The horizontal and vertical axes are toroidal and poloidal launching angles, respectively. The region having high mode-conversion efficiency expands over wide angles in the highest filed condition of B_{ax} = 875 G. These numerical results suggest that the O-X-B scenario plays a dominant role in production and heating with 2.45 GHz microwaves at very low field condition on CHS.

As an important future work, further optimization of this ray-tracing cord is required to investigate the X-B scenario, power deposition profile by multi-ray and so on.

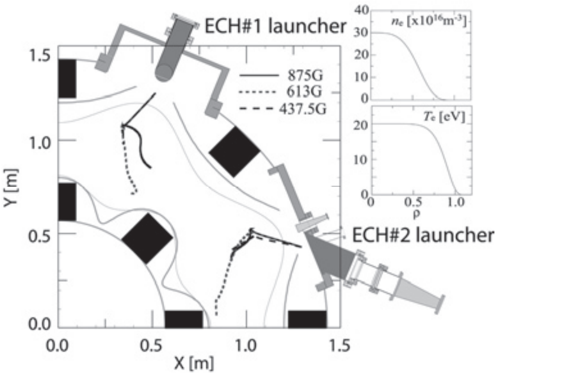

Fig.1 Ray trajectories injected form ECH#1 and ECH#2 launcher at B_{ax} = 875, 613 and 437.5 G.

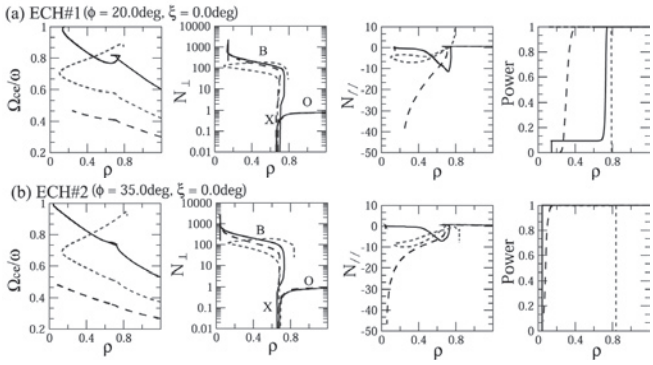

Fig.2 Radial profiles of Ω_{ce}/ω, $N_\perp$, $N_{//}$, power absorption on each ray trajectory in Fig. 1.

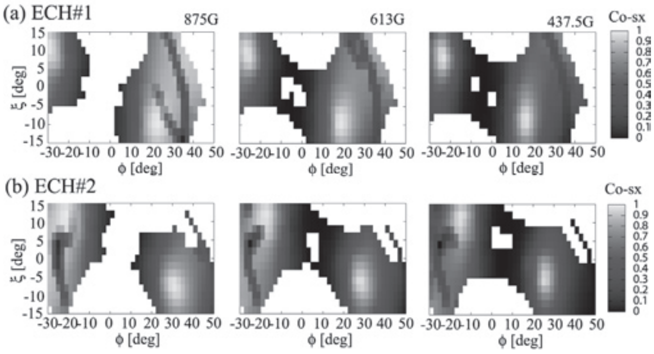

Fig.3 Contour plots of the O-X mode-conversion efficiency in the toroidal and poloidal launching angles for ECH#1 (a) and ECH#2 (b), at B_{ax} = 875, 613 and 437.5 G.

[1]R. Ikeda *et al*., Physics of Plasmas, Vol. 15, pp.072505-1~13, (2008).

[2]R. Ikeda *et al*., Journal of the Korean Physical Society, Vol. 49, pp.S206~S210, (2006).

[3]H. Igami *et al*., submitted to Plasma Science and Technology (2009).