§13. Direct Measurement of Transmitting Electron Cyclotron Beam through Plasma on the LHD

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In order to ensure the effective heating and the controllability of local-plasma parameters by electron cyclotron resonance heating (ECRH), investigation of the EC beam refraction effect is important. However the refraction of an EC beam due to a presence of plasmas has been predicted, that has not been verified by experiments up to now. A target plate facing on the ECRH antenna has been set in the vacuum vessel on the Large Helical Device (LHD) in order to measure the transmission power of EC beam, which is not absorbed into the plasma in the single path.

The EC-beam-target plate (diameter: 280 mm, thickness: 15 mm) made of isotropic graphite has been set 2.5 m lower from the equatorial plane of the LHD. The temperature rise of the plate due to the EC beam has been measured using the IR camera. The target plate receives the EC beam ejected from the facing-on upper launcher.

In order to verify the dependence of the beam refraction on the plasma condition, three conditions were selected for the experiments such as no plasma, the line-averaged electron density of 0.2 and $0.4\mathrm{x}10^{19}$ m^{-3}. In the experiments, the 77-GHz EC beam with 560 kW/0.3 s was superposed on the plasma sustained by a NBI as the O mode under the magnetic field of 1.375 T, where the EC beam absorption to the plasma was expected to be considerably small. Figure 1 shows the profiles of the temperature rise of the target plate in three conditions. The EC beam was focused on the center of the target plate in all cases. Clear dependence of the beam refraction on the electron density was observed from the landing-point of the EC beam on the target plate. In the case without the plasma, there is no effect of beam refraction thus the highest temperature rise was observed around the center of the target plate and the profile of the temperature rise was similar with that of the EC-beam-power density. On the other hand, the beam landing point moved in the *R* direction in the case with the plasma and the displacement in the toroidal-clockwise (CW) direction from the center of the target plate became larger with increase in n_e. The peak-temperature rise got low due to the presence of plasmas. This is explained from that the EC beam was partially absorbed into the plasma and the power of the transmitting EC beam became small. Also the peak temperature rise in $n_e = 0.4\mathrm{x}10^{19}$ m^{-3} case was lower than that in $n_e = 0.2\mathrm{x}10^{19}$ m^{-3} because of the larger absorption power into the plasma.

Figure 2 shows the dependence of the displacement of the EC beam center from the target plate center on n_e. The solid and the broken lines represent the experimental results and the calculation of TRAVIS, respectively. The calculation showed good agreement with the experiment in the toroidal direction. While in the radial direction, the absolute value was considerably different, however $d\Delta R/dn_e$ showed similar tendency between the experiment and the calculation. A ray-trace calculation with appropriate experimental conditions, such as an electron density profile and magnetic field structure in the plasma peripheral region, a proper EC beam profile and a dielectric tensor, is necessary in order to explain the experimental results.

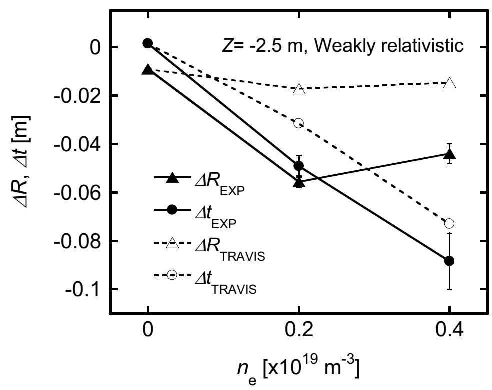

Figure 2. The dependence of the displacement of the EC beam center from the target plate center on n_e.

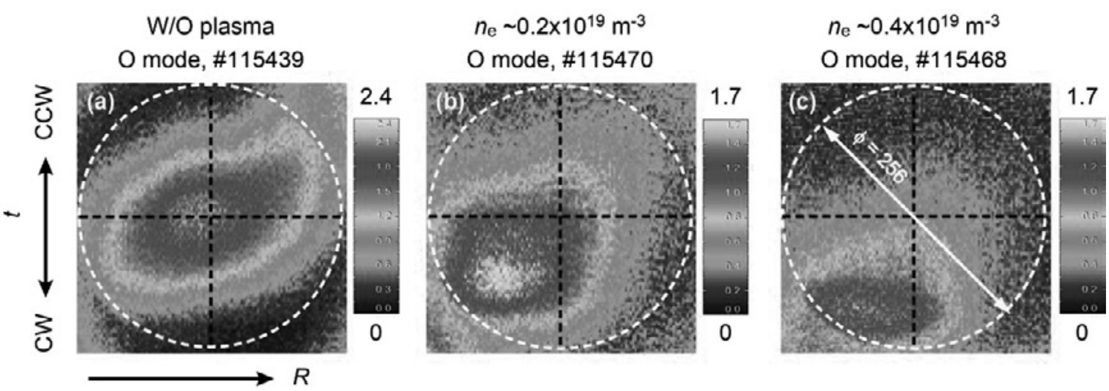

Figure 1. The profiles of the temperature rise of the target plate in the conditions for (a) no plasma, the line-averaged electron density of (b) 0.2 and (c) $0.4\mathrm{x}10^{19}$ m^{-3}.