§21. Electron Cyclotron Emission Measurement Using Well-Focused Beam Antenna

Idei, H. (Kyushu Univ.), Kubo, S., Shimozuma, T., Yoshimura, Y., Igami, H., Takahashi, H.

Electron Cyclotron Emission (ECE) radiometry using the well-focused viewing beam was checked up for the LHD experiments. In the LHD, the excellent launcher system to obtain the well-focused beam in the plasma has been developed to conduct the local Electron Cyclotron Heating and Current Drive (ECH/CD) experiments. The perpendicular and oblique well-focused viewing are also available for the ECE measurements if the ECH/CD launcher system will be shared to them.

In the high-density plasma like the Super Dense Core (SDC) shot in the LHD, the electron cyclotron (EC) emission frequency became lower than the cutoff frequency in the high-density plasma. The Electron Bernstein Emission (EBE) radiometry has been developed to measure time evolutions of electron temperature profiles in the over-dense plasmas. The Electron Bernstein (EB) wave cannot propagate in the vacuum due to the electrostatic mode. The electrostatic EB wave should be converted to the electromagnetic EC wave to be measured. Some mode conversion processes are requested in the EBE radiometry. In the B-X-O mode conversion, the EB mode first converted to the eXtraordinary (X) mode at the upper hybrid resonance, and then the X-mode converted to the Ordinary (O) mode at the O-mode cutoff. The converted O-mode wave can be detected as the EB emission. The mode conversion efficiency depends on the density gradient at the B-X and X-O mode conversions, and also the parallel refractive index $N_{//}$ to the magnetic field at the X-O mode conversion. The oblique viewing beam should be prepared for the EBE radiometry in the B-X-O mode conversion.

Figure 1 shows a contour plot of the mode conversion efficiency in the B-X-O mode conversion as a function of viewing focus positions (T_f, Z_f), where the focus major radius R_f is 3.9 m and (T_f, Z_f) are the focus toroidal and vertical positions, respectively. The putative antenna of an ECH/CD launcher at the horizontal port can focus the beam of 0.03 m at R_f =3.9 m in the oblique viewing. The magnetic axis and field strength were 3.72 m and 2.64 T. The central electron density and temperature were 1.0 x 10^{21} m^{-3} and 500 eV. The beta was 1.05 %. These were target plasma parameters of the steady-state SDC plasma using feedback-controlled pellet injection to keep the high-density state. The evaluated frequencies were 142-160 GHz as the second harmonic EBE components. The high mode conversion efficiencies were evaluated in the narrow B-X-O mode conversion window of (T_f, Z_f). The effective EBE radiometry was expected in the high-density SDC plasma using the horizontal ECH/CD launcher in the LHD.

Since the emission is a reversal process for the absorption / deposition process, the EB emission profile was evaluated from the deposition profile in the ECH/CD injection using the launcher. Figure 2 shows deposition profiles for the ECH/CD injection with the same plasma parameters for Fig.1. The focused positions (T_f, Z_f) = (-0.7 m, 0.22 m) were set to obtain the maximum mode conversion efficiency at 142 GHz. The emission profiles were evaluated including the mode conversion efficiency. The density and magnetic field profiles along the emission ray were shown in the figure as those of $(\omega_{pe}/\omega)^2$ and (Ω_{ce}/ω), where ω was the emission frequency and ω_{pe} and Ω_{ce} were the electron plasma and cyclotron angular frequencies, respectively. The significant deposition or emission profiles were evaluated in the broad normalized radius ρ positions of ρ = 0.1-0.4. The density of the emission position exceeded the cutoff density for the emission frequency as 2-4 times higher value. The emission profile of 160GHz was evaluated to be weak due to the bad mode conversion efficiency in the optimized viewing beam for the 142 GHz emission.

This work was realized by the collaboration organized by NIFS (NIFS09KCHR007).

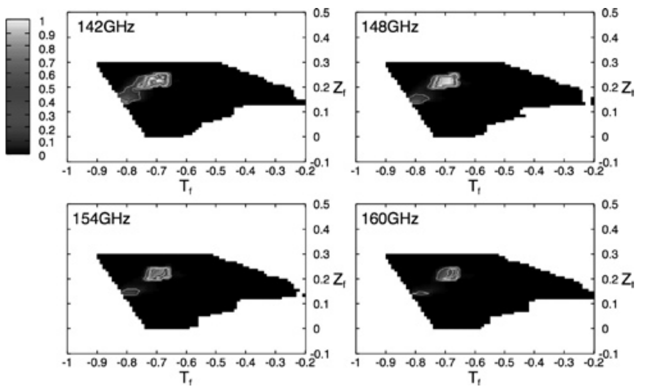

Fig.1. Contour plot of mode conversion efficiency in the B-X-O mode conversion as a function of viewing focus positions (T_f, Z_f). The focus major radius R_f is 3.9 m and (T_f, Z_f) are the focus toroidal and vertical positions.

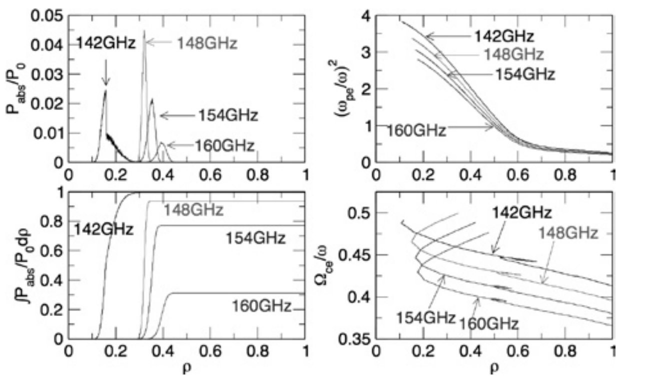

Fig.2. Electron Bernstein emission profiles of 142-160GHz as second harmonic components. The density and magnetic field profiles, $(\omega_{pe}/\omega)^2$ and (Ω_{ce}/ω), are shown along the emission ray.