

§4. Primary Result of the Emission Measurement with the Transmission Line for the ECH on the Super Dense Core (SDC) Plasma

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Electron cyclotron heating (ECH) by Electron Bernstein wave (EBW) has a possibility for local heating in over-dense plasma where the electron density exceeds the cutoff density of the electron cyclotron wave and ECH by the normal electromagnetic mode is not applicable. In an extremely high dense plasma like the SDC plasma where the electron density is more than double of the cutoff density of the electron cyclotron wave, oblique launching of the ordinary (O-) mode from the low field side with the optimum angle is a possible way to excite the EBW via the ordinary (O-) extraordinary (X-) EBW (B) mode conversion process. Possibility of ECH by EBW in the SDC plasma was numerically analyzed 1). The result suggests that the power absorption region is located outside the last closed flux surface (LCFS) for the case of launching of the 77GHz millimeter wave that is now mainly used for ECH in LHD. On the other hand the absorption regions of the waves in second harmonics range (142~160GHz) are located inside the LCFS where $\rho < 0.5$, where ρ is the normalized minor radius.

In over-dense plasmas, an EBW is thermally emitted in the electron cyclotron resonance layer and is mode converted to the electromagnetic wave then emitted to the vacuum via the reversed way of the heating. Therefore if the emitted wave is measured with use of the launching antenna for ECH, ECH is available with the same setting of the aiming and polarization via the transmission line.

A radiometer system has been newly installed in one of the transmission lines for ECH for measurement of the emitted wave in second harmonics range (150~168GHz) that is originated from the thermally emitted EBW in over-dense plasmas in LHD. The launching antenna is installed in the horizontal port. Figure 1 shows a schematic view of the newly installed double side band (DSB) radiometer. The local frequency can be swept from 150GHz to 168GHz and the intermediate frequency range from 50MHz to 300MHz of the lower and the higher side band is detected.

Figure 2 shows the primary result of the emission measurement on the SDC plasma. With the feedback injection of the fueling pellet the SDC plasma is sustained for about 4.3 seconds. Before the SDC is formed by pellet injection the electron temperature is 2 keV and after the formation of the SDC the electron temperature decreases 0.5 keV. The intensity of the radiometer signal of 154GHz after the SDC formation decreases to about fourteenth of the intensity before the SDC formation. The electron density in the core region is remained around the cutoff density of 154GHz during the SDC formation. It seems that the intensity of the signal does not respond to whether the electron density exceeds the cutoff density or not.

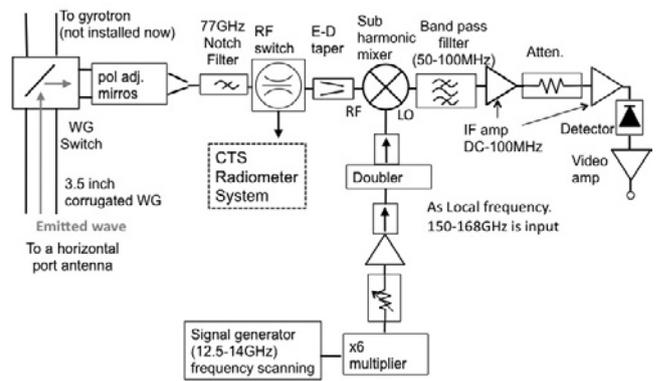


Figure 1 : Schematic view of the radiometer installed in one of the transmission lines for ECH in LHD.

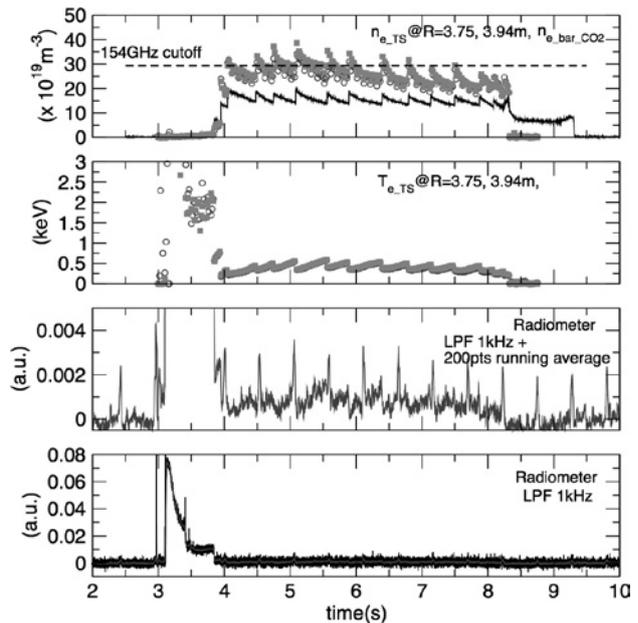


Figure 2: (top) Electron density calibrated with line averaged density measured by millimeter wave interferometer, (second) electron temperature, (third and fourth) 154GHz radiometer radiometer signal. Spikes shown in the third box causes from noise.

There may be some possibilities about the origin of the measured emitted wave. Those are EBW emitted to the vacuum via the B-X-O mode conversion process, the electron cyclotron emission (ECE) from the third harmonic electron cyclotron resonance layer that is located near the plasma boundary, the second harmonics ECE as a stray light. Analysis with the ray tracing calculation is required in consideration of experimental density and temperature profiles for identification of the origin of the emission.

1) IGAMI, H. et al., *JSPS-CAS Core University Program Seminar on Production and Control of High Performance Plasmas with Advanced Plasma Heating and Diagnostic Systems* 1-4 November, 2010, Guilin, China