§72. Progress of Electron Bernstein Wave Heating via the O-X-B Mode Conversion Process

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In the LHD, electron cyclotron heating (ECH) by the electron Bernstein wave (EBW) has been studied to develop a heating method in extremely high dense operation where the conventional ECH by normal electromagnetic modes cannot be available[1-2]. Because the EBW has no density limit in propagation and is cyclotron dumped in the electron cyclotron resonance (ECR) layer. There are some methods to excite the EBW by launching the electromagnetic wave from the outside of the plasma. One is to launch the ordinary (O-) mode from the low magnetic filed side toward the point where the plasma cutoff and the left hand cutoff are located very close to each other. Near the point the incident O-mode is connects to the extraordinary (X-) mode and proceeds to the upper hybrid resonance (UHR) layer and is mode converted to the EBW there (O-X-B mode conversion).

In the 15the experimental campaign the O-X-B heating experiment was performed in two magnetic configurations, they are (R_{ax},B_t) =(3.75m, 2.4T), (3.75m, 2.2T), where R_{ax} is the position of the magnetic axis and B_t is the magnetic field strength at the magnetic axis. Fig.1 shows the waveforms of the discharge when are (R_{ax},B_t) =(3.75m, 2.4T) was selected. During the ECH power injection, the stored energy W_p and electron temperature T_e

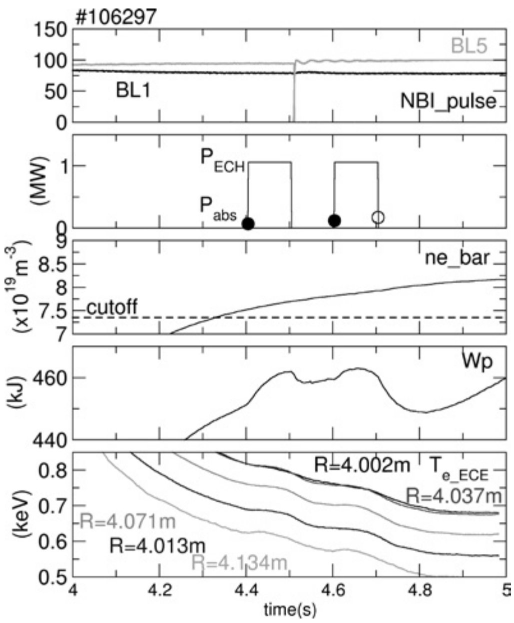

Fig.1. (From the top) NBI pulses, ECH launched power and absorbed power, line averaged density, stored energy, and electron temperature measured by ECE radiometer. The magnetic configuration was (R_{ax},B_t) =(3.75m, 2.4T).

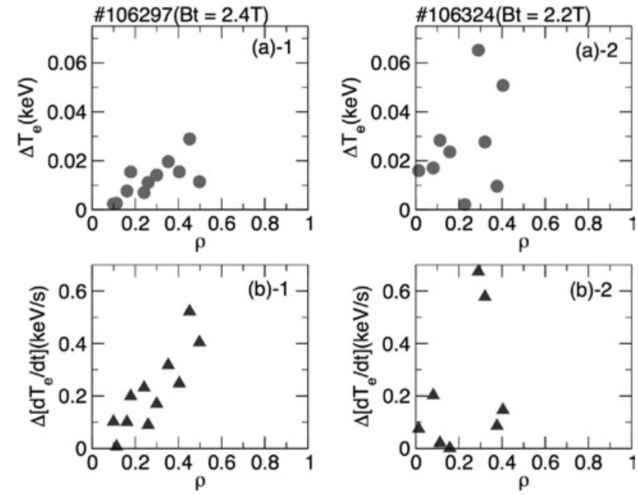

Fig. 2. (a)-1,2 :Increase of the electron temperature after deduction of decreasing trend. (b)-1,2: Change of the temporal differentiation of the electron temperature.

increased although the line averaged electron density was higher than the cutoff density. The absorbed is estimated from the difference of the temporal differentiation of the stored energy between before and after turning on/off of the ECH power and are plotted in Fig.1. The average is about 12%. For the case of (R_{ax},B_t) =(3.75m, 2.2T), the stored energy and electron temperature also increased during the ECH power injection. The estimated absorbed power was similar level. In the experiment the launching angle was changed shot by shot. In Fig. 2, increases of the electron temperature ΔT_e and temporal differentiation $\Delta(dT_e/dt)$ are plotted versus the normalized minor radius ρ for the two cases of the magnetic field configuration. For the case of (R_{ax},B_t) =(3.75m, 2.4T), the peak of ΔT_e and $\Delta(dT_e/dt)$ is located at ρ=0.45 unfortunately there are not ECE channels outside ρ=0.5 with enough S/N ratio. For the case of (R_{ax},B_t) =(3.75m, 2.2T), the peak of ΔT_e and $\Delta(dT_e/dt)$ is located at ρ=0.29. The region where T_e increases shifts toward the magnetic axis compared to the former case of magnetic configuration. Previous numerical prediction with use of the ray-tracing indicate that the power absorption region shifts toward the magnetic axis as B_t decreases. This tendency is consistent with the results of the previous numerical prediction[1)] however the absorption regions are located more inner region. Numerical analysis with ray-tracing with use of the real experimental density and temperature profiles to determine the power deposition region are required. However, the optimum launching angle suggested in the numerical calculation and that found in the experiment do not coincide. Procedure to reconstruct the electron density profile as a function of ρ and procedure to calculate the O-X-B mode conversion rate near the cutoff should be improved.

1) Igami, H. et al.: Plasma Sci. Technol. **11** (2009) 430.
2) Igami, H. et al.: Plasma and Fusion Research (accepted)