§17. Experimental Observation on ICRF Mode Conversion Heating

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In the second cycle of LHD experiments, the ICRF heating experiments were carried out using a pair of loop antennas. A series of electron heating experiments was carried out changing the ratio of the number of injected hydrogen atoms to that of injected helium atoms, $n_H/(n_H+n_{He})$. The ECH target plasma had an average electron density, $n_e=8.5\times10^{18}m^{-3}$ with a central electron temperature, T_e=400eV. The applied ICRF frequency was selected to be 25.6MHz and the magnetic field strength was 1.5T. In this condition, a hybrid resonance layer is located at the normalized radius of $\rho \approx 0.7$. The ratio of $n_H/(n_H+n_{He})$ was changed from 0 to 0.46 by changing a pulse length of a hydrogen gas puffing at the constant flow rate of 0.82Pam^3 from 0msec to 100msec as described in the previous section. The amount of He was constant at 0.194Pam^3 in every shot.

The RF power absorbed by electrons at a unit volume, P_e is derived from the decay rate of the electron temperature at the end of the ICRF heating pulse using the electron density in the following equation,

$$P_e = \frac{3}{2} n_e \{(dT/dt)_{t=t_0-0} - (dT/dt)_{t=t_0+0}\} \quad (1)$$

where t_0 is the time of the end of the ICRF heating pulse. The electron density was measured by a 13 channel HCN laser and the electron temperature was measured by 32 channel ECE (electron cyclotron emission). Figure 1 shows a typical time evolution of the electron temperature in the case of the hydrogen gas puffing ratio of $n_H/(n_H+n_{He})$=0.39 and $\rho = 0.58$. The slope of the decay of the electron temperature changes when the ICRF heating pulse was turned off.

The radial profile of the RF power absorbed by electrons is obtained from equation (1). Figure 2 shows experimental results in the 3 different cases of the hydrogen gas puffing ratio, e.g. $n_H/(n_H+n_{He})$=0.05, 0.30 and 0.46. The intense electron heating is found in the case of $n_H/(n_H+n_{He})$=0.30. P_e is 38kW/m^3 at $\rho = 0.7$, which is just the place of the hybrid resonance layer.

The total electron heating power can be obtained by integrating P_e over the plasma volume. Figure 3 shows the dependence of the electron heating efficiency on the gas puffing ratio of $n_H/(n_H+n_{He})$. The electron heating efficiency is the total electron heating power divided by the total ICRF heating power of 300kW. Strong electron heating can be recognized at $n_H/(n_H+n_{He})$=0.3. This strong electron heating can be explained using Budden model in the next section (Theoretical Calculation of ICRF Mode Conversion Heating Efficiency).

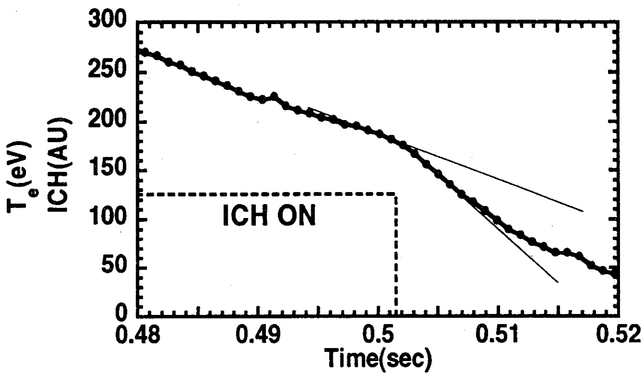

Fig. 1. The time evolution of the electron temperature measured by ECE.

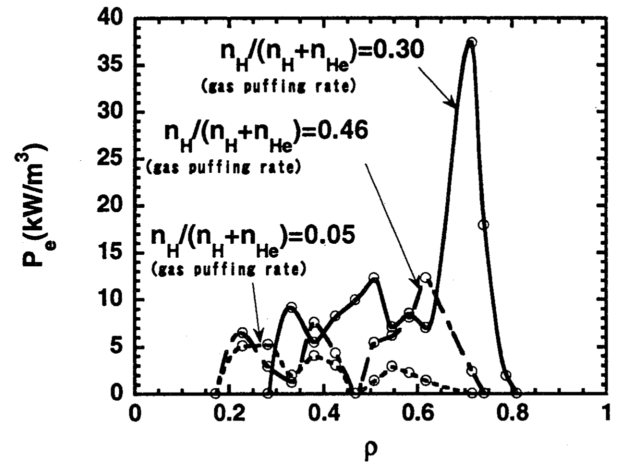

Fig. 2. The radial profile of the RF power absorbed by electrons in 3 different cases of $n_H/(n_H+n_{He})$=0.05, 0.30 and 0.46.

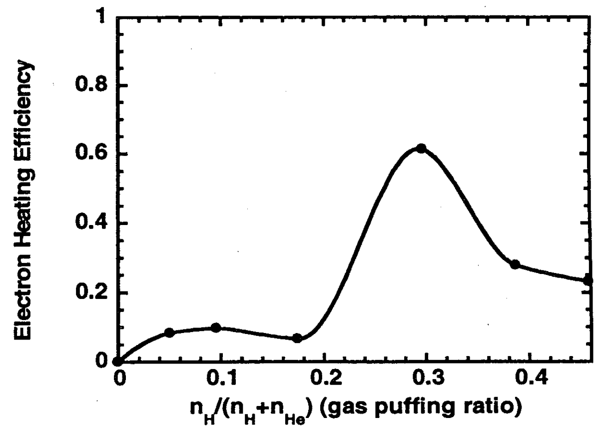

Fig. 3. The dependence of the electron heating efficiency on the hydrogen gas puffing ratio.