§53. Influence of Hydrogen Ratio on Mode-Conversion Heating by ICRF Waves in LHD

Seki, T., Mutoh, T., Kumazawa, R., Saito, K., Kasahara, H.

Mode-conversion heating by ion cyclotron range of frequencies (ICRF) waves has been investigated in LHD. The wave frequency was 28.4 MHz and the magnetic field strength was 2.75 T at the magnetic axis of 3.6m. Helium and hydrogen mixture was used as a working gas. The location of resonance layers in the plasma poloidal-cross section is shown in figure 1. Ion cyclotron resonance layers are located at the plasma peripheral region and ion absorption at the resonance layers is expected to be weak. The launched fast wave is mode-converted to the ion Bernstein wave at the two-ion hybrid resonance layers (mode-conversion layers). Electron heating is expected by the ion Bernstein wave through the wave absorption mechanism of the transit time magnetic pumping and/or electron Landau damping. The position of the mode-conversion layers is closely related to the hydrogen ion ration to the helium ions. As the hydrogen ratio increases, mode-conversion layers approach the plasma core region. High hydrogen ion ratio is required to heat the plasma core region. In fig.1, $n_H/(n_H+n_{He})=0.65$ is assumed.

Figure 2 compares the plasma discharges sustained by the mode-conversion heating in the case of with and without the hydrogen ice pellet injection. The plasma was deteriorated during the ICRF pulse without the pellet injection. With the repetitive pellet injection, the plasma was maintained during the ICRF pulse. The hydrogen ratio measured by a spectroscopy increased about 20 % with the pellet injection. However, it reflects the plasma surface region, and the hydrogen ratio at the inside of the plasma is thought to be higher than this value. No high-energy ion tail was observed during the mode-conversion heating. The electron temperature profile was broad.

Full wave calculation has been carried out assuming the one-dimensional slab plasma model. The features of the calculation using the W1 code$^{1)}$ is that it includes the mode-converted ion Bernstein wave in addition to the fast wave. The helical magnetic configuration is introduced in the calculation through the helical ripple, ε_H as follows:

$$B(x) = R / (R + x) + \varepsilon_H * \rho^2, \qquad (1)$$

where R is a major radius and x is minor radius direction, and ρ is a normalized minor radius. The relation between the magnetic field configuration and the flux surface is different from the actual LHD configuration. It is assumed that the central electron density is $0.8\times10^{19}\mathrm{m}^{-3}$ and the central electron and ion temperatures are 0.6 and 0.4 keV, respectively. Figure 3 shows the electron absorption profile in the cases of the two different hydrogen ratios, 30 and 50 %. Electron absorption mainly occurs. The electron absorption near the mode-conversion layer is stronger in the 50 % case. Further investigation is required to discuss about the wave behavior and absorbed power and so on.

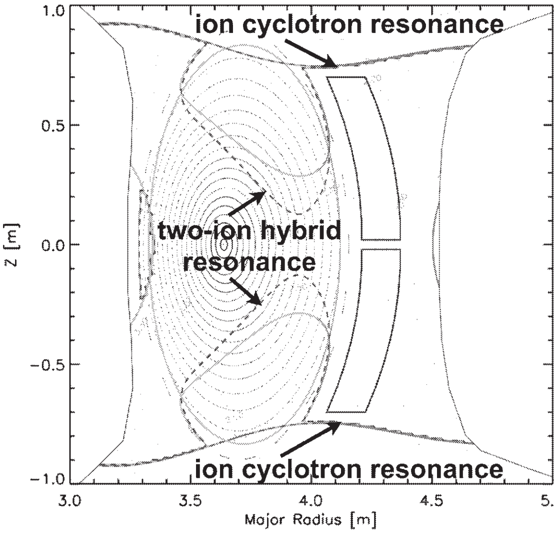

Fig. 1. Location of resonance layers in the plasma poloidal-cross section for the mode-conversion heating.

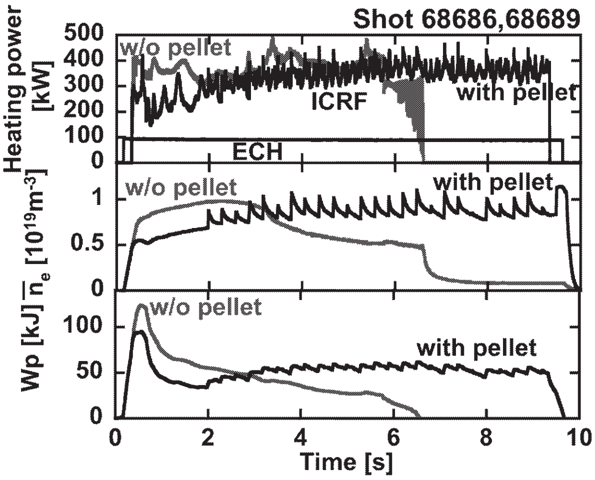

Fig. 2. Comparison of the plasma discharges with and without repetitive hydrogen pellet injection.

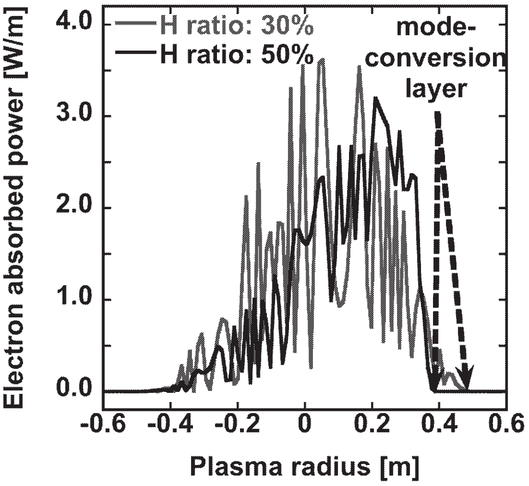

Fig. 3. Electron absorption profile calculated by the one-dimensional full wave code.

1) Fukuyama, A. et al. : Nucl. Fusion **23** (1983) 1005.