§12. Variation of Power Deposition Region of Electron Bernstein Waves in Electron Density Scanning Experiment

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Overdense plasma heating at the plasma center where the central electron density is higher than the left-hand cutoff density ($14.7\times10^{19}\mathrm{m}^{-3}$) of the applied 77GHz electron cyclotron waves (ECWs) has been confirmed. Only the electron Bernstein waves (EBWs) mode-converted from injected ECWs in X-mode polarization from high magnetic field side (slow-XB heating) are attributed to the electron heating in the overdense plasmas.

In the 17th experimental campaign, to emphasize and study the heating effect by mode-converted EBWs, slow-XB experiments with lower density were performed. The range of line average electron density $n_{\mathrm{e\_ave}}$ was from 1 to $9\times10^{19}\mathrm{m}^{-3}$.

Figure 1 shows the plasma stored energy W_{p} measured with a diamagnetic loop and electron kinetic energy W_{pe} calculated from the radial profiles of electron temperature and density measured with Thomson scattering measurement, obtained in a typical slow-XB discharge #118499. The magnetic axis position R_{ax} and the toroidally averaged magnetic field on axis B_{t} were 3.6m and 2.75T, respectively. The target plasmas with $n_{\mathrm{e\_ave}}$ of $1\times10^{19}\mathrm{m}^{-3}$ were sustained with ion cyclotron heating (ICH) with heating power of ~1.6MW and electron cyclotron heating (ECH). Due to a particular time sequence of ECH and ICH pulses, W_{p} and W_{pe} shows complicated waveforms. However, after the time t = 4.3s, the plasma was sustained only by ICH power and from t = 4.5s to 4.7s a 77GHz ECW pulse in X-mode polatization was injected from high field side. Since W_{p} and W_{pe} are nearly identical, it is considered that the change in W_{p} is evident. W_{p} was decreasing just until the start of the slow-XB ECW injection. Turning on (off) of the slow-XB ECW caused distinguished increase (decrease) in W_{p}, and the heating efficiency evaluated from the changes in W_{p} recorded enough high value, ~90%.

Density scan experiment with slow-XB ECW injections was performed and the results were plotted in Fig. 2. The ECWs were injected with power modulation so that the power deposition analysis could be performed using multi-channel electron cyclotron emission (ECE) signals. R_{ax} and B_{t} were 3.6m and −2.75T, respectively. The data set of ECE revealed clear dependence of the change in power deposition region and $n_{\mathrm{e\_ave}}$. $n_{\mathrm{e\_ave}}$ was varied with the values of 1.5, 2, 5, 6, 7, $9\times10^{19}\mathrm{m}^{-3}$. The peak positions of the amplitude distribution of ECE signals shift from ρ ~ 0.7 to ~0.35 with the increase in $n_{\mathrm{e\_ave}}$. Also, the bottom positions of the phase difference distribution shift from ρ ~ 0.7 to ~0.4. Thus, both the data of ECE amplitude and phase difference indicate that the power deposition position shifts inward by the increase in $n_{\mathrm{e\_ave}}$. The shift would be caused by the changes in the ray trajectories of X-mode waves and EBWs. Precise validation of the experimental results by use of simulation code is needed to clarify the propagation and absorption of EBWs.

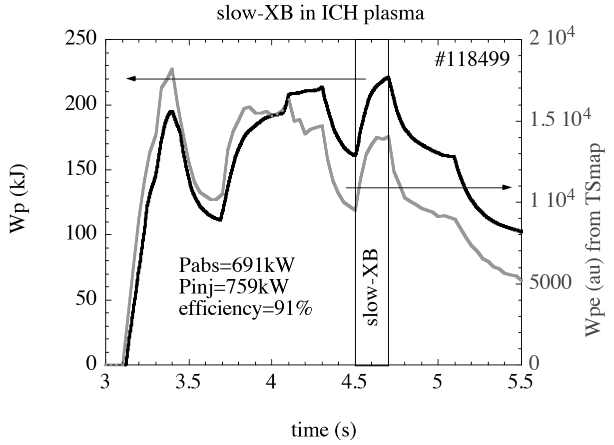

Fig. 1. Waveforms of plasma stored energy and electron kinetic energy in a slow-XB discharge.

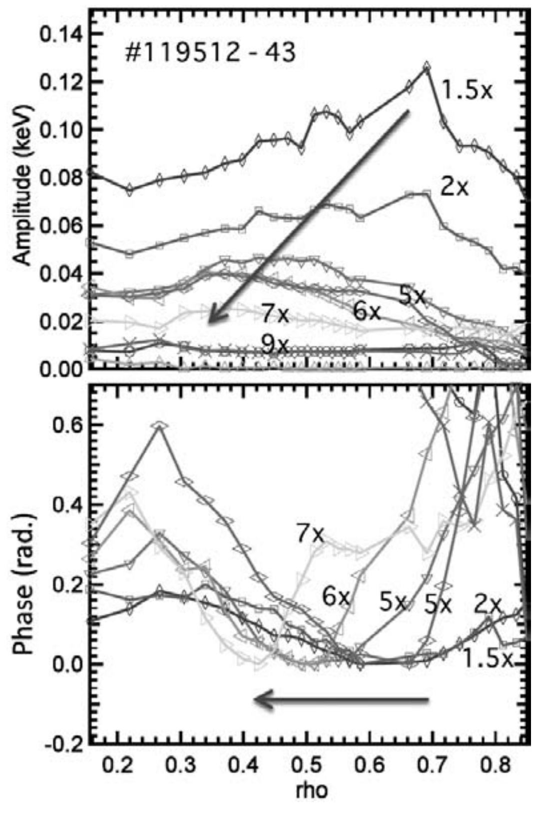

Fig. 2. Top: radial distributions of the amplitude of multi-channel ECE signals, and bottom: radial distributions of the phase difference of the ECE signals in the density scan experiment with power-modulated slow-XB ECW injections.