§22. Effects of Electron Bernstein Wave Heating at Very Low Magnetic Filed on Plasma Confinement in Heliotron J

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The main objectives of this bi-directional cooperative research on Heliotron J are the studies of production of over-dense plasma by electron Bernstein waves (EBWs) converted from long wave length electromagnetic waves at very low toroidal magnetic field (B_t), and turbulent transport properties in thus produced plasmas. This approach using 2.45 GHz electron cyclotron waves (ECWs) at very low B_t less than 0.1T was initiated on the Compact Helical System (CHS) [1], and overdense plasmas were successfully generated [2]. The power deposition profiles obtained by power modulation technique were consistently explained by X-B and O-X-B mode conversion scenarios [2]. Moreover, ray tracing and absorption calculation of mode-converted EBW also confirmed that both conversion schemes are possible, because of low directivity and low selectivity of polarization at 2.45 GHz frequency range [3].

In this year campaign of this experiment on Heliotron J, 2.45 GHz ECW power was increased up to 20 kW, and was injected into deuterium, helium and neon gases filled steadily. The magnetic field strength on the magnetic axis was adjusted to be about 700 G, but both fundamental and second harmonic resonance layers locate inside LCFS in certain toroidal sections. On Heliotron-J, both O-X-B and X-B scenarios are possible similar to CHS.

Neon plasmas having the line averaged electron density of $<n_e>$ ~$8x10^{17}$ m^{-3} were produced with 15 kW ECW injection. The achieved $<n_e>$ corresponds to 10 times larger than the O-mode cut off density. In neon plasmas $<n_e>$ is sustained quasi-stationary. The power deposition profile obtained by ECW power modulation of 7 kHz showed a peak around r/a~0.3, and the obtained electron density profiles were considerably peaked. The electron density near the plasma center reached a very high value of ~$1.8x10^{18}$ m^{-3}, which is about 24 time of the cutoff density. The central electron temperature is fairly low (~8 eV).

On the other hand, the line averaged electron density $<n_e>$ evolved in time considerably in deuterium plasmas. This will be caused by large change of fueled gas because gas fueling is done by the steady gas filling instead of gas puffing. Interestingly, $<n_e>$ suddenly increased at $t=t_1$~300ms and quickly decreased from $t=t_2$~350 ms, as shown in Fig.1. After $t=t_1$, the electron density (n_e) profile beacme peaked considerably, as shown in Fig.2. This leads to formation of the overdense plasma core. Electron temperature (T_e) profile was also peaked, similarly to the electron density profile. Accordingly, a peaked electron pressure profile was formed after $t=t_2$. The power deposition profile was also measured with power modulation technique used in CHS [2]. Figure 3 shows the time evolution of electron temperature perturbation

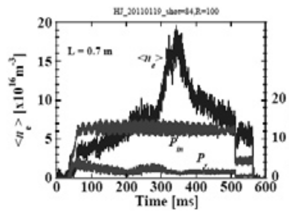

Fig.1 Waveforms of the line averaged electron density, injected ECW power and the reflected power in deuterium plasma.

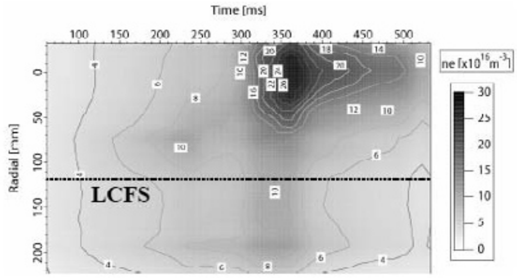

Fig.2 Time evolution of electron density profile in deuterium overdense plasma produced by the discharge scenario shown in Fig.1. The position of the last closed flux surface in the measurement port section is indicated with the dotted line and “LCFS”.

(dT_e) induced by modulated microwave power. The data clearly indicates the power deposition is localized well inside the overdense region shown in Fig.2. In conclusion, mode converted EBW generated peaked oversdense plasmas, also using deuterium gas.

It is interesting that considerably peaked density profile is produced in this experiments in contrast to high temperature helical plasmas [4]. One possible reason is that the generated plasmas are still in high collisionality regime. In the next experimental campaign, we will explore the production of overdense plasmas with low collisionality through magnetic configuration scan to investigate particle transport in the EBW produced plasmas at very low toroidal field.

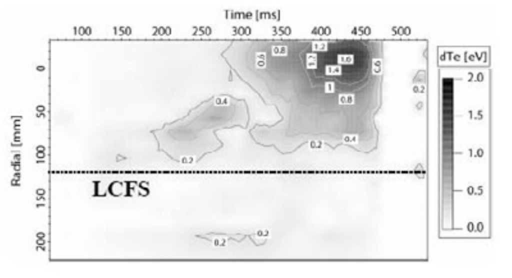

Fig.3 Time evolution of the radial profile of electron temperature perturbation induced by modulated ECW power in deuterium plasma produced by the discharge scenario shown in Fig.1.

[1] K. Toi et al., 29th EPS on Plasma Phys. Control. Fusion, Montereux, 2002, Paper No. P4-06.
[2] R. Ikeda et al., Phys. Plasmas **15**, 072505(2008).
[3] R. Ikeda et al., Contrib. Plasma Phys. **50**, 567 (2010).
[4] K. Tanaka et al., Fusion Sci. Technol. **58**, 70 (2010).