§6. Study of CERC Using Newly Installed 77 GHz Gyrotron in LHD

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Since July 2007, the installation of a 77 GHz-1 MW gyrotron has progressed in the Large Helical Device (LHD).[1] This high power gyrotron can be effective tool for controlling the local plasma parameters due to the high power density. Also, this will contribute to an investigation how local-parameter changes affect a CERC formation.[2] Here, we examined the local heating effects for CERC formation using the newly installed 77 GHz ECRH system and compared the behaviour of the radial electric field measured using Heavy Ion Beam Probe (HIBP) with the theoretical prediction.

The experiments were carried out with the configuration of R_{ax} = 3.6 m and B_0 = 2.75 T, which the 77 GHz ECRH is resonant with on axis. The stepwise injections of 82.7 (0.32 MW) and 77 GHz ECRH (0.5 MW) were applied to the plasmas produced and sustained by balance-injected Neutral Beam (NB, 2.2 MW).

Figure 1 shows the dependence of the electron temperature at ρ = 0 (circles) and at 0.5 (triangles) on the focal point of 77 GHz EC wave. The EC wave was injected from the upper port and was scanned from ρ_{foc} = 0 to 0.7 along the resonance layer. It can be confirmed that T_e at ρ = 0.5 did not change over $0 \le \rho_{foc} \le 0.7$, on the contrary, the central T_e made a transition to high temperature state over $\rho_{foc} \le 0.4$, which is in the vicinity of the rational surface of $\iota/2\pi$ = 1/2, meaning the formation of steep gradient of T_e at the core region. These results imply that localized ECRH in the inner region within the lower order rational surface and/or the electron heat flux across the rational surface play important roles for the transition to CERC.

Heavy Ion Beam Probe (HIBP) is a powerful tool for measuring an electrostatic potential in toroidal plasmas. HIBP for the LHD has been developed and the measurable range of plasmas has been expanding year by year.[3] In this experiment, we measured the behavior of the plasma space potential V_s over $0 < \rho < 0.5$. Figure 2 shows (a) the time evolution of V_s at several positions and (b) the radial profiles of V_s W/O (triangles) and W/ (circles) ECRH. The solid lines in the Fig. 2(b) represent the predicted space potential, which are the integration of E_r calculated thorough the ambipolarity condition of the radial particle fluxes.[2] The 77 GHz ECRH injection was focused on $\rho \sim$ 0.1 in this discharge. As can be seen from Fig. 2(b), the profiles of experimental V_s showed good agreement with the theoretical predictions. Although the space potential showed almost flat profile or slightly negative E_r formation without 77 GHz ECRH, positive E_r was formed after the 77 GHz ECRH injection. A transition from weak negative E_r to strong positive E_r is one of the essential characteristics of CERC.

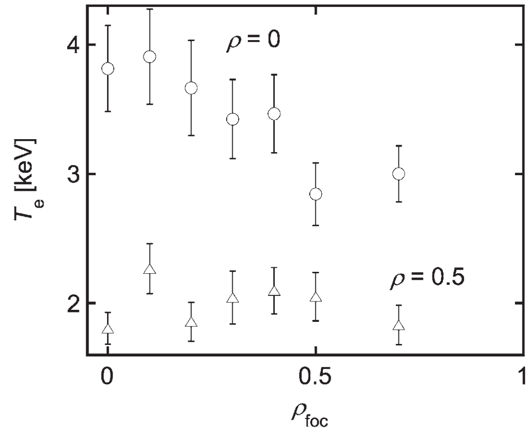

Fig. 1. The dependence of the electron temperature at ρ = 0 (circles) and at 0.5 (triangles) on the focal point of 77 GHz EC wave.

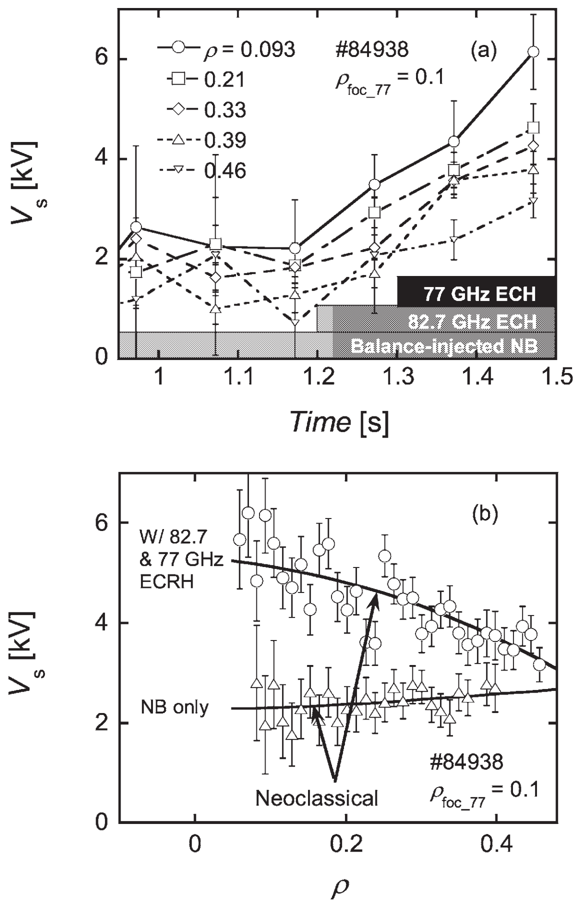

Fig. 2. (a) The time evolution of V_s at several positions and (b) the radial profiles of V_s W/O and W/ ECRH. The solid lines in (b) represent the calculated space potential.

1) H. Takahashi *et al.*, Fusion Sci. Technol., to be published
2) M. Yokoyama *et al.*, Nucl .Fusion **47** (2007) 1213
3) T. Ido *et al.*, Rev. Sci. Instrm. **77** (2006) 10F523/1-4