§7. Reversal of Radial Particle Flux of Carbon Impurity during Impurity Hole Formation on LHD

Yoshinuma, M., Ida, K., LHD Experiment Group

An extremely hollow carbon impurity profile (impurity-hole) has been observed associated with increase of ion temperature gradient in the discharges with ion-ITB on LHD. Simultaneous achievement of the impurity-hole and ion-ITB is favorable feature in nuclear fusion plasma, where both good energy confinement and ash exhaust are required.

The impurity-hole is characterized as small diffusion and large outward convection of impurities [1]. The outward convection observed in experiment contradicts to the prediction of neoclassical impurity transport and the convection velocity becomes larger as the magnetic axis shifted outward and the ion charge of Z is increased. The dynamic behaviors of the particle flux of carbon impurity during the formation of impurity-hole are studied.

Figure 1 (a) and (b) shows the time evolutions of the carbon density n_c and temperature gradient of ion and electron in the discharge sustained with the neutral beam (P-NBI). The time evolution of carbon density and ion temperature profile is measured with charge exchange spectroscopy. Additional power is injected from $t = 3.8$s with N-NBI. The magnetic axis position and magnetic field strength are 3.6m and 2.75T, respectively. After the additional heating, The temperature gradient of ion and electron increases due to the additional heating of N-NBI. The ion temperature gradient increases up to 5keV/m and then it decreases gradually. The gradient of electron temperature increases and the it is saturated faster than the gradient of ion temperature. The carbon density suddenly decreases in the middle of the increase of ion temperature gradient while the carbon density increases just before the decreasing. The electron temperature gradient does not changes significantly at the start of the decrease of carbon density.

Figure 2 shows the relation between carbon particle flux normalized by the carbon density and the carbon density gradient normalized by the carbon density. Positive and negative sign of the flux mean outward and inward flux, respectively. The flux of carbon changes dynamically in time. The flux is directed to inward early in the discharge and the direction is abruptly reversed from inward to outward without significant change of carbon density gradient. The contribution of the carbon impurity convection seems to be dominant in the dynamical change of the flux. The time scale of the reversal is faster than the time scale of changing the profiles of ion temperature, electron temperature, electron density and carbon density.

1) M.Yoshinuma, *et al.*, Nucl.Fusion **49**(2009)062002.

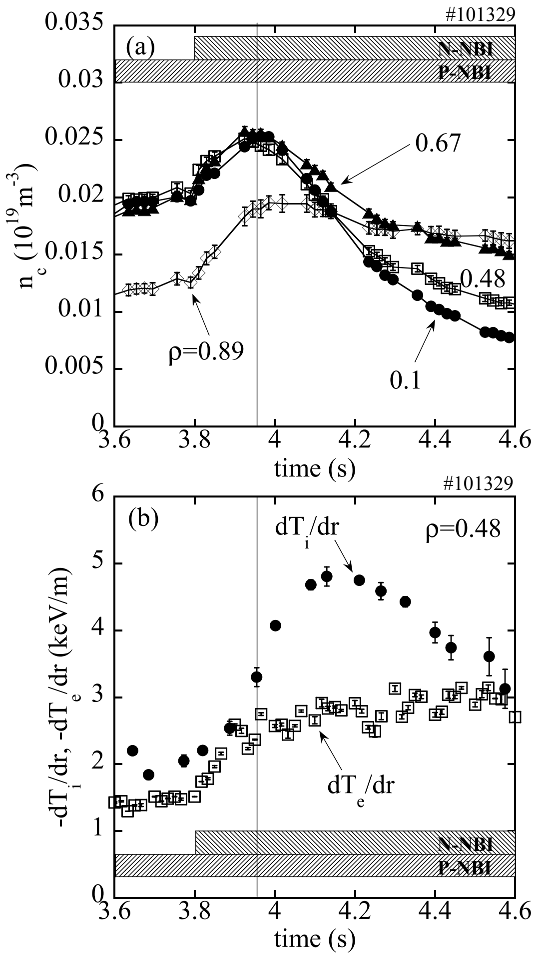

Fig. 1: Time evolutions of (a) carbon density at normalized minor radius $\rho = 0.1$(circle), 0.48(square), 0.67(triangle), and 0.89(diamond), (b) the gradient of ion temperature (circle) and electron temperature (square) near the mid-radii of the plasma

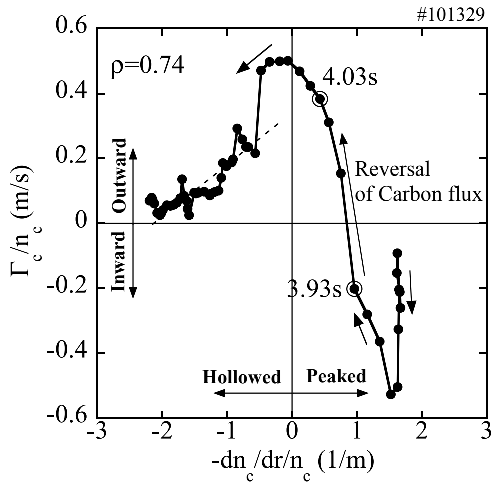

Fig. 2: Relation between flux of carbon normalized by the carbon density and gradient of carbon density normalized by the carbon density.