§14. Experimental Study of Turbulence and Particle Transport in LHD

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The confinements in the most of the operational regime of LHD are dominated by the anomalous transport. Therefore study of the turbulent fluctuation is important. Recently, particle transports at Rax=3.6m are studied from density modulation experiments and parameter dependence of the diffusion coefficient (D) and convection velocity (V) are obtained [1]. The diffusion coefficients are found to be anomaly large compared with neoclassical prediction. The direction of the convection velocities are against neoclassical prediction in several cases. In order to study turbulent fluctuation, recently two dimensional phase contrast interferometer (2D PCI) was developed [2]. The 2D PCI is capable to measured fluctuation with around 0.2 of minor radius spatial resolution within frequency range (~2MHz) and wavenumber range (0.2~1.5mm^{-1}).

Figure 1 shows n_e, T_e and fluctuation amplitude under different heating power at B_t= 1.49T and Rax=3.6m. As shown in Fig.1 (b), hollow density profiles are observed in all three cases, and the peak density position shifts to outward as heating power increases. This is because V_{edge} increase in the outward direction at higher temperature gradient. As shown in Fig.1 (c), the peaks of fluctuation amplitude exist in plasma edge where density gradients are negative. The fluctuation amplitude becomes larger with higher heating power. Figure 2 shows profile of the particle flux of three cases. These are calculated using estimated D, V from the modulation experiments and measured n_e profiles. The diffusive and convective flux was calculated from –D grad n_e and nV respectively. The total flux is sum of two fluxes. The profiles are shown only up to ρ = 1.05 because the close to plasma boundary gradients becomes sharp and it becomes difficult to represent the diffusive flux. This sharp gradient around the plasma boundary is due to lack of resolution of the present FIR interferometer. Figure 3 shows relation between fluctuation level and normalized particle flux. Figure 3 consists of 16 shots. Here, the fluctuation level is the ratio of the observed fluctuation amplitude, which is averaged between ρ = 0.7 and 1.1 and k >0.5 mm^{-1} and 5 < f < 500kHz, to the averaged density at 0.7 < ρ < 1.05. Because the spatial resolutions of the fluctuation measurements are not very fine, average fluctuation levels are used. The normalized particle flux is calculated also at 0.7 < ρ < 1.05. As shown in Fig.3, a clear relation between normalized convective flux and fluctuation level are observed. At higher fluctuation level, normalized convective flux becomes larger. Although there is not clear relation is observed between fluctuation level and normalized diffusive flux. Fluctuation induced particle flux is determined not only by density fluctuation amplitude but also by the potential fluctuation amplitude and correlation between density and potential. One of the possible interpretations of lack of the clear relation between fluctuation level and normalized diffusive flux is due to the role of the potential fluctuation and phase relation between potential and density fluctuation. More detail consideration will be possible with help of the theoretical model about potential fluctuation and phase relation.

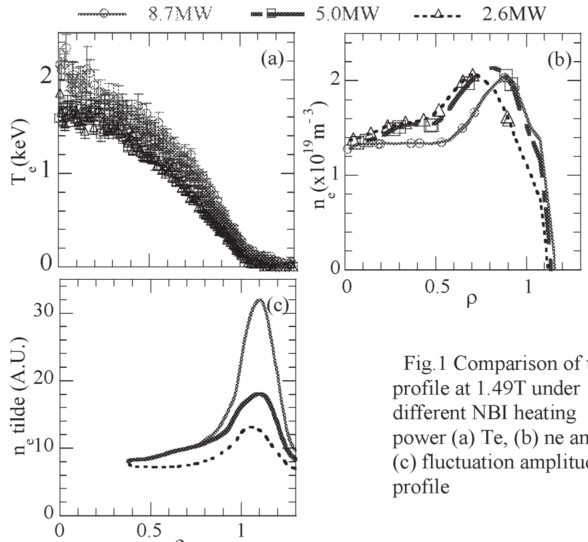

Fig.1 Comparison of the profile at 1.49T under different NBI heating power (a) Te, (b) ne and (c) fluctuation amplitude profile

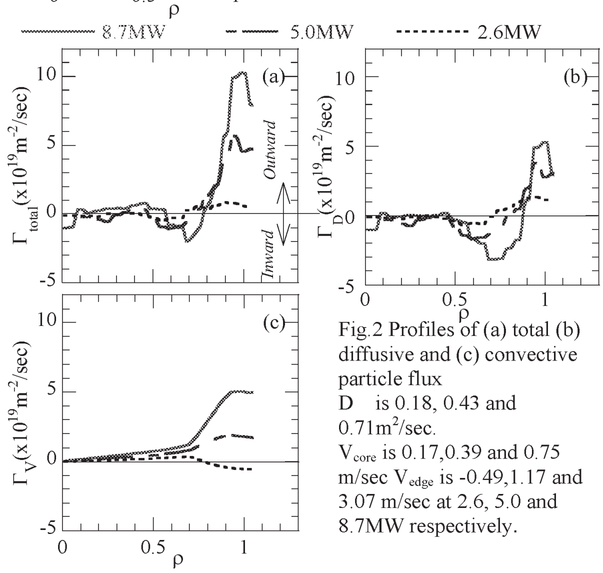

Fig.2 Profiles of (a) total (b) diffusive and (c) convective particle flux
D is 0.18, 0.43 and 0.71m^2/sec.
V_{core} is 0.17,0.39 and 0.75 m/sec V_{edge} is -0.49,1.17 and 3.07 m/sec at 2.6, 5.0 and 8.7MW respectively.

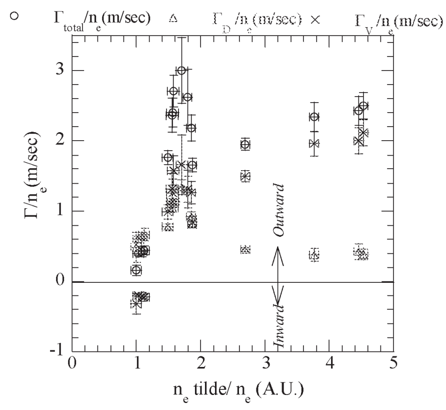

Fig.3 Relation of fluctuation level and normalized particle flu at Bt = 1.49T The error of the normalized flux is due to the fitting error of D and V. The error of the fluctuation level is fluctuation of the signal, which is mainly instability of the laser intensity.

Reference

1) Tanaka, K., et al., to be published Nucl. Fusion
2) Sanin, A.L., et al.., Rev. Sci. Instrum. 75, (2004) 3439