§18. Particle Transport in High Beta Plasma of LHD

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Particle transport in high beta plasma of LHD is important, because high beta plasma in LHD is achieved by increasing density at low toroidal magnetic filed (Bt~1T). There is an optimum magnetic axis to achieve high beta. At magnetic axis position (R_{ax}) =3.6m, the highest beta is obtained[1]. In this report, characteristics of particle transport are described at R_{ax}=3.55, 3.6 and 3.64m from density modulation experiments. Heating was combination of parallel and perpendicular injection beam with 13-18MW and B_t was1.0T. The achieved volume averaged beta was 2.5-3%.

Figure 1 shows comparison of profile in modulation experiments. Each profiles are accumulated over 1.2-1.6 seconds. Fitted data of n_e and T_e are from Thomson scattering and T_i are from charge exchange spectroscopy. The spatial profile of ionization rate is determined from cross section of ionization and Doppler broadening of Hα intensity[2]. As shown in Fig.1, T_e and T_i profiles are not different clearly, while n_e profiles shows clear differences. Density profiles are peaked at R_{ax}=3.55m, but hollowed at R_{ax}=3.6 and 3.64m as shown in Fig.1(a). Beside such difference of the density profile, the profile of the ionization rates are not clearly different each other as shown in Fig.1(c). Diffusion coefficient (D) and convection velocities (V) were estimated from 2.5Hz density modulation. Figure 2 shows comparison of D and V profiles and Fig.3 shows dependence of core (reff/a99=0.4-0.7) and edge (reff/a99=0.7-1.0) values of D and V on R_{ax}. As shown in Fig.3 (a), core D becomes larger and edge D becomes smaller at outer R_{ax}. Core V is small difference at all R_{ax} and edge V is negative (inward directed) at R_{ax}=3.55m, and positive (outward directed) at R_{ax}=3.6 and 3.64m. Global particle transport can be strongly affected by edge D since contribution of the edge volume becomes larger. However, edge D does not show minimum at R_{ax}=3.6m, where the highest beta is achieved. This suggests particle transport may not rule the optimum configuration to achieve high beta. D, V are determined to fit only modulation components. But, inward (outward) V at R_{ax}=3.55m (R_{ax}=3.6, 3.64m) corresponds to peaked (hollowed) equilibrium profiles are obtained.

Figure 4 shows ion scale ($k\rho_i$=0.1-1) fluctuation amplitude profile measured by two dimensional phase contrast imaging[3]. Highest amplitude is observed at R_{ax}=3.64m, where edge D becomes minimum. This is contrast to clear correspondence between increase of edge D and increase of edge fluctuation level in low beta regime[4]. With increase of beta and with degradation of edge χ_{eff}, increase of low k fluctuation $k\rho_i$<0.1 measured by interferometer is reported[5]. In high beta regime, such low k fluctuation may be important for particle transport in high beta regime. However, further study is necessary to reach firm conclusion.

1) S. Ohdachi, this annual report
2) M. Goto et al., Nucl. Fusion, **51**, (2011), 023005
3) K. Tanaka et al., Rev. Sci. Instrum. 79, 10E702 (2008)
4) K. Tanaka et al., Fusion Sci Tech. **58** (2010) 70
5) K. Y. Watanabe et al., Physics of Plasmas, 18, 5, 056119-1, (2011)

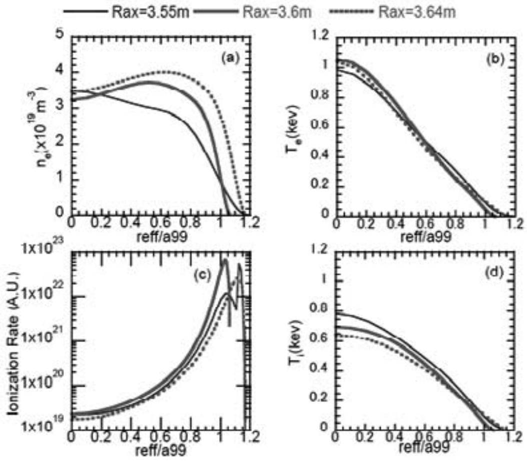

Fig.1 Comparison of profile with different RMP current. (a) n_e, (b) T_e, (c) ionization rate and (d) T_i

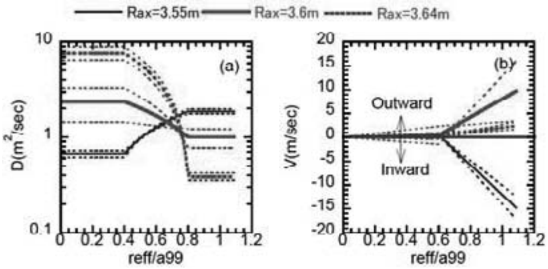

Fig.2 Comparison of (a) D and (b) V profiles. Legends are same in Fig.1 Dashed line indicates upper and lower bounds of fitting error

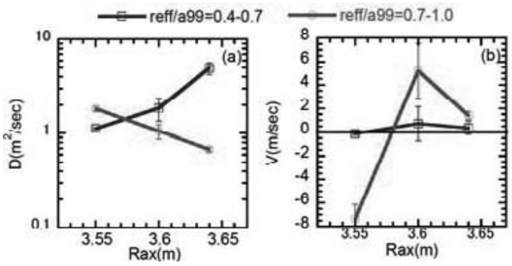

Fig.3 Dependence of (a) D and (b) V on R_{ax}

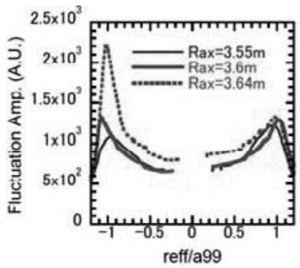

Fig.4 Comparison of the fluctuation amplitude profiles