§46. Experimental Study of Particle Transport on LHD

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Particle transport coefficients, which are diffusion coefficients (D) and convection velocity (V), are experimentally estimated from density modulation experiments in order to investigate particle transport characteristics under different discharge conditions on LHD. Figures 1 (a) and (b) show electron density (n_e) and temperature (T_e) profiles of NBI plasmas with high (8.5MW) and low (1MW) heating power in the inward shifted configuration with the magnetic axis (R_{ax}) of 3.6m at 2.75T and 2.8T. The n_e profile tends to become hollow, as the heating power is increased. The particle source is always located outside of the last close flux (LCFS) surface and particle fueling from NBI is negligible in these cases. Therefore, the distinction between n_e profiles in Fig.1 (b) is not due to the difference of the particle source but due to the dissimilarity in the transport

The values of D and V are obtained from fitting the solution of the perturbed particle balance equations to experimental data. Two fitting variables for both D and V are used. One is core value and the other is edge value. Core and edge transport can be different. For example, n_e gradient changes at $\rho = 0.7$ as shown in fig 1 (b) for 8.5MW heating case, indicating a transport change at $\rho = 0.7$. The values of D are assumed to be constant in the core and edge and change at $\rho=0.7$. The value of V at $\rho = 0$ is constrained to be zero and the V profile is assumed to be piecewise-linear changing at $\rho=0.7$. The values of V at $\rho = 0.7$ and 1.0 represent the core and edge respectively. The temperature dependence of D provides a means for comparing anomalous transport models. For Bohm-like diffusion, where long-wavelength fluctuations (up to the plasma minor radius) are important, D is proportional to T_e, while for gyro-Bohm-like diffusion, where short-wavelength fluctuations (around ion gyro-radius) are important, D is proportional to $T_e^{1.5}$. On the other hand, non-zero values for V indicate the existence of off diagonal terms in the transport matrix. One possible approach is to investigate the dependence of the inverse temperature scale length ($L_{Te}^{-1} = 1/T_e\, dT_e/dr$) on V, since hollow density profiles are correlated with peaked temperature profiles as shown in fig 1. For these investigations, a systematic scan of NBI heating power (1~5.2MW) keeping averaged density constant ($n_{e\text{-}bar}$~$1.2\times10^{19}m^{-3}$) is done. Spatially averaged values of T_e and L_{Te}^{-1} are used to characterize the core and edge. As shown in fig. 3 (a), D shows a different T_e dependence in the core compared with the edge. The observed D is found to be proportional to $T_e^{1.5}$ and $T_e^{1.2}$ in the core and edge respectively. This suggests the existence of different modes of turbulence in the core and edge. The D is around one order larger than neoclassical values calculated by DCOM[1] code. As shown in fig.2 (b), in the core, V changes direction from inward to outward as - L_{Te}^{-1} increases suggesting that the off-diagonal term appears to be due to T_e gradient. In the edge, V is always directed inward signifying a different origin for off-diagonal terms. Toroidal field is also scanned to keep the average density and T_e profiles constant. As shown in fig.3 (a), the T_e profiles are almost identical, although n_e profiles are significantly different. For almost identical T_e profiles, flat and hollow n_e profiles are observed at 1.49 and 2.75T. A 10 Hz modulation of the NBI beam power was done to estimate D and V. Here, spatially constant D is assumed, while V adopts the same model as in previous analysis. D is found to be 0.93+-0.27, 0.15+-0.03 m^2/sec at B_t=1.49, 2.75 T respectively. The dependence of D on B_t is gyro-Bohm like ($\propto B^{-2}$) rather than Bohm like ($\propto B^{-1}$). V is 11.0+-4.1, −1.1+-1m/sec at B_t=1.49, 2.75 T. From this we conclude the T_e gradient is not the only driving term to induce outward particle convective flux.

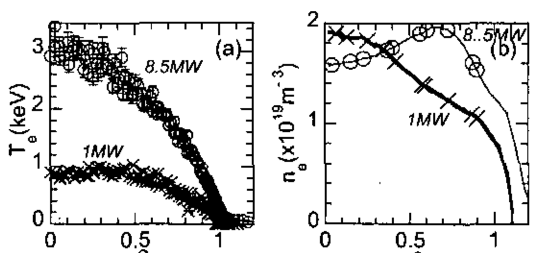

Fig.1 (a) T_e and (b) n_e profile under different heating power

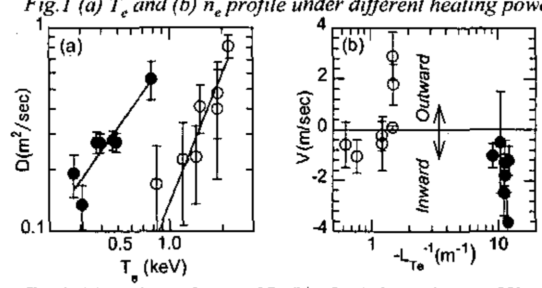

Fig.2 (a) T_e dependence of D (b) $-L_{Te}^{-1}$ dependence of V.
○ and ● indicate core and edge values respectively.

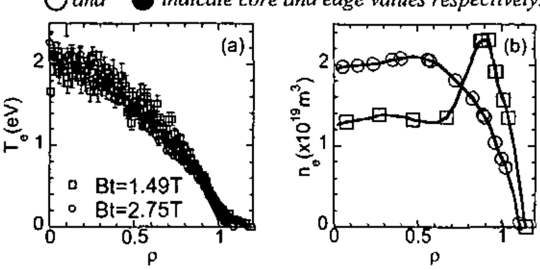

Fig.3 (a) T_e and (b) n_e profile under different B_t

Reference

[1] S. Murakami *et al.*, Nuclear Fusion 42 (2002) L19-L22