§13. Ion Heating Power Dependence of Central Ion Temperature in LHD

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Perpendicular neutral beam injection (NBI) installed recently made a significant progress to extend high ion temperature (high-T_i) regime in LHD, which is one of the most important mission in 11th LHD experimental campaign. The improvement of ion heat transport was identified in neutral beam heated plasmas and the central ion temperature of 6.8keV was achieved with the averaged electron density of 2×10^{19}m^{-3} [1].

The high-T_i plasma was realized just after superimpose of tangential NBI to perpendicular NBI heated plasma. The central T_i starts to increase just after additional NBI heating and reaches the maximum value at about 0.3-0.5s after that. The high-T_i phase is sustained for a few times longer than the energy confinement time, and then decrease. The ion heat diffusivity significantly decreases in high-T_i phase, however the improved mode is a transient phenomena [2]. In order to investigate the characteristics of the improvement of ion heat transport, the ion heating power dependence of central T_i is shown in Fig. 1. The central T_i increases with $(P_i/n_e)^{0.4}$ in low power region (<2MW/10^{19}m^{-3}), and the dependence significantly glow stronger in high power region. The similar dependence is observed in T_i gradient in the core region, which is shown in Fig. 2. The scale length of ion temperature gradient also shows the similar power dependence (see Fig. 3), which indicates that the peaked T_i profile was formed in the improved mode. The clear power threshold is identified to realize the improved mode. In the transport analysis, the ion thermal diffusivity decreases with the ion heating power when the improved mode is realized, that is, $\partial\chi_i/\partial P_i < 0$. Similarly, the T_i dependence of ion thermal diffusivity with $\partial\chi_i/\partial T_{i0} < 0$ is obtained in the improved mode. These dependences of the ion thermal diffusivity characterize the improvement of ion heat transport in helical plasmas, which are also obtained in electron ITB plasma in LHD [3].

[1] Yokoyama M., Nagaoka K., et al., Phys. Plasmas **15**, 056111 (2007).
[2] Nagaoka K., Yokoyama M., et al., Plasma Fusion Res. (to be published).
[3] Ida K., et al., Phys. Rev. Lett. **91**, 085003 (2003).

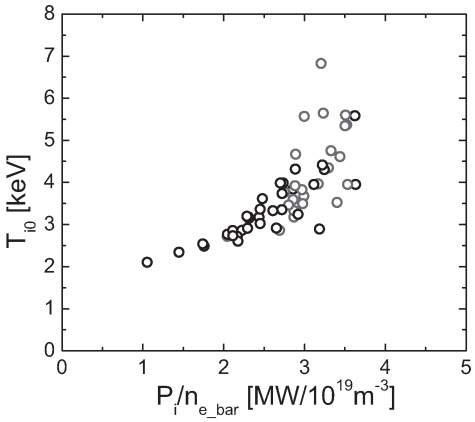

Fig. 1 The central ion temperature v.s. direct ion heating power of neutral beam normalized by electron density.

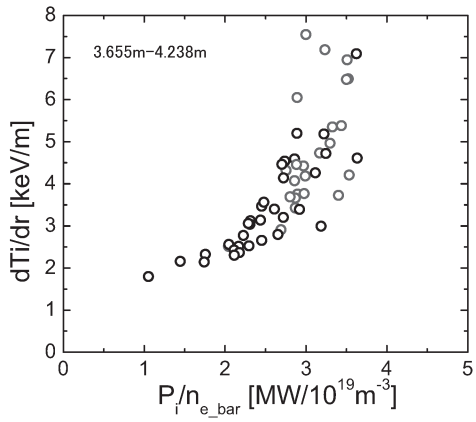

Fig.2 The ion temperature gradient v.s. direct ion heating power of neutral beam normalized by electron density.

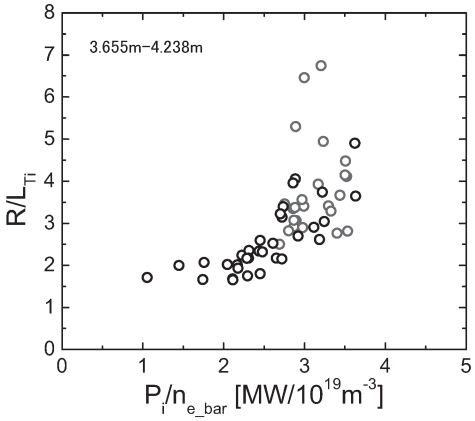

Fig.3 The scale length of ion temperature gradient v.s. direct ion heating power of neutral beam normalized by electron density.