§18. Comparison of Electron and Ion Energy Transport in the Hydrogen and Helium Plasma of LHD Normal Confinement Plasma

Tanaka, K., Tokuzawa, T., Yokoyama, M.

Understanding of ion species effects on transport are important to improve plasma performance of LHD D-D experimental campaign starting from 2016 and also important for the future D-T fusion reactor operation. In 18th cycle experimental campaign, systematic power balance analysis of the hydrogen and helium plasma with NB heating was done. Confinement mode is normal confinement which follow ISS04 scaling.

The ratio of H and He are controlled by the wall conditioning and fueling. The power balance analysis was done by using TASK3D-a code [1]. Figure 1 (a) and (b) shows collisionality dependence of ion thermal conductivity (χ_i) and electron thermal conductivity (χ_e) in hydrogen and helium rich plasma. In the data set of hydrogen rich plasma, the ratio of H^+ ion and He^{2+} ion (n_H/n_{He}) is larger four, while in the data set of helium rich plasma, n_H/n_{He} is smaller than unity. The normalization of the collisionalty was done at boundary between 1/ν regime and plateau regime of electron neoclassical transport. χ_i and χ_e are averaged at ρ=reff/a99=0.4-0.7, where output of TASK3D-a is the most reliable. As shown in Fig. 1 (a), χ_i in He rich plasma is higher than that in H rich plasma at same ν_{ei}. This is opposite result of high T_i discharge, where higher T_i is achieved in He rich plasma[2,3] suggesting lower χ_i in He rich plasma. The difference is likely to be due to the difference of the ν_{ei} and heating power. The heating power of NB of this series of experiment is less than 10MW, while in high T_i discharge, heating power is 23MW and ν_{ei} is less than unity. Also, lower χ_i is observed in low density EC heating plasma, where ν_{ei} is less than unity as well[4]. On the other hands, no clear difference of χ_e is seen in H and He rich plasma as shown in Fig.1 (b). This indicates that effect of ion species is different in ion and electron transport channel.

Figure 2 shows collisionality dependence of the fluctuation level, which defined as the ratio between averaged fluctuation and averaged density at ρ=0.45-0.7 measured by 2D-PCI [5]. There are no clear difference of collisionality dependence in H and He rich plasma. The fluctuation level monotonically increases with decrease of ν_{ei}. This tendency is similar with collisionality dependence of χ_e as shown in Fig.1(b) at ν_{ei} <10. The fluctuation level is likely to be indication of electron energy transport at this regime. In this dataset, fluctuation have core mode, which exists at ρ=0.4-0.9 and edge mode, which exists at ρ>0.9, which is observed in high T_e ECH discharge[6]. In high T_i discharge at ν_{ei}<1, only core mode exists [7]. The existence of the edge mode might be reason of the different ion energy condiment character between normal confinement regime and high T_i improved confinement regime.

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4) Makino, K., et al, this report
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6) Tanaka, K., this report "Comparison of turbulence in the hydrogen and helium plasma of LHD high T_e discharge"
7) Tanaka, K., this report "Comparison of turbulence in the hydrogen and helium plasma of LHD high T_i discharge"

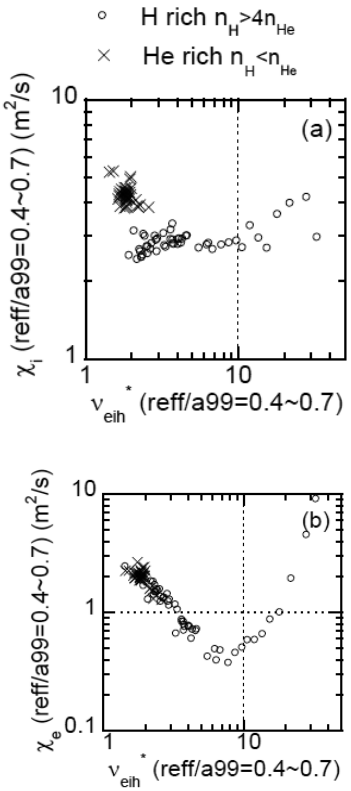

Fig.1 Collisionality dependence of (a) χ_i and (b) χ_e

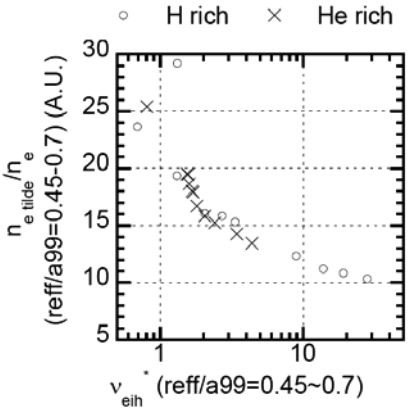

Fig.2 Collisionality dependence of density fluctuation level