§6. Comparison of Turbulence in the Hydrogen and Helium Plasma of LHD High T_e Discharge

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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 study of the hydrogen and helium plasma experiments with high EC heating was done. 5 MW EC and 5MW positive ion base perpendicularly injected NB (P-NB) was used for the heating. Comparable T_e are observed in He and H rich plasma, while T_i is around factor 1.6 higher in He rich plasma for almost same port through power[1]. This result is also consistent with density scan experiment of EC heaintg plasma, where ion energy confinement is better in He rich than in H rich plasma[2]. In NB heating plasma also shows higher T_i for almost same port through heating power in He rich plasma. These results suggests that ion energy transport is better in He rich plasma than in H rich plasma. However, this improvement is likely to be only in low collisionality regime, because higher collisionality regime of normal confinment mode (ν_{eih}>1), χ_i in He rich plasma is higher than χ_i in H rich plasma[3].

Figure 1 shows time trace of He and H rich discharges. Three pulses of P-NB are for the Ti and Er measurements using CXRS. Figure 1 (a-4) and (b-4) show temporal evolution of line integrated density turbulence measured by 2D-PCI [4]. Unlike NB heating plasma, clear difference of the fluctuation amplitude modulations are not clearly observed. Figure 2 shows comparisons of profiles in H and He rich plasma. Two modes of the turbulence are observed in both cases. One (core mode) is fluctuation component at ρ=0.5-0.9 propagating toward the ion diamagnetic direction in laboratory frame and the other (edge mode) at ρ=1.0 propagating toward the electron diamagnetic direction in laboratory frame. The former likely propagates ion diamagnetic direction in plasma frame as well, suggesting this mode is ion temperature gradient mode. The latter of the phase velocity is close to V_{ErxB}. In low density EC heating plasma, other mode is observed at around ρ=0.5, which is likely to be trapped electron mode [6,7]. But this mode is not observed in this experiment.

The total amplitude of the turbulence in two cases are almost same, however, ratio of the two mode is different. As shown in Fig.2 (a-3) and (b-3), core mode is larger than edge mode in He rich plasma, while edge mode is larger than core mode in H rich plasma. Smaller edge mode in He rich plasma may results in higher normalized T_i gradient at ρ>0.95[1]. Interestingly, the edge mode disappears in high T_i NB discharge[5]. These observations suggests edge mode play a role on edge T_i and its gradient.

1) Takahashi, H., et al, this report
2) Makino, R., et al, this report
3) Tanaka, K., et al, this report," Comparison of electron and ion energy transport in the hydrogen and helium plasma of LHD normal confinement plasma"
4) Tanaka, K., et al, Rev. Sci. Instrum. 79, 10E702 (2008)
5) Tanaka, K., et al, this report "Comparison of turbulence in the hydrogen and helium plasma of LHD high T_i discharge"
6) Tanaka, K., et al, this report, "Turbulence response under heating power scan in LHD"
7) Tanaka, K., et al, this report, "Linear characteristics of turbulence under heating power scan in LHD"

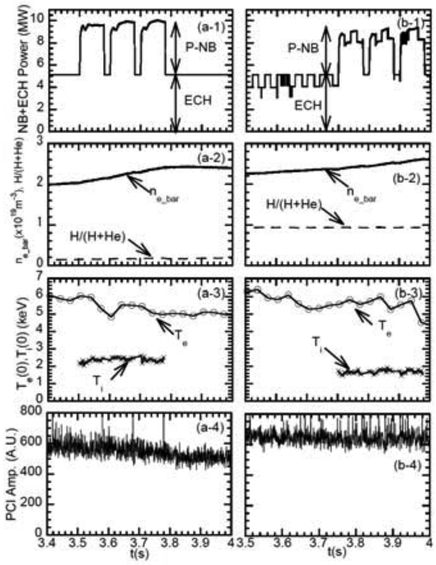

Fig.1 Comparison of temporal evolutions (a-1)-(a-4) #127380 He rich plasma, (b-1)-(b-4) #126515 H rich plasma.

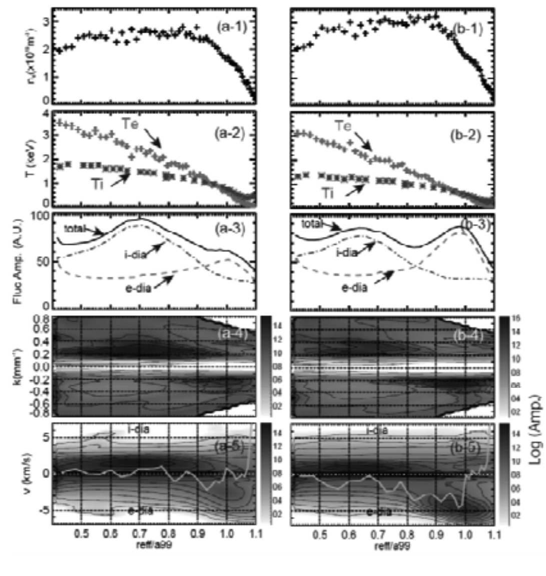

Fig.2 Comparison of profiles
(a-1)-(a-4) #127380 He rich plasma at t=3.54sec for ne, Te, Ti, t=3.5-3.58sec for PCI, (b-1)-(b-4) #126515 H rich plasma at t=3.74sec for ne, T_e, T_i, t=3.7-3.78sec for PCI. Lines in (a-5), (b-5) indicate V_{ErxBt} measured by CXRS.