§5. Comparison of Turbulence in the Hydrogen and Helium Plasma of LHD High T_i 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 NB heating was done. Factor 1.4 higher central ion temperature is obtained in He rich plasma[1]. The modeling analysis using TSAK3D-P shows that higher Ti achievement is not due to the small ion density resulting in higher deposition power for each ions and smaller neoclassical transport, but due to the reduction of the anomalous transport [2].

Figure 2 shows time trace of He and H rich plasma. Port through NB power and line averaged density is almost same, while achieved Ti(0) is clearly different. Figure 1 (a-4) and (b-4) show temporal evolution of line integrated density turbulence measured by 2D-PCI. Turbulence amplitude calculated every 0.5msec. The averaged turbulence amplitude is almost same, however, amplitude modulation is clearly higher in H rich plasma. When amplitude saturated at t=4.3sec, increase of Ti(0) stops almost in H rich plasma, while Ti(0) continues to increase after amplitude saturation in He rich plasma.

Figure 2 shows comparison of profiles in He and H rich plasmas. As shown in Fig.2 (a-5) and (b-5), the main part of the turbulence exists at ρ=0.6-0.9 in both cases. This is same observation as previous results of high Ti discharge[3]. In high Ti discharge, edge turbulence at ρ>1.0 is not observed by 2D-PCI, while it is clearly observed at EC heating or NB normal confinement[4]. The absence of edge turbulence will affect edge transport. Figure 3 shows comparison of normalized Ti gradient (a/L_{Ti}). In He rich plasma, a/L_{Ti} is higher at ρ>0.9, where turbulence peak does not exists. In previous gyrokinetic analysis, linear critical gradient of ITG turbulence roughly agree the experimental observations [5] and recent non linear gyro kinetic simulation predicts 80% of experimental normalized Ti gradient [6]. If a/L_{Ti} at ρ<1.0 is determined by the ITG critical gradient, the higher Ti achievement in He rich plasma can be due to the higher edge T_i. This is phenomenologically similar to the tokamak critical gradient model. Absence of the edge turbulence may help to increase edge Ti, although the underlined physics of higher T_i in He rich plasma is not yet understood.

Correlation between density and magnetic fluctuation may play role on ion transport as well. Higher bi coherence between density fluctuation envelope and magnetic fluctuation is observed in H rich plasma as shows in Fig.4. This may cause the difference of transport in He and H rich plasma

1) Nagaoka, K., this report
2) Murakami, A., this report
3) Tanaka, K., et al, Plasma Fusion Res. 5 (2010) S2053
4) Tanaka, K., et al, this report, "Turbulence response under heating power scan in LHD"
5) Nunami, M., et al, Plasma Fusion Res. 6, 1403001 (2011)
6) Ishizawa, A., et al, Nucl. Fusion 55 (2015) 043024

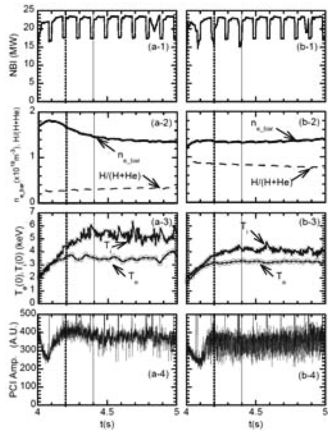

Fig.1 Comparison of temporal evolutions (a-1)-(a-4) #128670 He rich plasma, (b-1)-(b-4) #128717 H rich plasma.

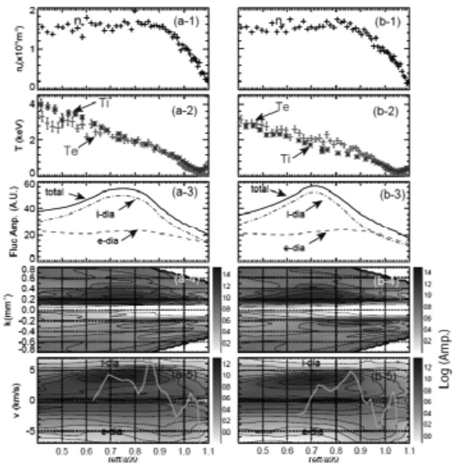

Fig.2 Comparison of profiles (a-1)-(a-4) #128670 H rich plasma, (b-1)-(b-4) #128717 He rich plasma at t=4.74sec for ne, T_e, T_i, t=4.7-4.78sec for PCI. Lines in (a-5), (b-5) indicate V_{ErxBt} measured by CXRS.

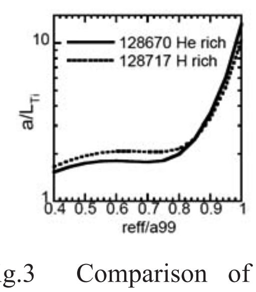

Fig.3 Comparison of normalized Ti gradient

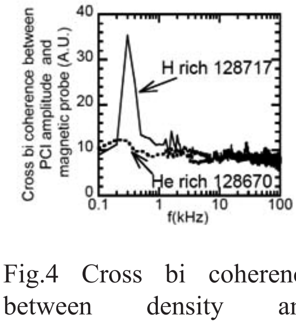

Fig.4 Cross bi coherence between density and magnetic fluctuation.