§20. Turbulence Response under Heating Power Scan in LHD

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Ion scale turbulence is investigated by measurements from two-dimensional phase contrast imaging (2D-PCI) [1] under the heating power scan experiments. Figure 1 show time history of discharge of analysis target. Plasma is produced by on axis heating using 77 and 154GHz gyratron, then, positive ion based NB is injected perpendicularly followed by parallel injection of negative ion based NB. As shown in Fig.1 (b), central electron, ion temperature and their ratio change in time due to the different combination of EC and NB heating. Electron density changes in time as well as shown in Fig.1 (a), this is mainly due to the change of transport depending on the temperature.

The profiles of four different phases namely phase1-4, of are shown in Fig.2. These phases are shown by arrows in Fig.1 (a). In Fig. 2 (c)-(d), turbulence propagating ion and electron diamagnetic direction in laboratory frame are shown separately. In Fig.2 (d), E_rxB_t ploidal rotation velocity (V_{ErxBt}) are show. V_{ErxBt} is measured by HIBP and CXRS. The measurements of HIBP are shown by dashed line and CXRS by plain lines. Their error bars are +-1 and 2 km/s for HIBP and CXRS. Comparing phase velocity of turbulence measured by 2D-PCI and V_{ErxBt}, propagation direction in plasma frame are shown. Wavenumber and frequency resolved measurement of turbulence by 2D-PCI shows three different peaks at three different location. One exists at ρ =reff/a99=0.4-0.7 (inner mode), the second exists at ρ=0.7-1.0, the third exists at ρ=1~1.1 (edge mode). These three modes responds differently in four phases. Inner modes exists in phase 1 and 2, when T_e/T_i is high and n_e is low. Its phase velocity is comparable with V_{ErxBt}. The normalized wavenumber ($k\rho_i$) of inner mode is 0.6. The outer mode exists through four phases. Its phase velocity is comparable with V_{ErxBt} in phase 1 and ion diamagnetic direction in plasma frame in phase 2-4. The propagation direction in laboratory frame changes between phase 3 and 4 indicating change of Er and increase of turbulence phase velocity. The $k\rho_i$ of outer mode is 0.3 and lower than that of inner mode. The edge mode exists from phase 1 and phase 3, the phase velocity is comparable with V_{ErxBt}. The $k\rho_i$ is around 0.2 and is lower than that of inner and outer mode.

These observations suggest that three different modes exists with different driving and stabilizing mechanism. These modes may play different role on transport. Linear characteristics are studied in this report [4]

1) Tanaka, K., et al, Rev. Sci. Instrum. 79, 10E702 (2008)
2) Ido, T., et al, Plasma Fusion Res., 3, 031 (2008)
3) Yoshinuma, M., et al, Fusion Sci. Tech., 58, 375 (2010)
4) Tanaka, K., et al., "Linear characteristics of turbulence under heating power scan in LHD "

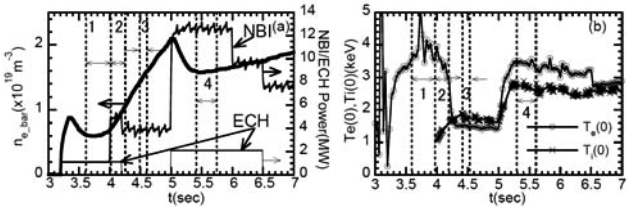

Fig.1 Time history of (a) n_{e_bar}, ECH/NBI power and (b) central electron and ion temperature

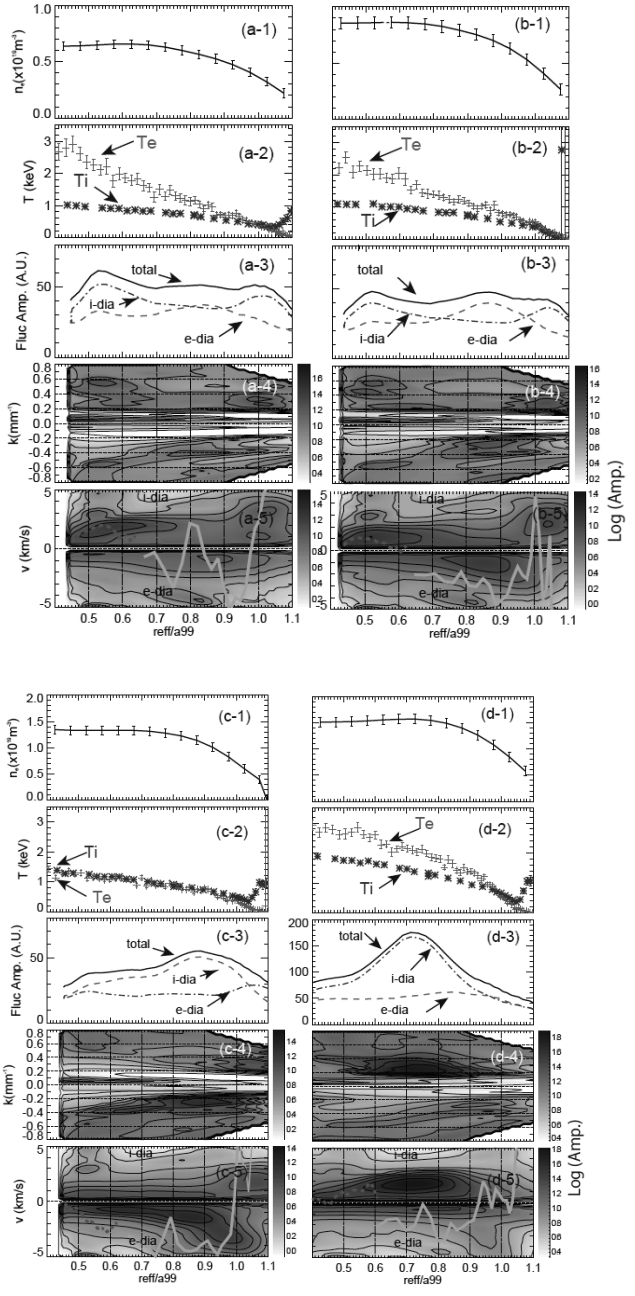

Fig.2 Comparison of profiles of four different phases (a-1)-(a-5) for pahse1, (b-1)-(b-5) for phase2, (c-1)-(c-5) for phase 3, (d-1)-(d-5) for phase 4. In (a-5) - (d-5), dashed and plain line indicate V_{ErxBt} measured by HIBP [2] and CXRS respectively [3].