§12. Characteristics of Microturbuelnce and its Impact on Particle and Momentum Transport in LHD

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The ion scale microturbulnece such as ion temperature gradient mode (ITG), trapped electron mode (TEM) plays an important role on particle and momentum transport. In LHD, different spatial profile of n_e and V_{tor} are obtained scanning heating power. Ion scale microturbulnece, where $k\rho_i$=0.1-1 and poloidally dominated components, are measured simultaneously by using a two dimensional phase contrast imaging (2D-PCI) [1].

Figure 1 shows comparison of profiles with low power (3.4MW perp. NBI) and high power (5.9MW para. NBI=2.9MW Co 3MW Ctr.) heating. Density profile is peaked in low power and flat in high power. In both cases, the external toroidal torque is negligible, however, spontaneous toroidal rotation is clearly observed as shown in Fig.1 (c). This toroidal flow is not account by neoclassical effects. It is likely driven by turbulence effects [2]. Figure 2 shows fluctuation profiles in both cases. Clear difference of the spatial structure is seen. There are two peaks. One is at r_{eff}~0.36m in core, the other at r_{eff}~0.63m in edge region. The former changes propagation direction in laboratory frame from electron with low power to ion direction with high power, although direction in plasma frame is not known. The latter shows almost zero phase velocity with low power and electron direction with high power in plasma frame from comparison with E_rxB_t velocity. These suggest turbulence characters are different in core/edge in low/high heating power. Figure 3 shows linear spectrum at around peak of the fluctuation. At r_{eff}=0.38m corresponding core fluctuation peak, growth rate (γ) is larger and real frequency (ω_r) is smaller with low power. The peak of γ is around $k\rho_i$=0.5 in both cases. Since ω_r is ion direction, dominant instability is ITG in both cases. However, as shown in Fig,4 (a),(c), Eigen function with low power is modulated by local magnetic ripple, indicating contribution of TEM. At reff=0.63m at edge fluctuation peak, larger γ is extending to higher $k\rho_i$ and ω_r is electron direction in the most of $k\rho_i$ region indicating dominant instability is TEM. As shown in Fig. 4(b), (d), Eigen function spread in wider poloidal angle compare with core fluctuation. Also, spreading is more dominant with high power case indicating larger contribution of TEM. This corresponds to Fig.2 (b),(d), where fluctuation velocity in plasma frame is larger in electron direction with high power. These indicate core turbulence is dominated by ITG and increases TEM contribution with lower heating power and edge turbulence is dominated by TEM and increases TEM contribution with higher heating power.

1) Tanaka. K. et al.:Rev. Sci. Instrum. **79**, 10E702 (2008)
2)Nagaoka, K. et al.,:Phys of Plasma, **20**, 056116 (2013);
3) Dorland, W., et al., Phys. Rev. Lett., **85**, 5579 ,(2000)

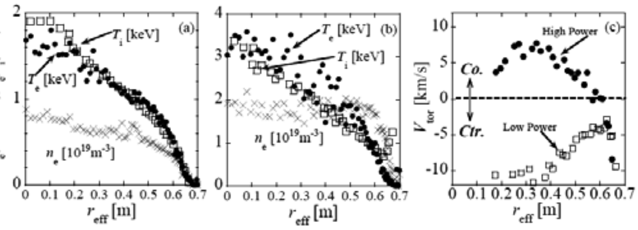

Fig.1 n_e,T_e,T_i profile in (a) low power (3.4MW perp NBI) ,(b) high power (5.9MW para. NBI=2.9MW Co。3MW Ctr.)) heating and (c) comparison of toroidal rotation

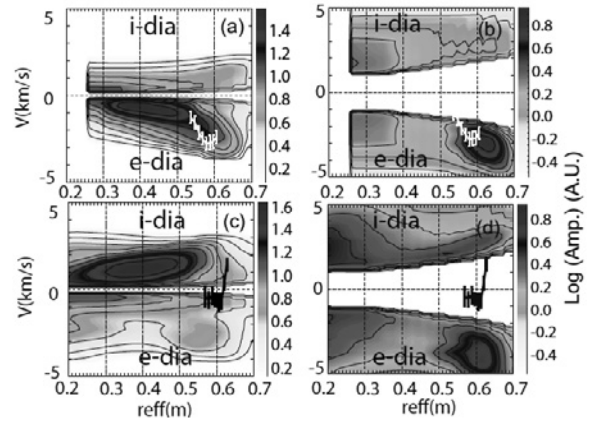

Fig.2 Fluctuation profiles in low power heating (a) 20-500kHz(b) 200-500kHz and in high power heating (c) 20-500kHz (d) 200-500kHz. White lines in (a),(b) black lines in (c), (d) indicates E_rxB_t velocity

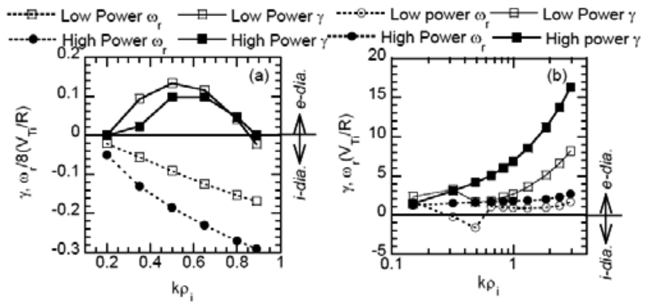

Fig.3 Spectrum of γ and ω_r at (a) r_{eff}=0.38m(r_{eff}/a99=0.6) and (b) r_{eff}=0.63m(r_{eff}/a99=0.99) calculated by GS2[3]

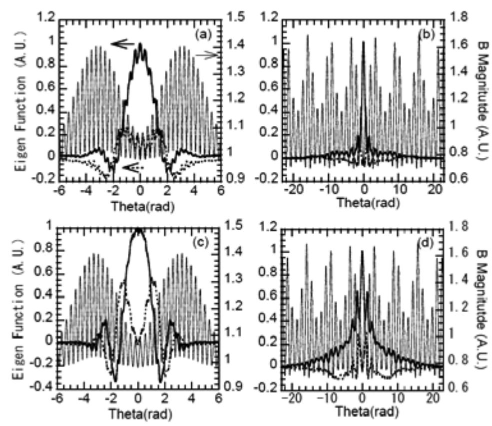

Fig.4 Eigen function and B magnitude in low power at (a) r_{eff}/a99=0.6 (b) r_{eff}/a99=0.99 in high power at (c) r_{eff}/a99=0.6 (d) r_{eff}/a99=0.99 kρi=0.5 calculated by GS2[3]