§19. Fluctuation Behavior in H Mode of LHD

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A clear reduction of the micro turbulence associated with the improvement of particle confinement was observed in an H mode discharge at outwardly shifted low field configuration (the magnetic axis position R_{ax}=3.9m, B_t=0.9T) by using two dimensional phase contrast imaging (2D-PCI) [1]. It was in contrast to the observation at an inwardly shifted configuration (R_{ax}=3.6m), where the turbulence increased after the transition [1,2]. It should be noted that the both neoclassical and anomalous transport is larger at R_{ax}=3.9m than at R_{ax}=3.6m [3], while the transition was clearer at R_{ax} = 3.9m. Figure 1 shows time history of the H mode discharge at R_{ax}=3.9m. Under constant NBI injection power, the line integrated density increased at t = 4.795s. The reduction of Hα after the transition was observed. These indicate the improvement of the particle confinement. ELM activity is seen before the transition in the edge chord of the interferometer and line integrated fluctuation signal measured by 2D- PCI. They disappeared after the transition. The time scale of the reduction of the fluctuations is less than 0.5ms. The line integrated density increased just after the reduction of the turbulence. Thus, the reduction of the turbulence caused an improvement of the particle confinement. The H factor, which was defined as the global energy confinement time normalized by the value of the international Stellarator Scaling 95 increased from 0.5 to 0.55. The improvement in the energy confinement was modest.

Figure 2 shows a comparison of n_e, T_e, T_i, and the fluctuation amplitude and its phase velocity profiles before (t = 4.74s) and after (t = 4.94s) transition. The measurements of 2D-PCI were available at both upper and lower sides of the mid plane. Therefore, the profiles of fluctuations are shown in the positive and negative ρ. The former and latter corresponds to the lower and upper sides of the plasma mid plane respectively. Some asymmetries are seen at positive and negative ρ, but the general tendencies were similar. The same data of n_e, T_e and T_i are plotted for the same absolute number of positive and negative ρ, since they are a function of flux surface. The 2D PCI measures poloidally dominated components. Thus, the propagation direction of the turbulence was determined by electron and ion diamagnetic directions. These are compared with the ExB poloidal rotation in Fig.2 (d) and (h). The phase velocities almost follow the ExB rotation velocity. Both electron and ion temperature were almost identical before and after the transition, while the electron density clearly increased after transition. The peak value of the fluctuation amplitude at ρ = - 0.9 decreased clearly and the peak value at ρ = 0.9 decreased slightly after the transition. However, the density at ρ = 0.9 increased from $2x10^{19}m^{-3}$ to $3x10^{19}m^{-3}$, the normalized fluctuation level by background density decreased clearly both at ρ = - 0.9 and ρ = + 0.9. As shown in Fig.2 (d) and (h), before the transition, the fluctuation phase velocity continuously increased from ρ = 0.1 to 1.0, but, after transition, this continuity was broken at ρ = 0.6-1.0. This indicates that a strong radial shear of the fluctuation velocity was formed resulting in the improvement of particle confinement.

1) Tanaka, K., et al., Rev. Sci. Instrum. 79, 10E702 (2008)
2) Toi, K., et al., Phys. Plasma ,12,020701 (2005)
3) Tanaka, K., et al., Fusion Sci. Tech. 51,97,(2007)

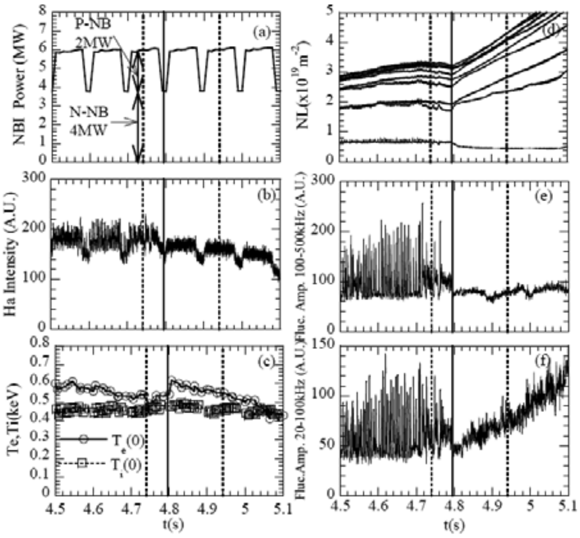

Fig. 1 Time trace of H mode discharge (a) NBI power, (b) Hα intensity (c) central T_e and T_i, (d) line integrated density and line integrated fluctuation amplitude at (e) 20-100 and (f) 100-500kHz. The timing of transition and profile measurements of Fig.2 are was shown by the plain dashed line.

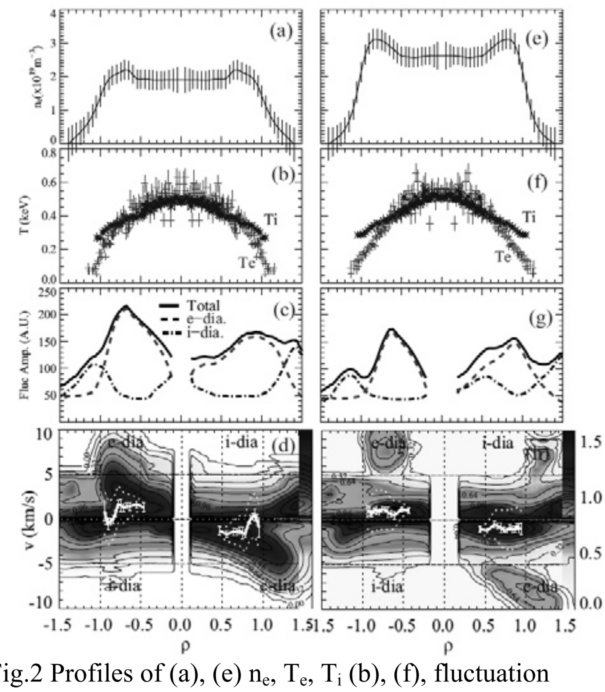

Fig.2 Profiles of (a), (e) n_e, T_e, T_i (b), (f), fluctuation amplitude (c), (g) and phase velocity (d),(h). (a)-(d) and (e)-(h) are before transition (t = 4.74) and after transition (t=4.94). Contours of (d) and (h) are Log(amplitude). ExB rotation velocities are plotted by the line in (d) and (h). The dashed lines indicated Doppler shifted drift velocities