§13. Response of Ion Scale Turbulence with E_r Profile Using Scanning Electrode

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The radial electric field (E_r) and its spatial shear have a profound impact on transport properties. E_r can affect the orbit of helically trapped particles and plays an important role in neoclassical and anomalous transport through zonal flow generation. The spatial shear of radial electric field (E_r) is one of the possible mechanisms to suppress ion scale microturbulence. In tokamak and stellarator devices, reduction of turbulence with formation of E_r shear is widely observed. While in LHD, clear correspondence between turbulence response and formation of the E_r shear is not yet observed. In these experiments, turbulence response is studied by variation of E_r and E_r shear using an electrode. This electrode is originally installed in order to study neoclassical viscosity by applying a bias voltage with changing electrode head position [1]. We used electrode to modify the plasma profiles without applying voltage.

The plasma is produced and sustained by 200kW 77GHz ECRH. The magnetic axis (R_{ax}) is 3.9m and toroidal magnetic field (B_t) is 1.38T. The potential is measured by heavy ion beam probe (HIBP) [2], and ion scale turbulence, where normalized wavenumber $k\rho_i = 0.1 - 1$, are measured by two-dimensional phase contrast imaging (2D-PCI) [3]. 2D-PCI measure poloidally dominated k. Thus the measured phase velocity is turbulence phase velocity Doppler shifted by $E_r x B_t$ poloidal rotation in laboratory frame. At R_{ax} = 3.9m, both HIBP and 2D-PCI cover almost entire region of the plasma, thus, comparison of E_r /E_r shear and turbulence is very suitable at this configuration.

Figure 1 shows spatial profile of potential and E_r. Two cases of different electrode positions are compared. One corresponds to electrode head position at reff/a99=0.8 while the other is related to reff/a99=1.0. In both cases, potential changes its gradient at around the electrode position as shown in Fig.1 (a), then, E_r has minimum at around this location. Figure 2 shows comparison of the profiles. The electron temperature is almost zero at outer of electrode head position, while electron density is not zero as shown in Fig.2 (a-1), (a-2) and (b-1), (b-2). The spatial profile of turbulence is clearly different in two cases as show in Fig.2 (a-3)~(a-5) and (b-3)~(b-5). As shown in Fig.2 (a-5), with head position reff/a99=1.0, propagation is toward ion diamagnetic direction (i-dia.) at reff/a99=0.2~0.8 and reff/a99 > 1.1 and toward electron diamagnetic direction (e-dai.) at reff/a99 = 0.9 ~ 1.1. The profile of the turbulence phase velocity (Fig.2 (a-5)) is similar to E_r profile (Fig. 1-(b) (red)). Also, with head position reff/a99=0.8, similar spatial profile of turbulence phase velocity (Fig.2 (b-5)) to E_r profile (Fig. 1-(b) (blue)) are seen. Higher phase velocity at reff/a99=0.4~0.8 with head position reff/a99=0.8 correspond to the higher E_r at this location compared with head position reff/a99=0.8. These indicate phase velocity of the turbulence can be used as a monitor of E_r. However, in both cases, at position where E_r is zero, the measured phase velocity is non zero and i-dia, directed. These suggests turbulence at reff/a99=0.4~0.8 propagates i-dia. in plasma frame. At reff/a99>1, E_r shear is clearly higher with head position reff/a99=1.0 than the head position reff/a99=0.8 as shown in Fig. 1(b). In both cases, i-dia. propagating components exists at reff/a99>1.0 as shown in Fig.2 (a-4) and (a-5). As shown in Fig.2 (a-3) and (b-3), clearly smaller turbulence amplitude is seen with head position reff/a99=1.0, where E_r shear is stronger. This suggests edge turbulence is suppressed by formation of E_r shear.

1) S. Kitajima et al., Nuclear Fusion, 51, (2011) 083029
2) T. Ido et al., Plasma Fusion Res., 3, 031 (2008)
3) K. Tanaka et al., Rev. Sci. Instrum. 79, 10E702 (2008)

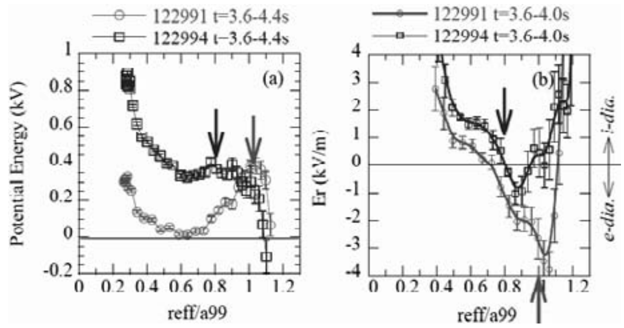

Fig.1 Spatial profile of (a) potential and (b) radial electric filed. The arrow shows the position of electrode head

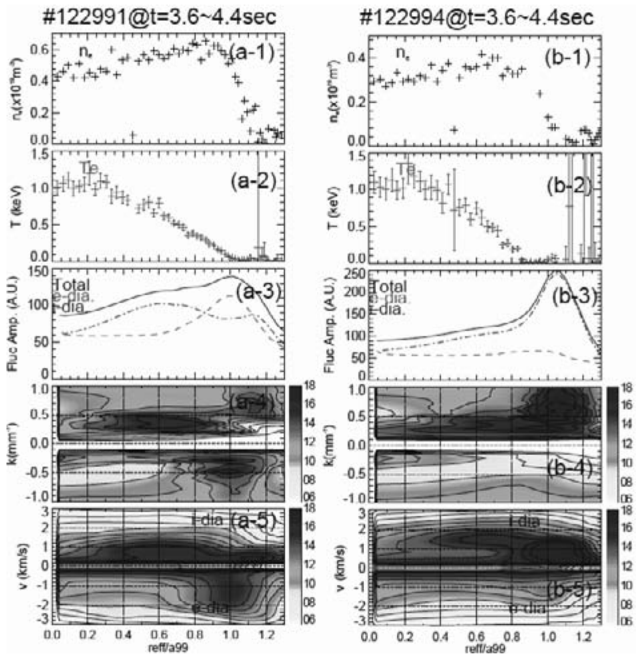

Fig.2 Comparison of profile in different electrode position. (a) electrode position is reff/a99=1 and (b) reff/a99=0.8