§23. Studies on the Edge E_r Structure

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In this report, we present the result from density scans experiment in the low β regime (0.5% ≤ β ≤ 1%) at the B_T = -2.85 T, investigating the E_r and its shear structures in the plasma edge region around the LCFS. The plasma configuration has a vacuum magnetic axis position of R_{AXIS} = 3.60 m having the helical pitch parameter of γ = 1.254. It should be noted that the plasma pressure–induced outward radial displacement of the centre of flux surfaces with minor radius (known as Shafranov shift) is expected to be not so large in low β regime, and hence the real location of the LCFS might be close to (or slightly outside) that for the LCFS location of the vacuum magnetic field configuration (termed "R_{LCFS}^{VACUUM}").

It is known that the E_r value for the helical plasma inside the LCFS becomes a negative value at the higher normalized collisionality ν_h^* (termed "ion root"), while it becomes a positive value in the lower ν_h^* regime (termed "electron root"). [1)]

During a multi-shot density scans, the electron temperature at the edge region seems to be almost unchanged, and hence we could change the edge collisionality values at the different radii by varying the edge density as shown in Fig. 1 (a) and (b). The edge E_r value inside the LCFS in a lower ν_h^* regime (electron-root) became more positive than that for a higher ν_h^* regime (ion-root), while the edge E_r value outside the LCFS kept a positive one during this density scans as illustrated in Fig. 1 (d). On the other hand, the locations whereon ∇E_r has the local maximum value (termed "R_{LCFS}^{CXS}") in both electron- and ion-root regimes are in close agreement (differences, ± 0.025 m) as illustrated in Fig. 1 (e). Therefore, with regards to determining the LCFS location via CXS measurements, the location whereon E_r has the value of zero should not be suitable (rather than that for the maximum ∇E_r), since there is the case of the lack of positional value of zero in the edge E_r (such as electron-root regime).

Since the p_e profiles must be a magnetic flux function, one can see an information related to the LCFS location at around whereon p_e and/or ∇p_e profiles has the value of zero. Indeed, looking at Fig. 1 (c), there are steep slopes (or gradients) in the p_e profiles at around the R_{LCFS}^{CXS} location. The most important point is that we can find the point whereon ∇E_r has the local maximum value as the R_{LCFS}^{CXS} location, while the ∇p_e profiles decrease continuously at around the LCFS as shown in Fig. 1 (c), and hence, we can not determine the exact LCFS location by means of an information from ∇p_e profile.

According to a knowledge from the neo-classical theory inside the LCFS and its comparison with previous experiments on LHD, the radial electric field inside the LCFS should be determined by the ambipolar condition of ion and electron fluxes that are trapped in the effective helical ripples.[1)] On the other hand, we considered that the formation of a positive E_r shear at around the LCFS seems to be due to a different parametric dependence of the E_r inside and outside the LCFS regions. This observation may support the idea for the mechanism of a positive E_r shear formation with its local maximum value at the LCFS through the loss of electrons on the open field lines to the first wall, leaving ions behind.

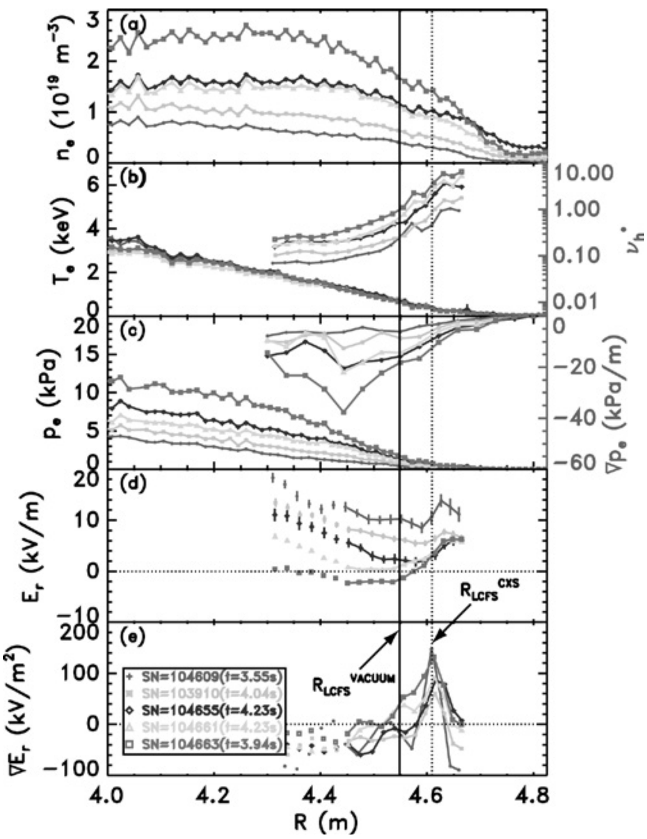

Fig. 1. Comparison of radial profiles during density scans experiment in the low β regime (0.5% ≤ β ≤ 1%) with -2.85 T toroidal magnetic field. (a) Electron density, (b) electron temperature and normalized collisionality, (c) electron pressure and its shear, (d) electric field, and (e) electric field shear. All shots have the same external momentum input of 3 units tangential (2 units co- plus 1 unit counter-direction) and 2 units perpendicular-NBI (P_{NBI}=27±1 MW). Vertical solid and dotted lines correspond to the location of the LCFS for the vacuum magnetic field and the local maximum ∇E_r value, respectively.

1) Ida, K. et al. : Nucl. Fusion **45** (2005) 391.