§18. Control of the Radial Electric Field Shear by Modification of the Magnetic Field Configuration in LHD

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Control of the radial electric field, E_r, is considered to be important in helical plasmas, because the radial electric field and its shear are expected to reduce neoclassical and anomalous transport, respectively. In general, the radial electric field can be controlled by changing the collisionality, and positive or negative electric field have been obtained by decreasing or increasing the electron density,respectively. Although the sign of the radial electric field can be controlled by changing the collisionality, modification of the magnetic field is required to achieve further control of the radial electric field, especially producing a strong radial electric field shear. In the Large Helical Device (LHD) the radial electric field profiles are shown to be controlled by the modification of the magnetic field by changing the radial profile of the effective helical ripples, ε_h[1]. Since the radial electric field in LHD is determined by the ambipolar condition of ion flux and electron flux that are trapped in the effective helical ripples, a change in the magnitude and radial profiles of effective helical ripples will be the most straightforward tool to control the radial electric field. In LHD, the radial profiles of effective helical ripples can be modified by a shift of the magnetic axis from 3.5m to 3.9m as seen in Fig.1.

Figure 2 shows the radial profiles of the radial electric field for the ion root (large neoclassical flux with negative E_r in the high collisionality regime), electron root (small neoclassical flux with positive E_r in the low collisionality regime) and the transition regime (between ion root and electron root) for various configurations with different effective helical ripple profiles. When the plasma collisionality decreases by decreasing electron density or increasing the temperature with higher heating power, the radial electric field changes its sign from negative in the ion root to positive in the electron root. Regardless the configuration, the transition from ion root to electron root is observed at the plasma edge if the electron density is decreased below $0.5 \times 10^{19} m^{-3}$. When the effective helical ripple increases gradually towards the plasma edge (R_{ax} = 3.75m, 3.9m), the electron root region extends to half of the plasma minor radius and the radial electric field shear produced is relatively weak. However, when the effective helical ripple increases sharply at the plasma edge (R_{ax} = 3.5m), the electron root region is localized at the plasma edge and strong radial electric field shear is produced. When the magnitude of the effective helical ripple is suppressed to a low level (R_{ax} = 3.6m), the transition region of the radial electric field is located at ρ = 0.9, not at the plasma edge, because there is no increase in the effective helical ripple at the plasma edge in this configuration. These results show that a strong electric field shear can be obtained at the plasma edge by shifting the magnetic axis inward rather than shifting the magnetic axis outward, where the achievement of electron root itself is relatively easy (even with higher collisionality).

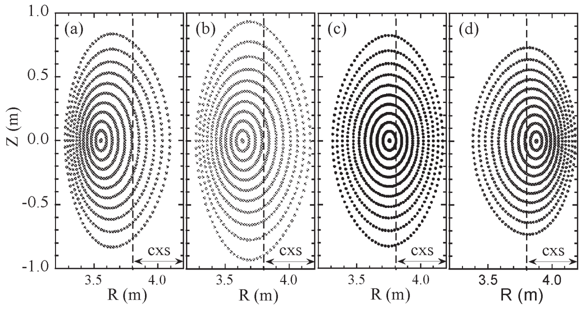

Fig. 1. Poloidal cross section of the magnetic flux surface for plasmas with various magnetic axis, R_{ax} of (a)3.5m, (b)3.6m, (c)3.75m, and (d)3.9m. The region of the radial electric field measurement using the charge exchange spectroscopy (CXS) is indicated with arrows.

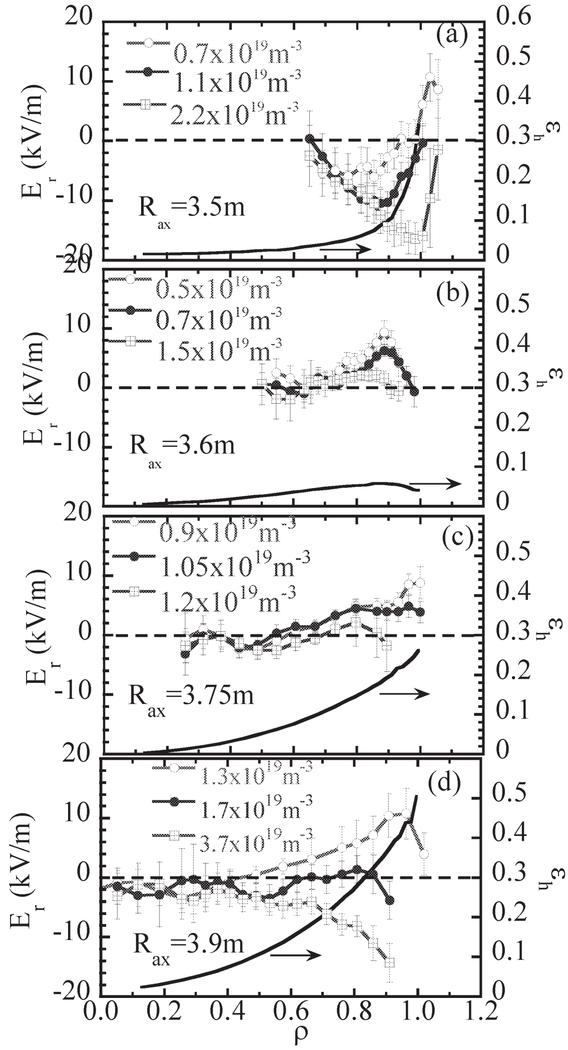

Fig. 2. Radial profiles of radial electric field, E_r and effective helical ripple ε_h for plasmas with various magnetic axis, R_{ax} of (a)3.5m, (b)3.6m, (c)3.75m, and (d)3.9m.

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