§60. Effect of Edge Ergodicity on Temperature Profiles in LHD

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One of the features of the heliotron configuration is a thick open ergodic region surrounding closed magnetic surfaces. Thickness of the ergodic region changes depending on the magnetic axis position, the beta value or the externally applied perturbation field, although it is not clear whether ergodicity itself changes or not. In this report edge ergodicity is estimated quantitatively and the relationship between ergodicity and temperature profiles is demonstrated especially for the outward shifted configuration with and without the perturbation field.1)

In the ergodic region magnetic field lines present chaotic trajectories. A flux tube there deforms its shape and the circumference d of the tube increases exponentially, which is described as $d(l)=d_0\exp(l/L_K)$ where d_0, l and L_K are initial value of the circumference, length of the flux tube and Kolmogorov length, respectively. Since L_K is the e-folding length of the exponential increase of the circumference, it can be a good measure of ergodicity, e.g., a large L_K^{-1} means large ergodicity. In order to obtain an L_K, 100 field lines were traced for 50 toroidal turns, i.e. ~ 1200m, from the circular starting points with 1mm in diameter on the poloidal cross section. Then the circumference d of the flux tube was measured every toroidal turn, which resulted in the averaging effect over one toroidal turn in measuring d. Small bundles of field lines for starting points were distributed on the midplane at the poloidal cross section where plasmas are horizontally elongated, and are exactly on the line of sight of the Thomson scattering.

Experiments in LHD were carried out with ECH initiated NBI plasmas. The averaged electron density and temperature at the center were $\sim 2\times10^{19}m^{-3}$ and ~1keV, respectively. The magnetic axis position R_{ax} was set at 3.9m and the last closed flux surface LCFS was at R=4.593m. A perturbation field with an m/n=1/1 component was applied externally by small coils to change ergodicity in the edge region. In the outward shifted configuration at R_{ax}=3.9m, there is no resonant surfaces with an m/n=1/1 component, thus the perturbation field only resulted in the change of edge ergodicity. No evident island was created by the field.

Figure 1 shows radial profiles of (a) inverse Kolmogorov length L_K^{-1} and (b), (c) electron temperature T_e. Open and closed circles represent without and with the perturbation field, respectively.

Applying the perturbation field, it is found from Fig.1(a) that the magnetic structure gets ergodic around the region 4.5m<R<4.6m where closed nested surfaces used to exist in the configuration without the perturbation field, while ergodicity outside of LCFS around the region 4.6m<R<4.73m is decreased. These changes in the magnetic structure are reflected in T_e profiles, i.e., a small flattening can be seen at R~4.52m and the position where T_e gradient becomes gentle shifts outward by applying the perturbation field, as shown in Fig.1(b) and (c).

Furthermore L_K in other configurations were estimated and found that it is about 10-30m with various R_{ax} positions and is always shorter than the connection length L_c everywhere in LHD, which means the LHD edge region is sufficiently ergodic to show its characteristics.

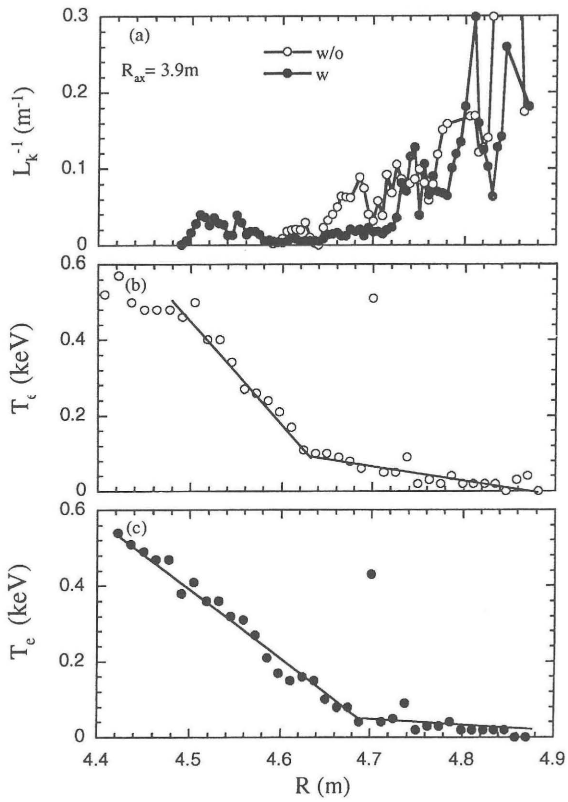

Fig.1. Radial profiles of (a) inverse Kolmogorov length L_K^{-1} and (b),(c) electron temperature T_e. Open and closed circles represent without and with perturbation field, respectively.

Reference

1) Morisaki, T., et al., 27th EPS ECA **24B**, (2000) 780.