§34. T_e and n_e Profiles in the Ergodic and Edge Surface Layer Regions in LHD

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The LHD edge magnetic structure is complicated, as illustrated in Fig. 1(a). Even definition of the last closed magnetic surface (LCMS, i.e., ρ=1 surface) is somewhat subjective since island layers with a toroidal mode number of 10 exist in the outer region. The LCMS is defined as a surface, within which only small isolated island layers exist. These islands will not influence the transport. With increasing radius beyond the LCMS, larger island layers with smaller poloidal mode number appear and eventually the overlapping of these island layers creates an ergodic structure, which modifies the transport. Beyond this region, there exists a region with multiple thin edge surface layers, a peculiar feature of the heliotron edge magnetic configuration. This structure is created by radial movement of the X-points and the high local rotational transform and high local shear at the edge on the outboard side of the torus. In addition, a small island (m/n=1/1) exists in the edge (0.9<ρ<1.0), generated by error fields. It is clearly detected by the electron beam mapping method. Its radial width can, however, be controlled by the external coils system.

Referring to Fig.1(b), these thin edge surface layers correspond to the spikes of the L_c (the field line length to the divertor plates, presently the vessel wall). Between the layers, there exist regions which are connected to the divertor plates in a short distance through the field line. The ∇T_e is negligibly small in the multiple surface layer region and the temperature is below 40 eV. On the other hand, a significant density gradient exists there and the density at R= 4.66 m, where T_e starts to rise, is ~ 50 % of the shoulder density, which is close to the average density. This means that particle confinement almost takes place in the surface layer region. This is not surprising since cold ions are well confined in the open edge region where the connection length is longer than ~300 m . In the ergodic region (4.60<R<4.66m), the temperature increases modestly from 40 eV at R=4.66 m to 80 eV at R=4.60 m (ρ=1). For the inward shifted configuration (R_{ax}=3.60 m , Fig.1(c)), the ergodic and multiple curved layer regions are much narrower. This results in a fair overlapping of the high ∇T_e and high ∇n_e regions, which is believed to be a favorable condition for the confinement enhancement. Indeed this configuration exhibits a factor of ~ 25% improvement of τ_E over the configurations with larger R_{ax} (=3.70m).

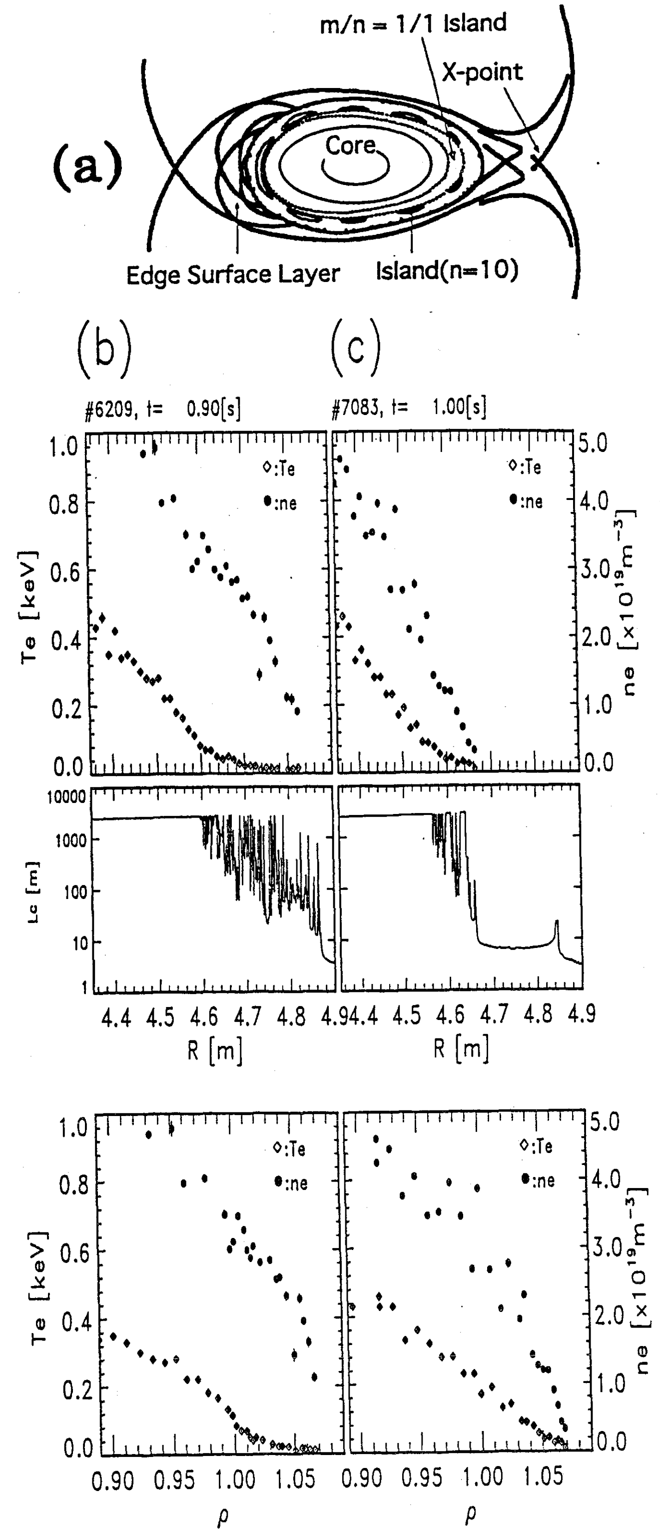

Fig. 1 : (a) An illustration of the LHD edge magnetic structure.
(b) T_e and n_e profiles, the connection length (L_c) in the edge region for the discharge with R_{ax} = 3.70 m and B=1.5 T.
(c) Edge profiles for the discharge with R_{ax} = 3.60 m and B=2.75 T.