§20. Study of Plasma Edge Boundary in LHD

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Vertical profiles of edge impurity emissions have been measured at upper half of horizontally elongated plasma cross section in Large Helical Device (LHD) using a space-resolved extreme ultraviolet (EUV) spectrometer [1], as shown in Fig.1. Vertical profiles from various kinds of impurity elements such as C, Ne and Fe have been observed from LHD plasmas. The profiles near upper O-point positioned just below helical coil are analyzed to study the plasma edge boundary of ergodic layer in LHD. As a result, C^{3+} ion emitting CIV spectrum is identified as an ion existing in the farthest edge of the ergodic layer. The CIV profile is then used in the present study.

The peak position of CIV (312Å) vertical profile is analyzed with edge temperature at LCFS ($T_e(\rho=1)$). Results are shown in Fig.2. The vertical position does not change at all even if $T_e(\rho=1)$ largely increases, whereas the position moves inside if $T_e(\rho=1)$ considerably decreases. In R_{ax} =3.75m, for instance, the peak position almost keeps constant when the $T_e(\rho=1)$ is higher than a threshold temperature of 130 eV. In R_{ax}=3.90m, however, the change of peak position is not observed because the range of $T_e(\rho=1)$ is shifted to higher values compared to other two cases. Even if the density is increased with enhanced gas puff rate, it is not easy to reduce the $T_e(\rho=1)$ below 150eV. As a result, it is found that the CIV position does not change at all in a wide temperature range of $150 \le T_e(\rho=1) \le 400$eV, whereas it moves inside the ergodic layer when $T_e(\rho=1)$ is reduced below a threshold temperature.

The CIV position is compared with the edge magnetic field connection length, L_c. Results are shown in Fig.3. It is also found that the CIV exists at a boundary between ergodic layer and open magnetic filed layer at which the L_c distributes in a range of 5 to 30m. The result indicates that the edge boundary near the O-point in LHD is determined by a starting point of the open filed layer [2], where a tokamak-like steeper edge temperature gradient is formed, although the edge boundary is quite obscure at the X-point region. No plasma exists between the edge boundary at the outside of ergodic layer and the vacuum vessel.

The CIV profile at the O-point is simulated using three-dimensional edge transport code of EMC3-EIRENE. The simulation is done with parameters of cross-field transports coefficients of particle and energy, input power and carbon source location. The result compared with the measurement indicates a clear difference of 8mm in the peak position of CIV for magnetic configuration with thick ergodic layer such as R_{ax}=3.90m, while only a small difference of 3mm is observed for that with thin ergodic layer. Therefore, the present study suggests us necessity of an additional mechanism to explain the experimental result, e.g., deformation of the stochastic magnetic field by the presence of plasma pressure.

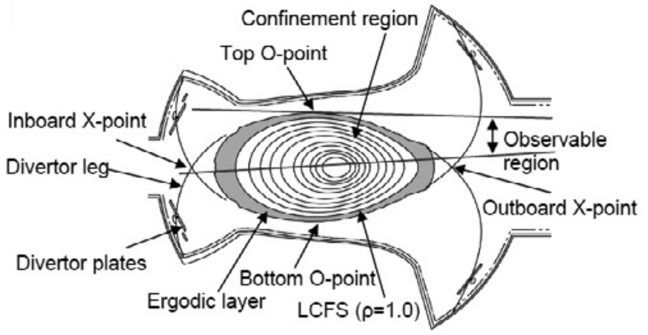

Fig.1 Magnetic surfaces and ergodic layer in LHD. Observation range is denoted with two solid lines.

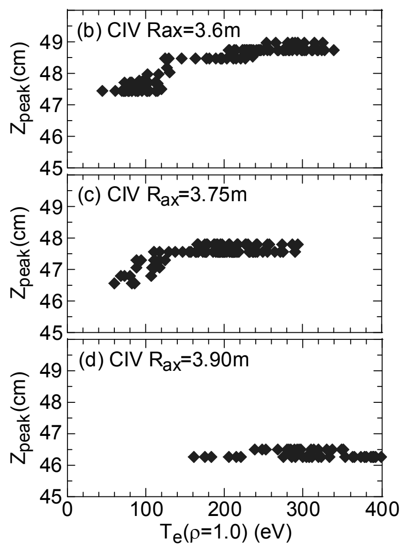

Fig.2 Peak positions in vertical profiles, Z_{peak}, of CIV at (b) R_{ax}=3.60m, (c) R_{ax}=3.75m and (d) R_{ax}=3.90m.

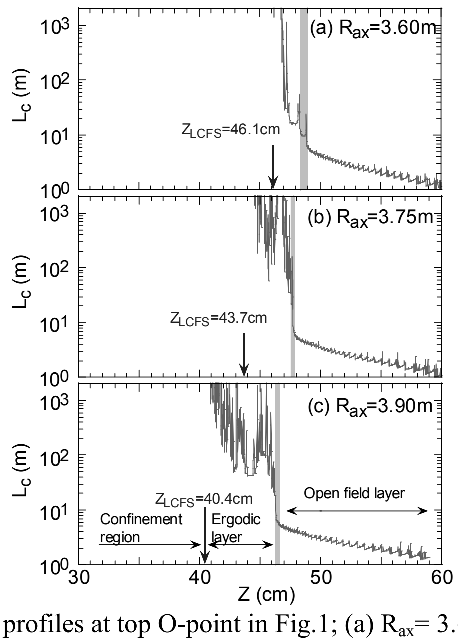

Fig.3 L_c profiles at top O-point in Fig.1; (a) R_{ax}= 3.60m, (b) 3.75m and (c) 3.90m. Shadow area denotes the CIV peak position.

1) C.F.Dong, S.Morita et al., RSI **81** (2010) 033107.
2) C.F.Dong, S.Morita et al. submitted to PoP.