§ 37. Edge Density Profile Measurements with a Lithium Beam Probe

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In the edge region of the Large Helical Device (LHD), the magnetic field shows the complicated ergodic structure, which is quite different from that in tokamaks. Such a thick ergodic layer is surrounding the last closed flux surface (LCFS), therefore the position of which is quite unclear. Actually the electron temperature and density profiles just outside the LCFS are high and no clear change of its gradient is seen[1], which suggests the ergodic layer to have enough capability for confinement properties. By measuring the electron density and temperature profiles in detail, effect of the magnetic field ergodicity on the edge transport can be investigated. In this report electron density profiles measured with a 20keV lithium beam probe (LiBP)[2] are presented.

The neutral lithium beam is injected to the LHD plasma horizontally from the outboard side of the torus, as shown in Fig.1. Emissions from the beam are detected with a CCD camera and electron density profiles are reconstructed along the beam as $n_e(x)$. The origin of the x-axis is defined to be the point where the beam (x-axis) encounters the R=3.90m plane. The time and spatial resolutions of the system are 17ms and 2cm, respectively. Experiments were carried out mainly with electron cyclotron heating (ECH) plasmas with a toroidal magnetic field B_t of ~1.5T. The magnetic axis position R_{ax} was set from 3.45-3.90m. The averaged electron density and the central temperature were 0.2-2x10^{19}m^{-3} and 1-3keV, respectively. Controlling the vertical field strength, the plasma column, i.e., the magnetic axis position R_{ax} can be shifted in LHD. This modification to the magnetic surfaces affects not only the particle orbit or the MHD characteristics but the properties of the ergodic layer in the edge region. In the outward or inward shifted configuration from the standard one (R_{ax}=3.60m), the thickness and the ergodicity of the ergodic layer become large.

Figure 2 shows the electron density profiles $n_e(x)$ measured with the LiBP with the same line averaged density of ~0.7x10^{19}m^{-3}. Clear shift of $n_e(x)$ is seen. From the precise analyses of the edge magnetic structure, it was found that the foot point in the density profile, where n_e begins to rise and its gradient becomes steep, corresponds to the boundary of the ergodic layer, not the LCFS position. It has also been confirmed that the foot point shifts little in the density scan. To clarify the effect of the magnetic structure on the edge particle transport, the relationship between the edge ergodicity and the density scale length L_n derived from $n_e(x)$ was investigated. Little dependence of L_n on the magnetic ergodicity was seen.

Further experiments and calculations are required to get the comprehensive understanding about edge transport.

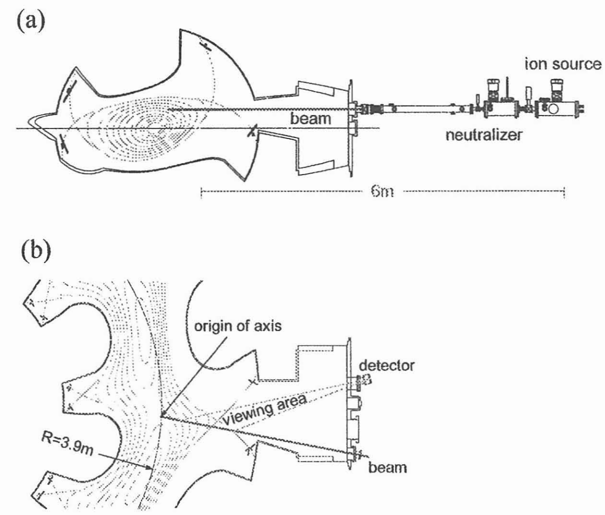

Fig.1. (a) Vertical and (b) horizontal cross section of the experimental setup. Beam path, viewing direction of the detector, and flux surfaces are depicted.

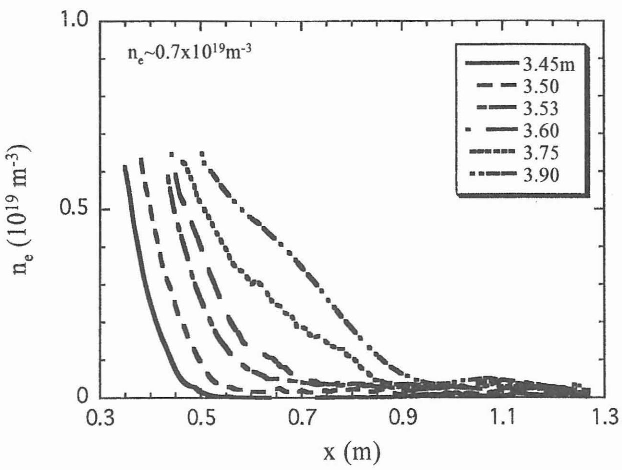

Fig.2. Density profiles measured with LiBP in various R_{ax} configurations.

References

1) Morisaki, T. et al. : J. Nucl. Mater.**313-316** (2003) 548.

2) Morisaki, T. et al. : Rev. Sci. Instrum. **74** (2003) 1865.