§60. Measurement of Two Dimensional Electron Density Profile in Edge Plasma Region by Thermal Lithium Beam Sheet

Takahashi, Y. (Dep. Energy Eng. Sci., Nagoya Univ.),
Morisaki, T., Toi, K.

Improved understanding and control of edge plasma are very important for takamaks and helical devices to achieve high confinement mode such as H-mode where edge transport barrier (ETB) is formed, and is partially destroyed by so-called edge localized modes (ELMs). Recently, H-mode is observed also in LHD [1]. The magnetic configuration of LHD is three-dimensional and has helical divertor, where the nested magnetic surfaces are surrounded by complicated ergodic magnetic field layer near the plasma edge [2]. Two dimensional measurement of edge plasma structure is very effective for understanding of edge plasma behavior in this complicated configuration such as LHD. We have developed a new type of lithium beam probing (LiBP) method using thermal beam with a sheet shape, and applied to low density LHD plasmas produced with electron cyclotron waves.

In this newly developed lithium beam probe, metallic lithium in an oven is heated up to about 800 K°, and lithium vapor is conduced to an LHD plasma through three horizontally orifices. This simple technique has successfully produced a thermal sheet beam. The beam is widely spread on the poloidal plane of an LHD plasma but its toroidal divergence is limited to a thin layer, as shown in Fig.1. We could measured two dimensional plasma electron density profile by using this prove system. The energy of the beam is ~0.08 eV, which corresponds to the beam velocity of $1.5 \times 10^3\ ms^{-1}$. Measurable upper limit of path-integrated electron density is ~$3 \times 10^{16}\ m^{-2}$. Two dimensional image of the resonance line Li I (670.8 nm) produced by the sheet beam injection is detected with a CCD camera.

In LHD, the sheet type Li beam was applied to a low density plasma of line averaged density $\langle n_e \rangle \sim 5 \times 10^{17}\ m^{-3}$ produced by low power electron cyclotron waves. For this plasma, the lithium beam is expected to penetrate up to ~ 200 mm from the plasma boundary. A typical images of Li I taken by the CCD camera in this plasma is shown in Fig.2. If a beam source is placed far away from a plasma, we can assume that many pencil beams arranged along the major radius of a plasma are injected vertically to the plasma. We can easily derive two dimensional electron density profile from the Li I image as shown in Fig.2.

Figure 3 shows the derived two-dimensional electron density profile from the data in Fig.2, where the profile is overlaid to the magnetic surface. The distortion of the profile near the inner wall may be caused by reflection near the inner wall of the vacuum vessel. This difficulty may be overcome by re-arrangement of the beam optics.

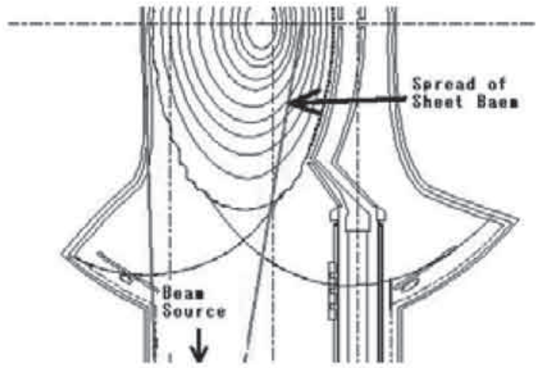

Fig.1 Spread of sheet beam in LHD poloidal plane

Fig.2 Intensity profile of LiI emission.

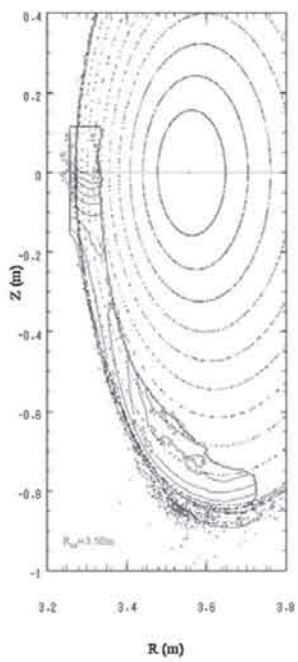

Fig.3 Electron density profile superpose on magnetic surface.

[1] K. Toi et al., Phys. Plasmas **12**, 020701-1 (2005)
[2] T, Morisaki et al., J. Nucl. Materials Vol.313-316,548 (2003)