# §51. Simulation of Sheet-Shaped Lithium Beam Probe Performance for Two-Dimensional Edge Plasma Measurement

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The edge plasma has been considered to affect the overall energy and particle confinement in fusion test devices, since the formation of the transport barrier, excitation of turbulent fluctuation, edge localized modes, ELMs, blobs, etc. are taken place in this region. Recently it has been known that such phenomena do not always appear symmetrically in toroidal and/or poloidal directions. Thus the one-point or one-dimensional (1D) measurement is not sufficient to know the overall picture of the phenomena. The 2D diagnostics with sufficient time and spatial resolutions would be helpful. A sheet-shaped thermal lithium beam probe has been developed, and the 2D edge density profiles at the poloidal cross section were successfully obtained by one shot in LHD [1]. The density profile is reconstructed from the light emission profile due to the interaction between Li atoms and plasmas. In the reconstruction process, the conventional procedure so-called “the beam attenuation method” is often employed [2].

According to “the beam attenuation method”, the plasma density $n_e(r)$ can be derived fromthe following equation.

$$n_e(r) = \frac{v_{th} I(r)}{\langle \sigma v \rangle_i \int_r^\infty I(r) dr} \qquad (1)$$

where $\langle \sigma v \rangle_i$, $v_{th}$ and $I(r)$ are the effective rate coefficient for ionization, the beam velocity and the rate of local photon emission, respectively. Since this method is based on the assumption that the density profile is in the steady state during the time concerned, there are uncertainties if it can simply be applied to fast and transient phenomena like blobs whose velocity is higher than that of the probe beam.

We simulated the 2D density profile reconstruction where a blob flies out from the confinement region to the SOL in the radial direction [3]. Referring to the reference [4], the diameter of a blob and its velocity in the radial direction were set to be $\delta_{max} = 0.05$ m, $V_{blob} = 5.0\times10^4$ m/s, respectively, using typical parameters of the LHD edge plasma. Fig.1(a) shows the assumed 2D density profile with a blob flying radially in the SOL. Fig.1(b) are the reconstituted density profiles, assuming that the Li I light is observed by an ideal ultra fast camera with very short exposure time. The beam was injected to the plasma vertically from the bottom. The upper right corner colored red shows the confinement region whose electron density was set to be $1\times10^{18}$ m$^{-3}$. The wide blue region represents the SOL with uniform density of $2\times10^{17}$ m$^{-3}$.

Using the beam attenuation method, the blob density was reconstructed to be about $0.6\times10^{18}$ m$^{-3}$ as shown in Fig.1(b), although it was assumed to be $1\times10^{18}$ m$^{-3}$ as shown in Fig.1(a). This difference is caused by the fact that Eq.(1) which is originally for the steady state analysis was however applied to the transient phenomenon. In this situation no beam attenuation occurs on the down-stream side of the blob, because the beam which experienced the high density blob has not arrived there within such an extremely short period. Thus the integral term in Eq.(1) becomes large. Consequently, the reconstructed density of the blob becomes low. Because of the same mechanism, the density on the up-stream side of the blob is also reconstructed to be low.

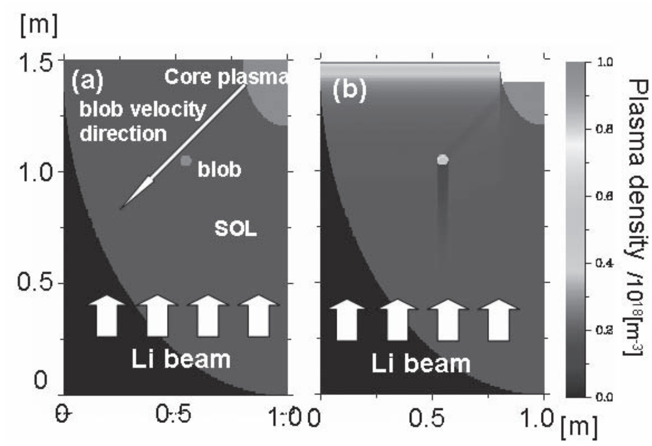


Fig.1 (a)assumed profile (b) reconstructed profile

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