§25. Intermittent Edge Plasma Transport around the LHD Divertor Leg with 3-D Magnetic Geometry

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Blobby plasma transport is a universally observed phenomenon among magnetic-confined devices. In tokamak devices, detailed propagation parameters have already been investigated. The cross-field transport could be responsible for 50% of radial particle flux in the SOL region; thus, various SOL physics are affected from the cross-field transport. In contrast, such quantitative measurements have not been sufficient in helical configuration compared with tokamaks.

In the previous work in LHD, it was found that blob-like transport happens in low-field side (LFS) of the divertor leg from the analyses of ion saturation current (I_{sat}) fluctuations measured with high-temporal and high-spatial resolutions [1, 2]. In this study, we have used a fast scanning Langmuir probe (FSP) with two electrodes (ch1 and ch2), and we aimed to estimate propagation parameters quantitatively in the LHD [3]. Figure 1(a) shows a photograph of the probe head. Two electrodes with an interval of 5 mm could measure I_{sat} simultaneously with 1 MHz. Their insertion trajectories around the divertor leg are shown in Fig. 1(b). Three-dimensional (3-D) distribution of connection length (L_c) for R_{ax} = 3.6 m is also depicted. It can be found that two electrodes are inserted into a thick divertor leg at different z-positions each other. In addition, there is a certain amount of degree of the angle between $-\nabla B$ and $-\nabla L_c$ vectors. The former vector indicates theoretical blob-propagation direction and the latter corresponds to low-pressure side direction ($-\nabla P_e$).

Figure 2(a) shows distributions of measured I_{sat} around the LFS region of the divertor leg. There is a spatial gap of approximately 6 mm along z-axis between them. Generally, Blobs are detected as positive spikes of I_{sat} in edge region; the third order moment normalized by the second order moment, skewness, has a positive value. Figure 2(b) shows the skewness distributions. Positive and negative skewness are observed in the divertor leg and the private region, respectively, at each electrode. Figure 2(c) shows cross-correlation coefficient, $C_{12}(\tau)$, between the two I_{sat} fluctuations. In this figure, positive correlation peak follows a unique trajectory, meaning that typical time delay between them changes at the different z-positions.

According to Fig. 2, the LFS region of the divertor leg is divisible into some characteristic regions, as shown in Fig. 2(a). By comparing results with those in TORPEX [4] and JET tokamak [5], these regions could be interpreted in relation to the blob-generation and propagation behaviors. In region (i), high-density and low-density perturbations, which would be (seeds of) blobs and holes, are detected at ch1 and ch2, respectively. In region (ii), high-density structures elongating in the $-P_e$ direction and distorted by $\mathbf{E} \times \mathbf{B}$ flow shear around the edge of the divertor leg might provide the positive spikes that propagate from ch2 to ch1. In region (iii), blobs propagating toward the LFS direction would be observed. On the assumption following the theory, blob-propagation speed (v_b) was quantitatively estimated ($v_b \sim 470$ m/s) from the time delay and the 3-D magnetic calculation.

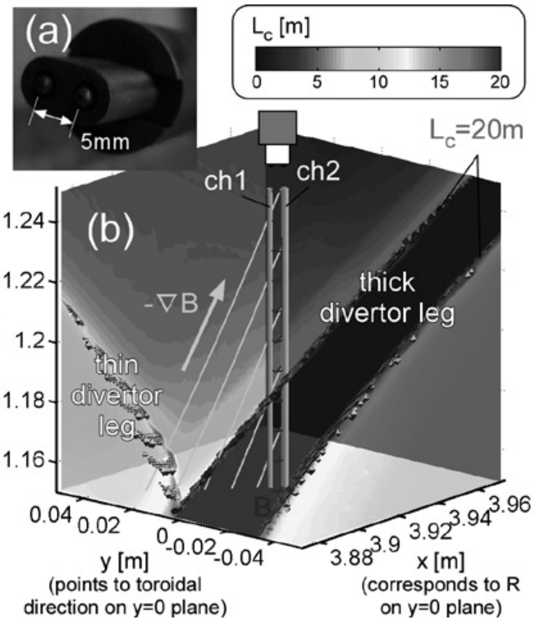

Fig. 1 (a) Photograph of a probe head and (b) 3-D L_c distribution around the divertor leg with insertion trajectories of two electrodes.

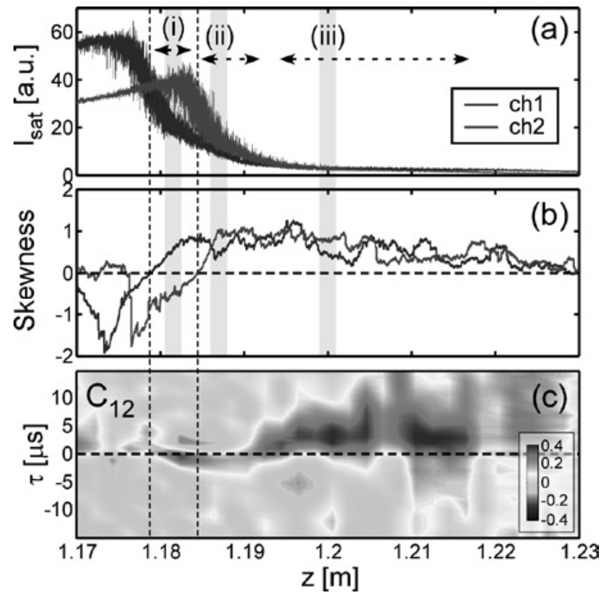

Fig. 2 Distributions of (a) I_{sat}, (b) Skewness, and (c) $C_{12}(\tau)$.

1) Masuzaki, S. et al.: Proc. of ITC/ISHW2007.
2) Tanaka, H. et al.: submitted to Plasma Fusion Res.
3) Tanaka, H. et al.: submitted to J. Nucl. Mater.
4) Furno, I. et al.: Phys. Rev. Lett. **100** (2008) 055004.
5) Xu, G.S. et al.: Nucl. Fusion **49** (2009) 092002.