§13. Multi-pin Langmuir Probe Measurement near the LHD Divertor Leg

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In tokamak devices, blobby plasma tranposrt is a well-known non-diffusive convective transport in the scrape-off Layer (SOL). The blobs, which has a field-aligned structure, are mostly detected in the low-field side (LFS) SOL. Blobs ejected from the vicinity of the last closed flux surface (LCFS) are theoretically predicted to propagate toward the LFS direction due to the **E** × **B** drift with an internal electric field (**E**) in the blob and the magnetic field (**B**). Past experimental results in tokamaks consistent with the theoretical prediction.

In the Large Helical Device (LHD), SOLs essentially locate in front of the helical coil can. Thus, there is no simple LFS SOL unlike as in tokamaks. Previous studies in the LHD showed that blob-like intermittent events were dominantly detected near the divertor leg[1−2]. A typical velocity of the blobs was estimated by using two distantly positioned probes. However, the existence of an internal electric field inside the blobs has not been confirmed yet.

In this study, we have firstly measured the internal electric field with a multi-pin Langmuir probe in the LHD[3]. Figure 1(a) shows the insertion trajectory of the probe head with a cross-section of the magnetic-field connection length (L_c) distribution. The probe head was inserted downward at a speed of approximately 1.5 m/s and cut across a divertor leg during a flat-top phase in a discharge. To measure the electric field inside the blobs propagating toward the LFS direction, we arranged the probe tips as shown in Fig. 1(b). On probe tip was used to measure an ion saturation current fluctuation (I_{sat}). The other two tips detected floating potentials (V_{f1}, V_{f2}). By assuming that electron temperatures of a passing blob on the two tips were the same, the electric field across the magnetic field on the probe surface can be deduced from the difference of the floating potentials.

We applied the cross-correlation and the conditional averaging techniques to fluctuations near the LFS edge of the divertor leg, where positive spikes of I_{sat} were observed. From the correlation analysis result, there is a positive correlation between I_{sat} and (V_{f1}-V_{f2}), implying that there would be the predicted electric field inside the blob-like events. Figure 2(a) shows the conditional averaged shape of I_{sat}. Central peak at $|\tau| \leq 1$ μs is partly caused by the noise component. Figure 2(b) shows cross-conditional averaged shapes between I_{sat} and V_{f1}, V_{f2}, and (V_{f1}-V_{f2}). This analysis indicates that the positive-peak amplitude of (V_{f1}-V_{f2}) was approximately 1V; this voltage corresponds to the propagation speed of blobs with approximately 110 m/s. Because there were a large number of detection errors due to the noise, these amplitudes are underestimated. This estimated speed is low but of the same order in the previous study with the two Langmuir probes[2].

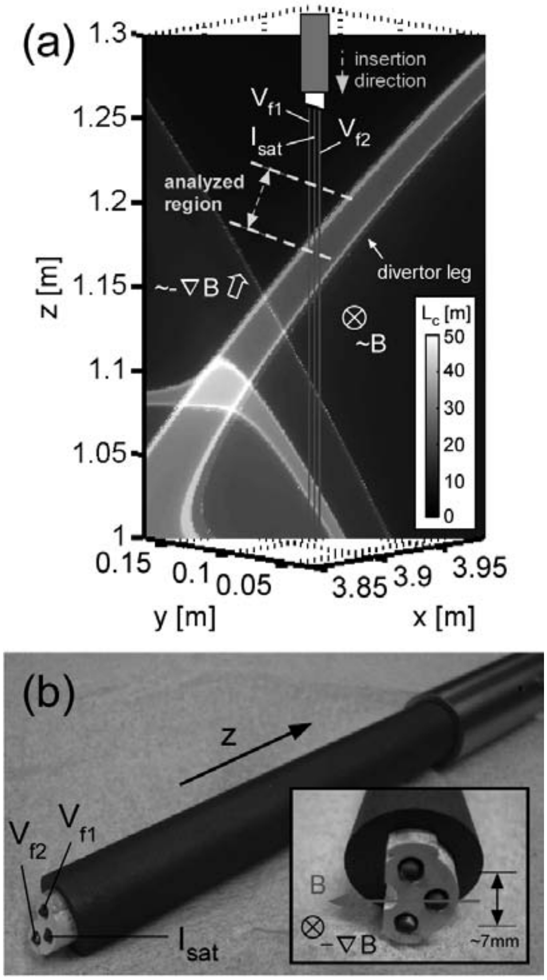

Fig. 1 (a) Insertion trajectories of probe tips and a cross-section of L_c which is roughly perpendicular to the magnetic field around the divertor leg. (b) Photographs of the probe head.

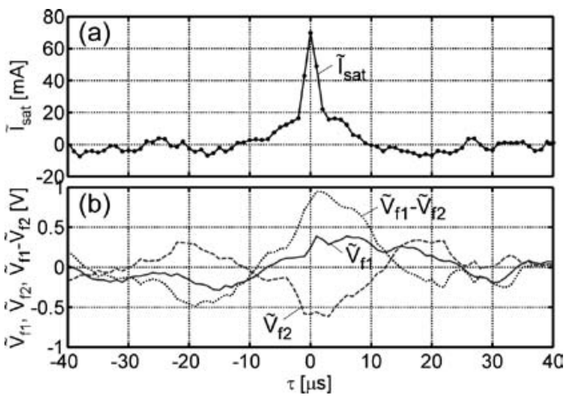

Fig. 2. Auto-conditional averaged shape of I_{sat}. (b) Cross-conditional averaged shapes of V_{f1}, V_{f2}, and (V_{f1}-V_{f2}).

1) Tanaka, H. et al.: Plasma Fusion Res. **7** (2012) 1402152.
2) Tanaka, H. et al.: J. Nucl. Mater. **438** (2013) S563.
3) Tanaka, H. et al.: submitted to J. Nucl. Mater.