§12. Analysis of Toroidal Asymmetric Properties of Non-diffusive Transport and Magnetic Island Geometry in the LHD Detached Plasma

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Control of heat and particle fluxes on the divertor target is an essential issue for success of the fusion reactor. One of the effective solutions is employing the “plasma detachment,” which uses plasma-gas interactions. In the LHD, an n/m = 1/1 resonant magnetic perturbation (RMP) field stabilizes the detached plasma condition with a highly-radiating zone inside the ergodic region[1)]. In the 16th cycle campaign, we confirmed that there were toroidal asymmetries of mean and fluctuation characteristics of the divertor flux during the detachment with the RMP field. Propagation of ion saturation current (I_{sat}) spikes across the magnetic field was observed on several divertor tiles with Langmuir probe arrays. This phenomenon would be caused by the convective plasma transport in the upstream region of the divertor tiles, which would contribute to a portion of the decrease of the divertor flux flowing into the strike point.

In the 17th experimental campaign, we applied high-temporal-resolution A/D convertors (1 MHz) to I_{sat} signals on 6R and 8L tiles (see Fig. 1(a)), where particularly characteristic fluctuations had been observed. On each tile, 20 probe electrodes were aligned every 6 mm across the strike point. During the discharge, applied field strength of the RMP which enhanced a magnetic island O-point at the outboard side in the #6 section was constant. Figures 1(b) and (c) show contour plots of I_{sat} measured on the 6R and 8L tiles. Before t ~ 4.9 s, I_{sat} at the strike points on the 6R and 8L tiles increased because the core plasma density increased; then, I_{sat} decreased due to the detachment. In addition, it can be found that positive spikes of I_{sat} appeared at the private and SOL sides from the strike point on 6R and 8L tiles, respectively. Figures 1(d) and (e) show magnified views of Fig. 1(b) and (c) in the detached phase, respectively. It is noted that spatially localized positive spikes distant from the strike point were observed on the 8L tile, unlike 6R tile.

To investigate the propagation direction on each tile, we applied the cross-correlation analysis technique. Figure 1(f) shows cross-correlation coefficients of neighboring probes. Correlation coefficient between ch 6 and 5 on the 6R tile, $C_{6,5(6R)}$, has a local maximal value with large amplitude at τ ~ +70 μs, indicating that the fluctuation propagated toward the private side with averaged time delay of ~70 μs. On the other hand, $C_{14,15(8L)}$ has a positive peak at a negative τ that is close to the sampling interval, which implies the fluctuation propagated toward the private side with a sufficiently small delay.

These results would be attributed to a locational difference of the cross-field transport from the measured position along magnetic field lines. We will clarify the positional relationship with the magnetic island structure.

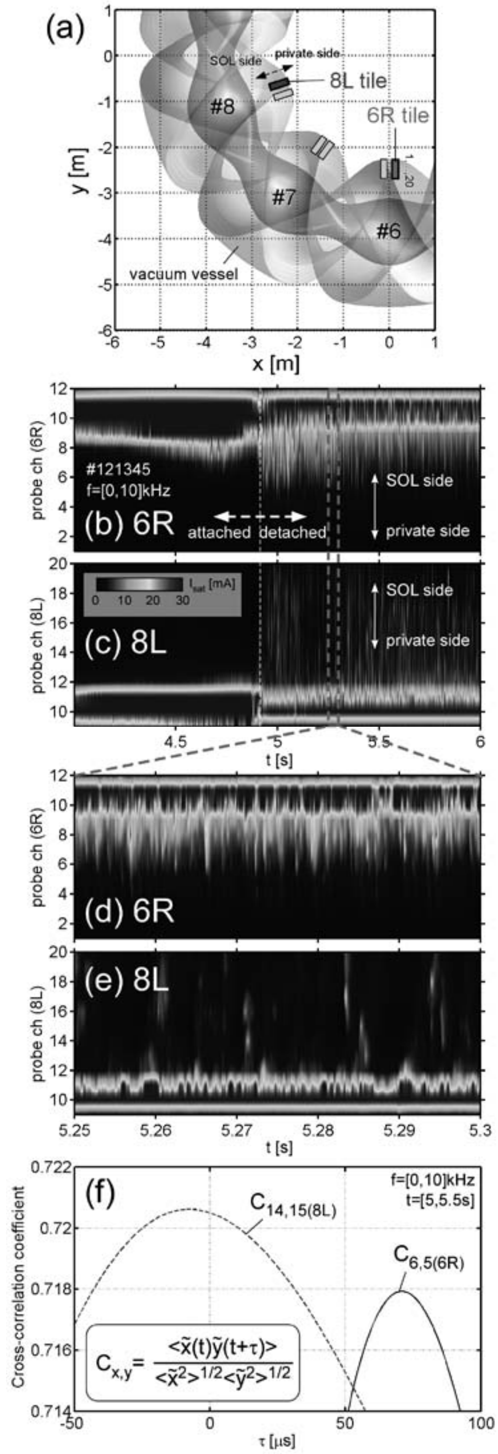

Fig. 1. Positional relationship of the divertor probe arrays (6R and 8L). (b) Contour plots of low-passed I_{sat} on 6R and (c) 8L divertor tiles. (d)(e) Magnified views of Figs. (b)(c). (f) Cross-correlation coefficients.

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