§17. Non-Diffusive Plasma Transport around the Detached Divertor in LHD

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Control of heat and particle fluxes on the divertor target is an essential issue for success of fusion reactor. To reduce the huge loads on plasma-facing materials, using the "plasma detachment" is especially prospective method. Basically, in the detached divertor phase, the charge exchange and radiation processes contribute to energy and momentum losses; the recombination process reduces an ion flux. Additionally, recent studies suggested that enhancement of cross-field transport would broaden the ion flux on the divertor plate[1, 2], which also leads to the reduction of peak loads.

In LHD, n/m = 1/1 resonant magnetic perturbation (RMP) field stabilizes the plasma detachment phase with radiation zone lying in the ergodic layer[3]. In this study, we have investigated the blob-like cross-field transport during the RMP assisted detached plasma operation in the LHD. We installed Langmuir probe arrays on divertor plates at several helical symmetric positions and measured fluctuations of ion saturation current I_{sat}. Twenty probe electrodes were aligned every 6 mm on each tile. Sampling frequencies were 250 kHz and 1 MHz for 280 and 24 channels, respectively.

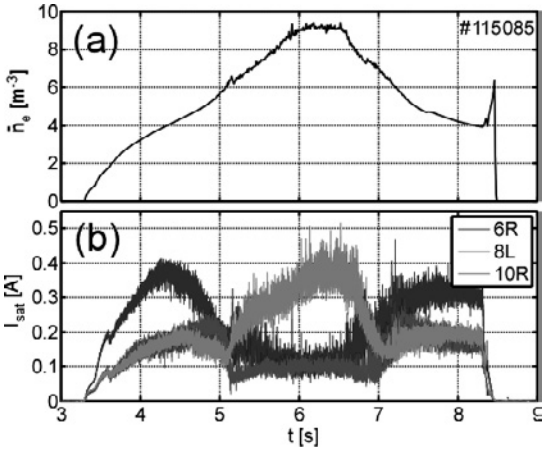

Fig. 1. Time evolutions of (a) line-averaged electron density and (b) I_{sat} on right-hand side (from outboard port) inboard tile at #6 (6R) (blue), left-hand side inboard tile at #8 (8L) (green), right-hand side inbord tile at #10 section (10R) (red), which were obtained by summing 20 channels.

Figure 1(a) shows a time series of line-averaged electron density during a discharge with the RMP (#115085). Hear, O-point of magnetic island was always expanded at outboard side in #6 section, and detached phase was produced by density ramp-up in the middle of the discharge. As a result, ion flux to the divertor plate was found to have entirely different characteristics at each position. As shown in Fig. 1(b), ion flux to 6R and 8L tiles decreased gradually and rapidly, respectively; on the other hand, reduction of I_{sat} was not observed at 10R. Moreover, it was found that positive spikes intermittently propagated toward the private side and SOL side on 6R and 8L tiles, respectively (see Figs. 2-4). Such an asymmetric behavior would be attributed to the toroidal asymmetric magnetic geometry made by the RMP.

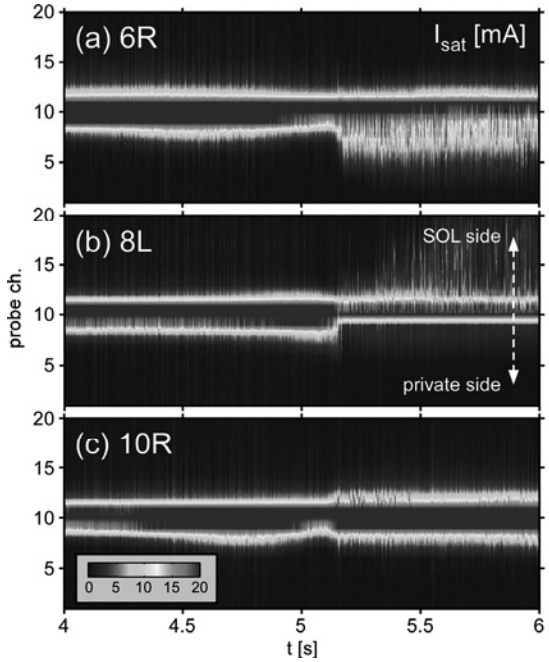

Fig. 2. Contour plots of I_{sat} on (a) 6R, (b) 8L, (c) 10R tiles.

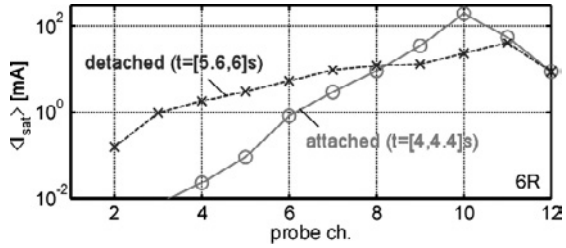

Fig. 3. Profiles of averaged I_{sat} on 6R tile in attached (red line) and detached phases (blue dashed line).

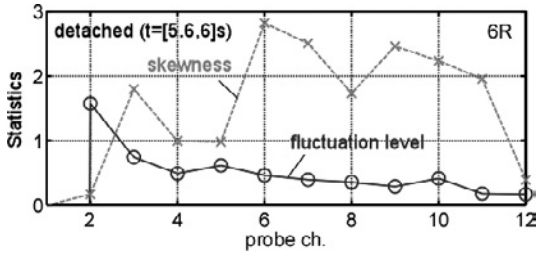

Fig. 4. Profiles of fluctuation level (blue line) and skewness (red dashed line) on 6R tile in detached phase.

1) Ohno, N. et al.: J. Plasma Fusion Res. **80** (2004) 275.
2) Tanaka, H. et al.: Phys. Plasmas **17** (2010) 102509.
3) Kobayashi, M. et al.: Phys. Plasmas **17** (2010) 056111.