§9. Toroidal Symmetry/asymmetry of the Impurity Seeding Effects in LHD

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Detailed understanding and improving the prediction of edge plasma parameters are crucial important for designing the high-heat flux fusion device such as DEMO. In the helical device LHD, outside of the ergodic region, the edge surface layer and the divertor leg have short characteristic length of the magnetic field, conducing a strong asymmetry in toroidal and poloidal directions.

In order to acquire the three-dimensional edge plasma parameters, we have operated several types of Langmuir probes in LHD:

(i) Toroidal divertor probe arrays
(ii) Poloidal divertor probe arrays
(iii) First wall probes
(iv) A fast scanning probe with three probe tips
(v) A fast scanning probe with an ion sensitive probe

The toroidal divertor probe arrays are composed of 280 Langmuir probes embedded on 14 divertor plates, which are located near the radially-inner midplane in seven toroidal sections, as shown in Fig. 1(a). In each section, 20-pin probe arrays are lying at left- (L) and right- (R) hand side of the private region.

By using the toroidal divertor probe arrays, we have investigated the toroidal distributions of the impurity seeding effects for the divertor particle and heat fluxes. Figures 1(b) and (c) show the polar plots of ΣI_{sat} ratios of before to after Ne and N_2 puffs, respectively. Here, ΣI_{sat} is defined by the sum of ion saturation current (I_{sat}) signals measured with 20 probe tips on a divertor plate. All ΣI_{sat} have less than one values in the Ne seeded discharge, indicating that ΣI_{sat} in all the toroidal sections decreased. Reduction degrees on L plates are relatively small compared with those on R plates. It might be attributed to change of the drift transport across the magnetic field. In contrast to the Ne seeded discharge, N_2 puff influences peculiar divertor positions. On the divertor plates in section #6, which is closest to the N_2 puffing port, there is almost no effect for ΣI_{sat}. On the L and R plates in sections #4 and #7, large ΣI_{sat} reductions were observed; on the same divertor plates, heat flux also decreased.

In order to interpret the asymmetric pattern of the N_2 seeded discharge, we have investigated magnetic field structure in between the divertor probe arrays and the poloidal cross-section near the N_2 puffing port. As a result, it was found that the I_{sat}-reduced plates are lying near the N_2 puffing port along the magnetic field.

The noticeable difference between the Ne and N_2 would be caused by differences of the ionization position and the recycling coefficient on the wall. In order to reduce divertor particle and heat fluxes in all the toroidal sections by the N_2 seeding, additional puffing ports would be needed.

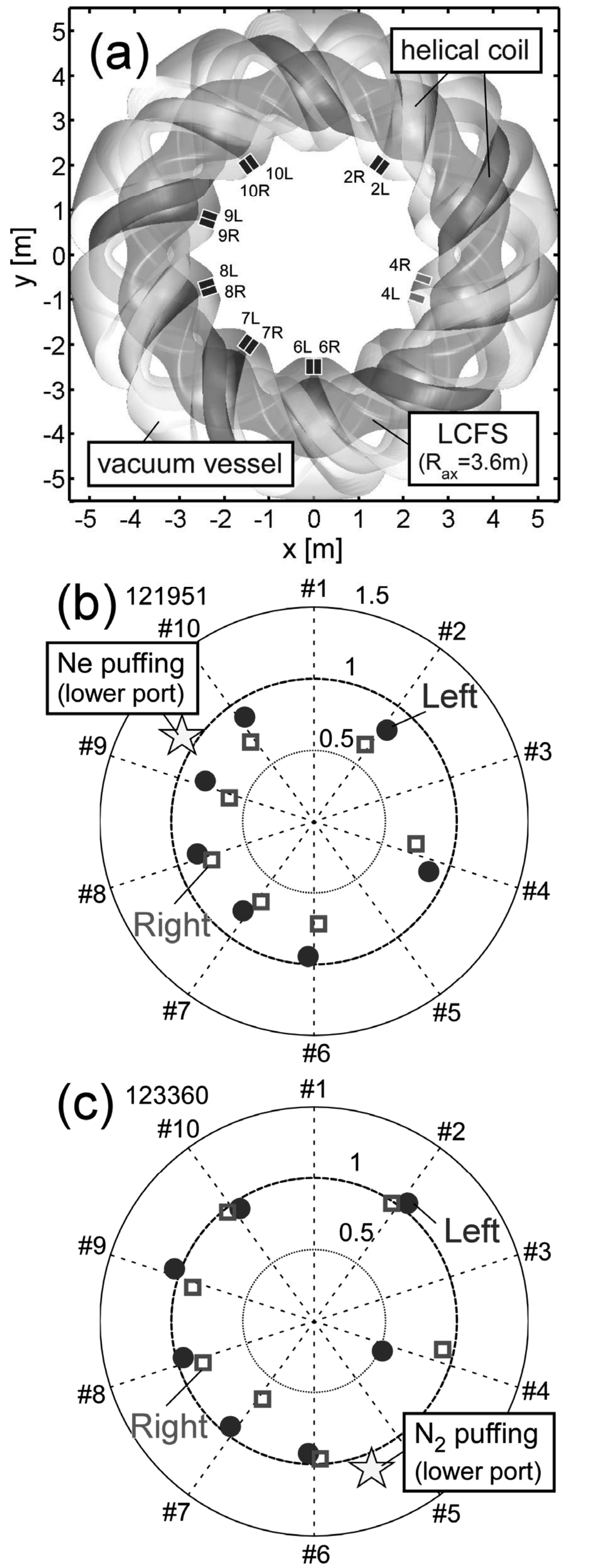

Fig. 1 (a) Top view of the toroidal divertor probe arrays. Polar plot of ΣI_{sat} ratios of before to after (b) Ne and (c) N_2 puffs on L (filled circle) and R (empty square) plates. Toroidal positions of Ne and N_2 puffing ports are also depicted (filled star).