§2. Vertical Profiles and 2-D Distributions of Carbon in RMP-assisted Detached Plasmas of LHD

Morita, S., Oishi, T., Huang, X.L., Goto, M.,
Zhang, H.M., Liu, Y. (SOKENDAI)

In LHD, the radial location of m/n = 1/1 magnetic island supplied by external RMP coils is critical for conducting a successful RMP-assisted detachment. The radial position of island location is just inside and outside the LCFS for R_{ax}=3.75 and 3.90m, respectively. The role of the m/n = 1/1 island in sustaining the plasma detachment is studied by analyzing the vertical profile and 2-D distribution of impurity carbon emissions (CIII–CVI). There is no clear enhancement in all the CIII–CVI intensities, even if the RMP is supplied at R_{ax}=3.75m. When the plasma axis is shifted to R_{ax}=3.90m, the plasma detachment is appeared by supplying the RMP field. The intensity of CIII–CV emitted near the m/n = 1/1 island is significantly enhanced near the island O-point and in the vicinity of outboard and inboard edge X-points.

When the RMP-assisted plasma detachment occurs at R_{ax}=3.90m, the profile of CIII–CVI totally changes due to the formation of m/n = 1/1 magnetic island and modification of stochastic magnetic field lines. For both the 6-O and 7-O islands a new edge peak appears in the CIII and CIV profiles at the island location near Z=±400 mm, while the original edge peak still remains at Z~420 mm (see Fig.1). The CIII and CIV are also enhanced in the vicinity of X-points at –400≤Z≤–250mm for the 6-O island and at –300≤Z≤300mm for both the 6-O or 7-O islands. The CV only moves inside during the detachment with keeping the same profile shape.

It is already known that the CIII and CVI are localized in the temperature range of T_e = 15–20eV. The flattened electron temperature at the island location also ranges in T_e = 10–20 eV in the detachment phase. This is a main reason why the CIII and CIV intensities are increased at the detachment phase. The intensity of CV is also stronger at the detachment phase as well as the CIII and CIV intensities, while the intensity of CVI decreases. It indicates an enhancement of the impurity screening effect similar to the R_{ax}=3.75m.

The CIII and CIV are drastically strong at the top and bottom edges and along the inboard X-point (see Fig.2). In addition, the intensities become stronger at the upper-left corner in the figures close to the island location for both the 6-O and 7-O islands (see Figs. 2(d) and (e)). The island O-point can enhance the edge carbon emission. The result also suggests that the RMP can create a sufficiently large island even in the ergodic layer. A new emission trajectory is appeared in the CIII and CIV parallel to the inboard X-point in the lower half of the figures. In particular, it is clear for the CIII emission in Figs. 2(b) and (c). It suggests that the magnetic field structure in the ergodic layer is considerably modified by the external RMP field. In contrast, the 2-D distribution of CV and CVI does not obviously change even in the detached plasma, while the CV emission is stronger in the plasma edge and CVI emission becomes weaker.

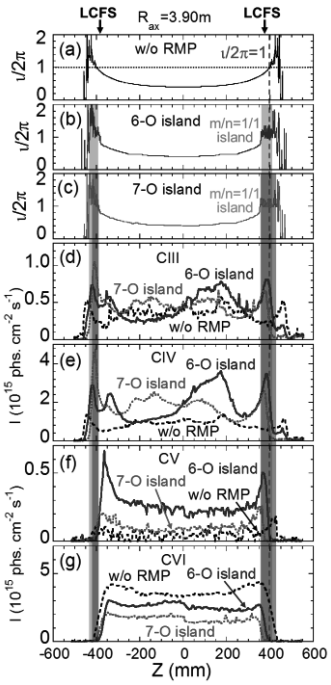

Fig. 1. ι/2π profiles (a) without RMP, (b) with 6-O island, (c) 7-O island and vertical profiles of (d) CIII, (e) CIV, (f) CV and (g) CVI at #10-O in discharges at R_{ax}=3.90m without RMP (dashed line), with 6-O island (solid line) and with 7-O island (dotted line). Radial locations of LCFS and ι/2π = 1 are indicated with vertical arrows and dashed line, respectively. The radial ranges of m/n =1/1 island are indicated by shaded area with different colors for two islands.

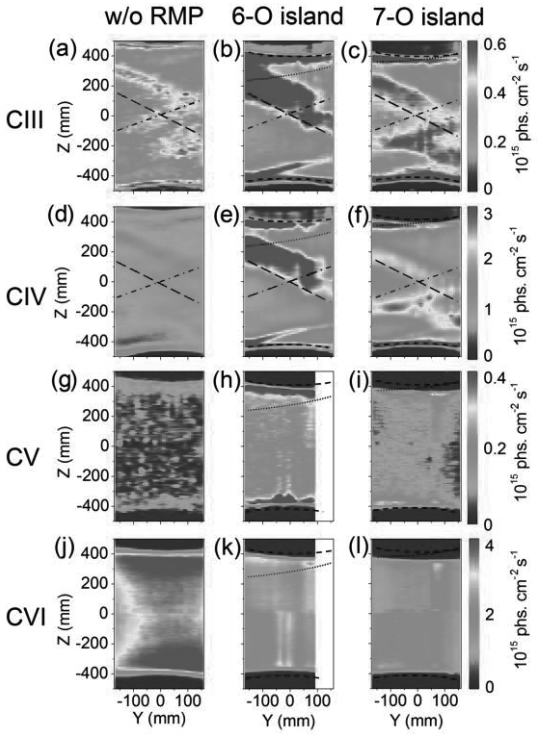

Fig. 2. 2-D distributions of (a)-(c) CIII, (d)-(f) CIV, (g)-(i) CV and (j)-(l) CVI. Trajectories of outboard and inboard X-points and island O-point are indicated with long dashed, dotted-dashed and dashed lines, respectively. The ι/2π=1 position is indicated with dashed line.