§21. Carbon Distribution during Plasma Detachment Triggered by Edge Magnetic Island Formation

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Heat load mitigation on divertor plates is one of the critical issues in the next-generation magnetically confined fusion devices. As a solution to this problem, the detached divertor has been proposed as the divertor scenario of the next-generation device. The detached plasma has been achieved by injection of working gas or gaseous impurity into divertor region of tokamaks. Recently, a new method to create the detached plasma is demonstrated in LHD by applying the 1/1 resonant magnetic perturbation (RMP) fields [1]. Since no additional impurity is introduced in the plasma, carbon is considered to be the main radiation species in the island-triggered detached plasma. The vertical profiles of carbon are measured by extreme ultraviolet (EUV) spectrometer [2]. In general, the vertical profile of CIV is characterized by a single intensity peak at plasma edge in LHD [3]. In detached plasmas triggered by the edge magnetic island formation, however, the vertical profile of CIV shows a significant difference. Double edge peaks of CIV are found during the plasma detachment and the CIV radiation is remarkably enhanced in the vicinity of X-point, whereas the vertical profile of CVI does not show any significant difference in both the attached and detached plasmas.

The time evolution is shown in Fig.1 for discharges with and without island. When the island is formed, the discharge changes to the detached phase at t=3.9s. The total radiation power is a little enhanced and the plasma shrinks after the detachment, although the global plasma confinement is not significantly degraded.

The CIV profiles are compared at 3.8 and 4.8s in discharges shown in Fig.1. The result is shown in Fig. 2. The double edge peaks appear in the detached plasmas and the intensity near X-point region is remarkably enhanced. For comparison, the CIV profile from attached plasma without island is also plotted in Fig. 2. It is clear that the CIV profile is not affected by the island formation itself, except for the profile near X-point region. Therefore, the result reveals that the double edge peaks only appear in the detached phase with island.

The electron pressure profile at plasma edge and the connection length distribution are shown with CIV profile in Figs. 3(a) and (b). Both of electron pressure profiles obtained from attached and detached plasmas in region of ρ=0.98-1.1 tend to be flat due to the magnetic island formation. The position of CIV at outer edge peak in the detached plasma is the same as that in the attached plasma. The radial position of CIV coincides with the position where the connection length starts to increase, indicating a clear edge boundary of the ergodic layer. On the other hand, the inner peak position of CIV coincides with the outer edge of the magnetic island, at which the connection length rapidly increases. Here, it should be noticed that Thomson scattering and the CIV profile are measured at different poloidal positions. Nevertheless, the double CIV structure strongly suggests a double edge layer in the island-triggered detached plasma.

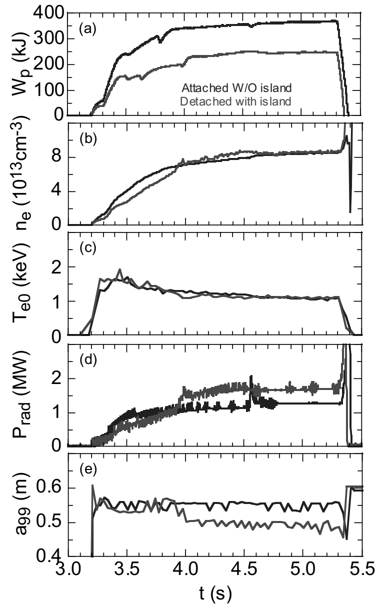

Fig.1 Time evolution of (a) stored energy, (b) electron density, (c) central electron temperature, (d) total radiation power and (e) minor radius, a_{99}, for attached plasma without magnetic island and detached plasma with magnetic island.

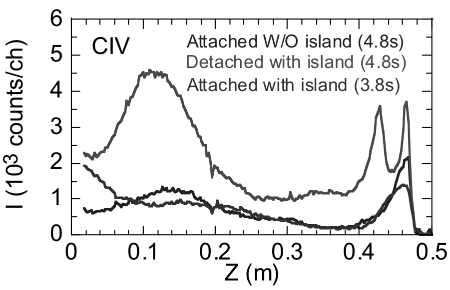

Fig. 2 CIV profiles for attached and detached plasmas.

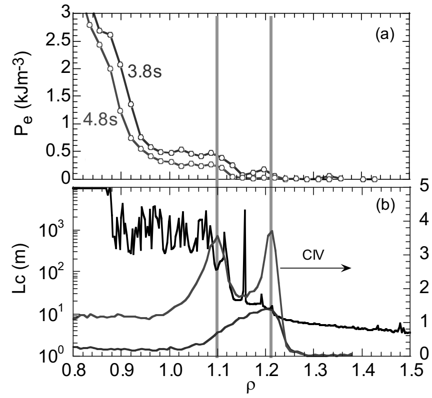

Fig.3 (a) Electron pressure profile at plasma edge and (b) connection length distribution and CIV profiles.

1) M. Kobayashi, et al., Phys. Plasmas **17** (2010) 056111.
2) C.F. Dong, et al., Rev. Sci. Instrum. **81** (2010) 033107.
3) C. F. Dong, et al., Phys. Plasmas **18** (2011) 082511.