§43. Effect of Ergodic Layer on Plasma Performance

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The effect of ergodic layer on plasma performance was studied using hydrogen-puffing NBI discharges at R_{ax} = 3.6 m and B_t = 2.75 T. Since the 1/1 island is formed at the $\iota/2\pi$ = 1 surface position inside the helical separatrix, the volume of the core plasma is reduced in the LID configuration. Accordingly, plasma parameters are expected to deteriorate, compared with those in the standard LHD configuration, unless plasma performance is enhanced in the LID configuration. One of the most important functions of the ergodic layer, which is located around the helical separatrix, is a shielding effect on neutral particles, defined by the following. Since the ergodic layer connects with the wall or the carbon plates for the helical separatrix, the particles ionized in the ergodic layer flow along the field lines to the wall, and hence, both ionized fueling particles and impurities cannot penetrate into the core plasma. Thus the plasma density in the core plasma and, especially, in the edge plasma should be reduced with the thickness of the ergodic layer. This is also true for all impurities such as iron, oxygen, and nitrogen. This function is coherent with the highly efficient pumping and core fueling, because the removal of ionized particles by the ergodic layer promotes the efficient pumping and the reduction, especially, of the density in the edge plasma causes a deep penetration of the pellet into the core plasma. The thickness of the ergodic layer is an increasing function of a resonant perturbation field, and changes in the experiments from ~14 cm to ~20 cm at the maximum near the X-point, located inside the torus at the midplane of the horizontally elongated cross section. On the contrary, there is a possibility that the particles ionized near the wall flow into the core plasma through the ergodic layer. The amount of these particles is very small, compared with the outward particles, because the volume of the ergodic layer surrounding the core plasma is much larger than that connecting the wall and the ergodic layer surrounding the core plasma. However, the amount of the inward particles is expected to become large, if the ergodic layer surrounding the core plasma touches the wall directly.

Figure 1 shows the radiation power emitted from the plasma, P_{rad}, measured by a bolometer and normalized by n_e^2, as a function of the LID coil current, I_{LID}. This indicates the variation of the shielding effect of the ergodic layer on impurities, and it is clearly shown that the normalized P_{rad} decreases with an increase in I_{LID}, that is, the thickness of the ergodic layer. This demonstrates that the ergodic layer prevents impurities from penetrating into the core plasma as well as the fueling particles are prevented resulting in the decrease in n_e. Typically, this was demonstrated in the long-pulse discharges, as shown in Fig.2. Figure 2 shows emissivity-profile evolutions, measured in the hydrogen puffing NBI discharges, whose duration is over 35 sec with the NBI power of ~0.8 MW. In Fig. 2(a), the intense-radiation area is located at ρ ~ 0.8 in the early stage of the discharge. Then it is moved to the plasma center. In Fig. 2(b), the ramp-up I_{LID} of 0 A to -1,800 A is imposed from 10 sec to 28 sec, and then I_{LID} is kept constant. Thus the intrinsic 1/1 island is enlarged from t = 10 sec. Apparently, the intense-radiation area shrinks with an increase in the island width from t ~ 12 sec, and disappears from the plasma center before t ~18 sec. There remains the intense-radiation area at ρ ~ 0.8. Accordingly, T_e in the plasma center increases by ~200 eV. This demonstrates clearly the shielding effect of the ergodic layer on impurities, which works better when the ergodic layer is thick and over ~15.5 cm wide near the X-point, located inside the torus at the midplane of the horizontally elongated cross section.

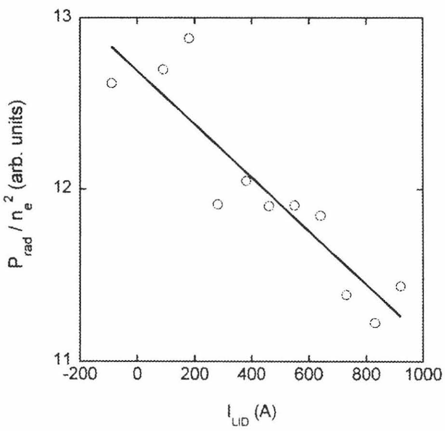

Fig. 1. Normalized radiation power as a function of I_{LID}.

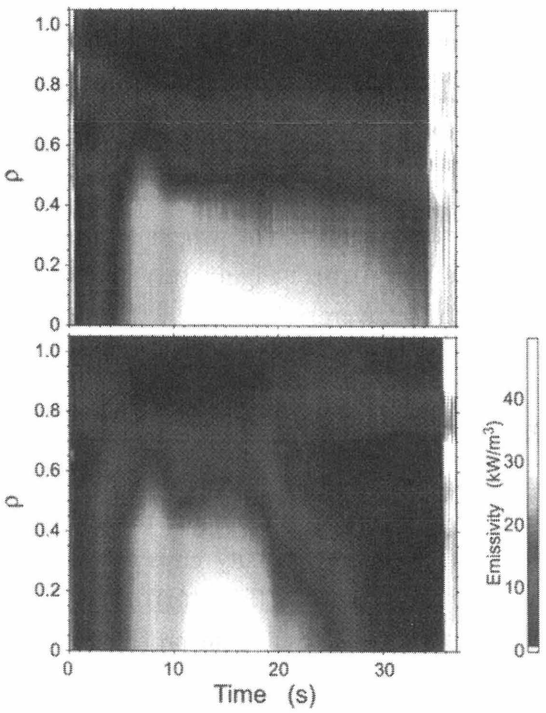

Fig. 2. Emissivity profile evolutions in long-pulse discharges.