§9. Investigation of the Intensity Profiles of Visible Emission by Neutral Hydrogen/ Helium in Baffle and Open Divertor Regions

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Two test modules of the baffle divertor have been installed in the inboard side from the 14th experimental campaign in order to check the performance of enhancement of neutral hydrogen density in the divertor region. Enhancement of neutral particle density in the divertor region by more than one-order of magnitude has been successfully achieved for a typical magnetic configuration (R_{ax}=3.60m). Not only the enhancement of neutral particle density but also neutral particle transport is a critical issue for investigating the effect of the baffle divertor. Analysis of transport and pumping of helium atoms is also an important topic for designing the divertor in future helical fusion reactors.

Filtered CCD cameras have been installed in outer ports (7-O and 9-O) for monitoring neutral particle transport in the baffle and the open divertor regions. Figure 1 shows the intensity profiles of visible emission by neutral hydrogen (H_α: λ=656.3nm) and helium (HeI: λ=587.7nm) observed with the filtered CCD cameras in the both divertor regions for R_{ax}=3.60m. The images were taken in a hydrogen fueled plasma discharge after additional helium injection experiments. Visible spectroscopic measurement showed that the ratio of helium ions on the total ions in the plasma periphery is less than 10% in the plasmas. The observed intensity profiles of H_α are similar to those of HeI in the both divertor configurations. It shows that the intensity of the emission in the area between two inner divertor legs in the inboard side (private region) is low.

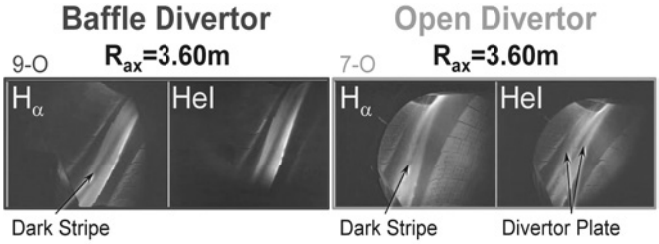

Fig. 1 Observed intensity profile of visible emission by neutral hydrogen (H_α) and helium (HeI) in the baffle and open divertor configurations for R_{ax}=3.60m.

For understanding the reason why the intensity profiles is not significantly changed by the divertor configurations, a fully three-dimensional neutral particle transport simulation code (EIRENE) was applied. In this simulation, the current of neutral particles (hydrogen and helium) released from divertor plates linearly depends on the plasma current onto the divertor plates. The intensity profiles of the visible emission are calculated by integrating the emission along the line of sights of the cameras (totally 140,000). The plasma parameter profiles inside the ergodic layer are calculations of EMC3-EIRENE. The plasma parameters on the divertor legs are obtained by one-dimensional plasma fluid analysis along magnetic field lines.

Figure 2 is the calculations of the intensity profile of the visible emission of hydrogen and helium in the both divertor configurations for R_{ax}=3.60m. The calculations are consistent with the observed profiles, which reproduce the low intensity area (dark stripe) in the private region in the both divertor configurations. Figure 3 shows the poloidal cross-sections of the calculated visible emission profiles of the neutral particles ($\varepsilon_{H\alpha}$ and ε_{HeI}) in the both divertor configurations at a toroidal angle where the plasma is horizontally elongated. It shows that most of neutral particles released from the divertor plates in the inboard side of the torus are ionized on the inner divertor legs near the divertor plates in the both divertor configurations. This is a reason for the dark stripe in the private region. The calculations prove that the baffle divertor significantly reduces H_α emission in the ergodic layer in the inboard side by a factor of about 2 compared to that in the open divertor case, which is effective for control of the peripheral plasma density. It also indicates that the baffle divertor is not so effective for reducing neutral helium density in the ergodic layer because most of helium atoms released from the divertor plates are ionized on the inner divertor legs due to the short mean free path of the helium atoms.

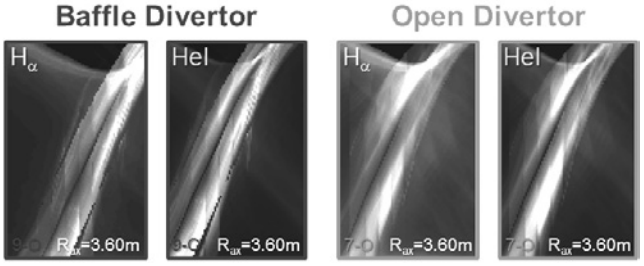

Fig. 2 Calculated intensity profile of visible emission by neutral hydrogen (H_α) and helium (HeI) in the baffle and open divertor configurations for R_{ax}=3.60m.

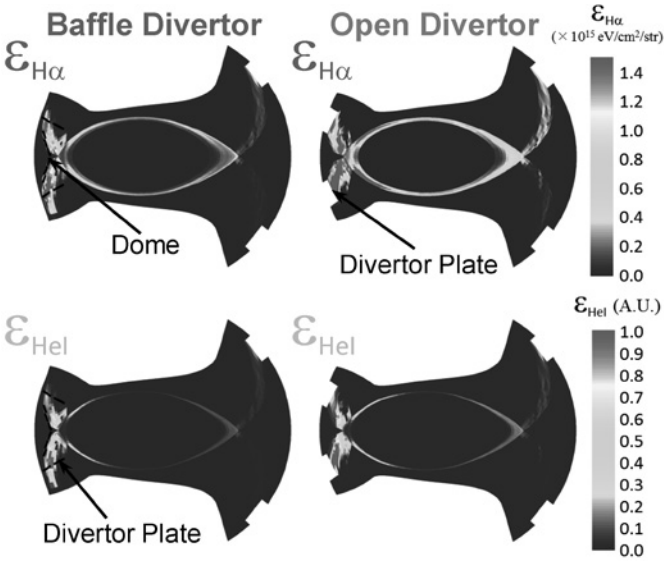

Fig. 3 Poloidal cross-sections of calculated visible emission profile by neutral hydrogen (H_α) and helium (HeI) in the baffle and open divertor configurations for R_{ax}=3.60m.