5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Noticeable reduction of heat on the SAS-like divertors in large scale Tokamaks

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In a reactor subject to long pulse operation, maintaining a steady state through continuous treatment of impurities and heat is the key. For this purpose, heat exhaust from the divertor is very important, as it is a part that directly interacts with hot plasma and neutrals. In the ITER or DEMO-class Tokamaks, the heat flux to the divertor is expected to exceed $20MWm^{-2}$, which is the technical limit of PFC. Therefore, it is very important to find a way to significantly reduce the heat flux dumped to the divertor target.

One promising solution to this goal is using and controlling the detachment phenomenon. From lots of previous studies, it has been confirmed that the change of the divertor structure (especially the shape) directly affects the detachment. The study was highlighted in the SAS-type divertor in DIII-D, and we confirmed the SAS-like divertor works well in the KSTAR environment too.

Through our recent study, we found that the distribution of neutral particles could be very specifically controlled by changing the divertor shape, and accordingly the difference of heat exhaust and detachment was also observed. This means that heat exhaust through change of divertor shape is still an interesting research topic, and also means that it is a strong candidate to solve the problem at hand. In this context, we examined the effects of SAS-like divertors to a ITER or DEMO class, large scale tokamak.

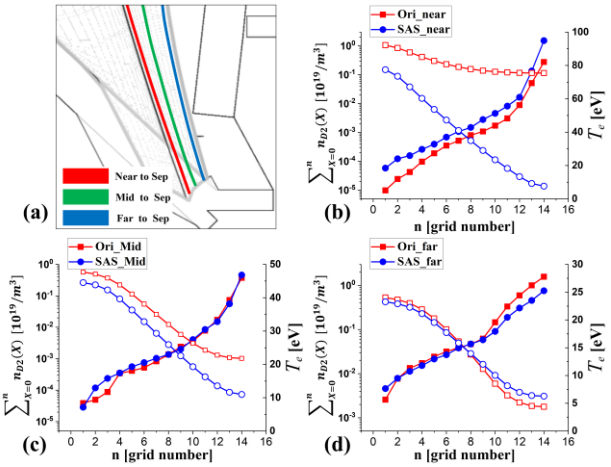

Fig. 1 The difference in density distribution of deuterium molecules and the resulting temperature difference for three different distances to the separatrix.

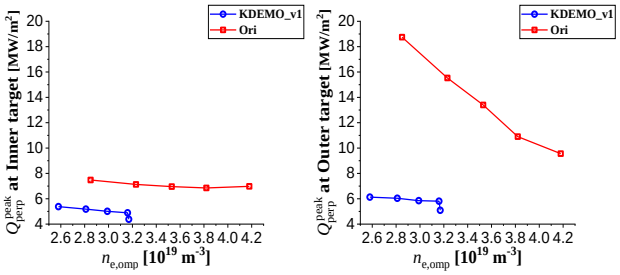

Fig. 2 The difference in heat flux according to the structure was confirmed for the outer midplane electron density. Original (Red) SAS-like(Blue)

We carried out comparison studies of original and SAS-like shapes on the ITER environment using the SOLPS-ITER package. From our simulations, we observed that the heat flux decreases by less than 1/3 in the SAS-like cases for similar upstream densities. Interestingly, although the SAS-like shape was employed only in the outer target, a considerable decrease of the heat was observed in the inner target also. This trend was not observed in the KSTAR cases, and in this study, it was observed that there was a very large difference in the flow of main ion flux or the trajectory of neutral particles due to the structural change. It seems that the difference in the path and distribution of neutral particles and main ions caused the difference in the inner target as well as the outer target that changed the shape. We investigated which parameter caused the change.

In conclusion, the change in structure affects the pressure balance of the particles, resulting in a very large difference in the divertor region.

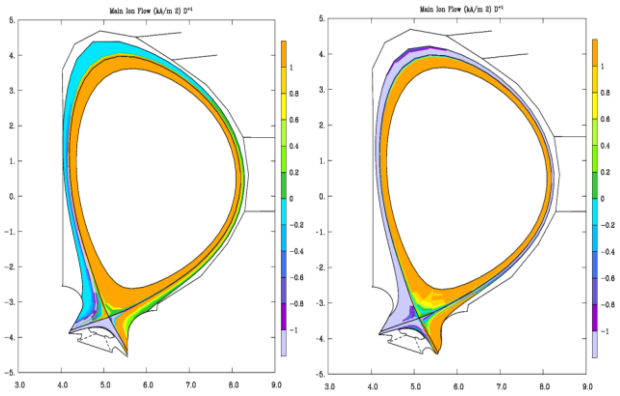

Fig. 3 Difference of Main Ion Flux according to Divertor Shape

References
Nucl. Fusion 61 (2021) 014001
Figure 1 Nucl. Fusion 61 (2021) 014001