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Enhanced Insights and Improvements in Power Exhaust Management through Numerical Simulations

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Addressing heat exhaust issues through numerical modeling is one of the critical challenges in making fusion energy a reality. Various code packages, including fluid and kinetic combined codes like SOLPS-ITER[1-2] and EMC3-EIRENE[3], are available for simulating the Scrape Off Layer (SOL). This presentation highlights research conducted using these codes, focusing on simulations within the KSTAR environment.

A key aspect of managing heat exhaust involves understanding the mechanisms of power dissipation as plasma energy transitions from the midplane to the target, interacting with recycled neutrals or externally introduced impurities. This presentation examines how changes in target shape and impurity injection conditions influence heat exhaust patterns.

We demonstrate that altering the target shape, such as adopting configurations like the Small Angle Slot (SAS)[4] on KSTAR's outer target, significantly impacts neutral distribution and detachment phenomena due to variations in radiation[5]. Our simulations reveal that the SAS configuration promotes detachment at lower outer midplane densities, leading to reduced heat flux, as illustrated in Figure 1. These findings indicate that detachment is more efficient with SAS-shaped targets even at lower densities.

Furthermore, our results indicate that the neutral distribution change and temperature drop induced by the SAS are insensitive to the slot's depth. We conducted simulations and analyses while maintaining consistent strike points and slot configurations across various slot depths. Our findings represent that detachment and other related phenomena are significantly influenced by the shape of the slot itself.

Additionally, we explore how changes in the poloidal location of impurity gas injection impact particle balance and overall heat exhaust efficiency. For KSTAR, red (D_2) and blue circles (N) in Figure 2(a) represent injection locations. For ITER, similar analyses are conducted as shown in Figure 2(b). In the case of KSTAR, the study utilizes SOLPS-ITER simulations, while for ITER, existing SOLPS-ITER results[6] are reproduced by EMC3-EIRENE simulations under similar conditions.

These simulation results indicate that the gas injection location has the potential to significantly influence the distribution of particles within the tokamak and the radiation zones. Under certain conditions, the injection location can impact the entire SOL region, highlighting the need for further research to optimize these parameters. This combined approach allows for a comprehensive comparison and deeper insights into the effects of impurity gas injection across different fusion devices.

References
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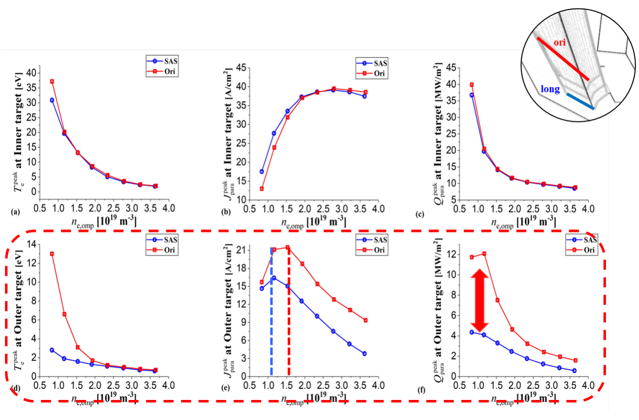
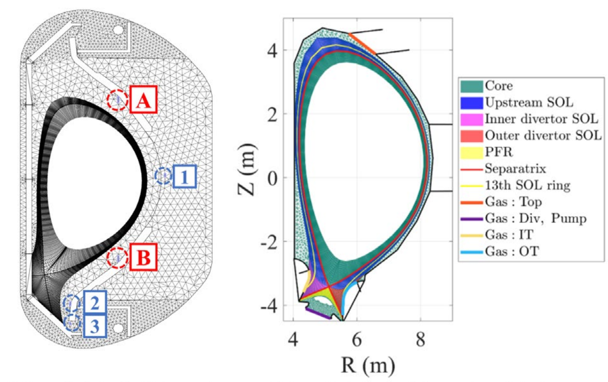


Figure 1. Image shows the difference in data when the divertor shape is changed in the KSTAR environment. The shape difference of the divertor(Outer target) is represented by the upper right corner.



(a) Image depicting the differences in gas injection locations for KSTAR

(b) Image depicting the differences in gas injection locations for ITER

Figure 2. Gas injection locations in KSTAR and ITER represented on their respective SOLPS-ITER simulation grid