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SOLPS-ITER simulations of an X-point radiator in the single-null and snowflake divertor configurations in ASDEX Upgrade and EU-DEMO

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The X-point radiator (XPR) is an attractive scenario to solve the power exhaust problem in future fusion devices. In ASDEX Upgrade (AUG), experiments with an XPR showed a dissipated power fraction larger than 90 %, fully detached divertor targets and ELM suppression with a moderate confinement degradation [1]. Recently, a reduced model [2] was derived to explain the physical mechanisms for initiating a stable XPR, highlighting the role of neutrals at the X-point and the magnetic connection length and flux expansion.

In this work, the 2D transport code SOLPS-ITER [3] was applied to reproduce the XPR phenomenon. The simulation results show qualitative agreements with the experimental measurements and the reduced model in AUG. By analyzing the particle, momentum and energy balances, the particle and heat transport in an XPR are depicted in detail. In addition to this, the important role of neutrals and the magnetic connection length in the generation of an XPR are demonstrated by the simulations with virtual neutral baffles and with various toroidal magnetic field strength, respectively.

An XPR regime was also achieved in SOLPS-ITER simulations of the snowflake divertor configurations in the new upper divertor of AUG [4] as well as in the alternative divertor concept of EU-DEMO [5]. With the substantially larger connection length and flux expansion compared to the conventional single-null divertor, the snowflake divertor showed an easier access of the XPR regime with a lower impurity concentration at the separatrix.

In order to demonstrate the feasibility of the XPR regime in future devices, a machine-size scaling of the access condition, the impurity compression and the maximum radiative fraction in the X-point volume is highly required. This remains an open question and will be discussed in this presentation.

References

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