Modeling a Lithium Vapor Box Divertor and Resulting Ion Flows on NSTX-U using SOLPS

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Divertor detachment with medium-Z impurities can be subject to radiating regions within the last closed flux surface [1]. The lithium vapor box divertor seeks to detach via near-target lithium evaporation such that the ensuing vapor gradient would prevent such a radiating region from forming. We show SOLPS predictions for the effect of a lithium vapor box divertor on NSTX-U. PFC geometry choices are examined and compared with predictions for lithium evaporation in the current open divertor geometry [2]. Closure is found to have significant benefits in reducing upstream lithium content via containment of impurity ionization, resulting in reductions of upstream lithium density. In high power cases, where the unmitigated heat flux to the target is found to be 65MW/m^2, different closure designs are considered. Baffling of the divertor is found to have benefits when compared to a slot divertor geometry for both heat flux and upstream lithium content reduction, as well as isolating of the divertor cooling from the outer midplane. The baffled geometry is found to be resistant to flow reversal in the far SOL where main ion flow is weak, thus the baffles eliminate a path for lithium contamination of the main plasma. The baffled system is able to reach sub-5 MW/m^2 heat fluxes at the cost of lithium density around 5% of the electron density at the outer midplane. The results of this study are tested for their sensitivity to choices of transport coefficients, upstream pumping rate, and puffing location. Even when transport coefficients are reduced to provide less particle flow from the core and higher heat flux at the target, sub-10MW/m^2 solutions are available to the lithium vapor box from an unmitigated 92 MW/m^2. Private Flux Region (PFR) puffing is seen to be more effective at reducing upstream lithium content while Common Flux Region (CFR) puffing is seen to be more effective at heat flux reduction. The efficacy of both puffing locations is increased by increases to the divertor recycling coefficient. Reducing pumping at walls upstream of the baffles improves the effect of the puffs, leading to cases with lower upstream lithium content for less heat flux.

References:

[1] A. Kallenbach et al Partial detachment of high power discharges in ASDEX Upgrade Nuclear Fusion **55** (2015), 053026

[2] Emdee et al. Nuclear Materials and Energy **27** (2021) 101004