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Integrated Power Exhaust Modelling for DEMO with Lithium Divertor

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Operation of a future demonstration fusion reactor (DEMO) requires the handling of a significant power flux that crosses the separatrix and enters the scrape-off layer. A considerable amount of energy has to be dissipated before the heat flux reaches divertor plates. The divertor may be exposed to high heat fluxes causing high temperature gradients and material fatigue. Such challenging conditions in the scrape-off layer demands developing solid state plate protection scenarios. In the liquid metal divertor, which is one of the considered solutions to the power exhaust problem, a liquid surface protects the solid plates against high heat loads, allowing for longer operation without the need of the divertor disassembly.
In this paper a DEMO reactor is considered with a liquid lithium divertor setup. The simulation is performed with the COREDIV code which self-consistently solves radial 1D energy and particle transport equations of plasma and impurities in the core region and 2D multifluid transport in the SOL. Influence of sputtering, prompt redeposition and evaporation of lithium is taken into account. An operational space of parameters is analyzed. Two regimes of operation are identified. The sputtering regime occurs when the divertor is tilted significantly with respect to the magnetic surface. Evaporation is low compared to the sputtering. In such a situation divertor power load is high and additional seeding is required in order to dissipate energy before it reaches the divertor plates. In the evaporation regime, evaporation is higher than sputtering. A high amount of lithium is released into the plasma diluting it and therefore reducing the power to the plates. Although in both regimes lithium dilutes the core plasma reducing fusion power, it is also fully stripped what results in low radiation and high power across the separatrix. Cooling of the plasma can then be achieved by seeding additional impurity.

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