SOLPS-ITER simulations for an EU-DEMO with a liquid Sn divertor target and Ar seeding

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Liquid metal divertors (LMDs) employing a capillary-porous structure (CPS) have the potential to provide a reliable solution to the heat exhaust problem in future fusion devices [1]. The self-healing nature of the plasma-facing surface is one of the most attractive advantages of LMDs over conventional solid (W) divertors. Moreover, the presence of the CPS prevents droplet emission and provides passive surface replenishment, thereby compensating for material losses associated to LM erosion due to evaporation and sputtering. On the other hand, eroded metal atoms can lead to plasma dilution (in case of low-Z materials, such as Li) or cause intolerable radiative energy losses in the core plasma (in case of high-Z metals, such as Sn) [2]. To assess the plasma compatibility of an LMD, it is essential to correctly model the transport of the eroded atoms in the SOL and core, including their interactions with the plasma and, possibly, the presence of purposely seeded impurities (e.g. Ar.)

In this work, we study the SOL plasma behavior in the presence of an LMD using Sn. We consider the EU-DEMO with a single-null configuration, having replaced the baseline W divertor with an LMD having the same shape of the PFCs. We use the SOLPS-ITER code to model the edge plasma interacting with the LMD targets. A multifluid, Braginski-like set of equations is employed to model the transport of ionized species (D⁺, Sn⁺-Sn⁰⁺, Ar⁺-Ar¹⁺⁺), whereas neutral atoms (D⁰, Sn⁰, Ar⁰) are modeled by means of a fluid model, for the sake of simplicity [3]. The emission of Sn⁰ from the target is evaluated self-consistently with the plasma heat load. This is achieved by coupling a thermal model of the target to SOLPS-ITER. The target geometry and materials are consistent with a recently proposed ENEA design for an LMD target [4].

In our simulations, different plasma scenarios are studied by varying the amount of seeded Ar and the outboard mid-plane electron density. Results show that a promising operational window exists where, with a relatively low amount of Ar, the Sn divertor can operate without excessive evaporation, and therefore with limited plasma contamination.


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