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Modelling fuel retention in the W divertor during the D/H/D changeover experiment in WEST

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The retention, outgassing and removal of hydrogen isotopes (HIs) in the plasma facing components are key issues for the development of fusion reactors. The WEST divertor is made of the same actively cooled tungsten (W) monoblock technology as in ITER. Thus, the investigation of fuel retention, outgassing and removal in the WEST divertor is key to estimate the tritium inventory in the ITER divertor.
During the C7 WEST campaign (February 2023), a D/H/D changeover experiment was performed in WEST to investigate isotopic exchange as a possible technique of fuel removal. The session of about 40 pulses was divided in 3: the first 6 pulses were fuelled by puffing D2, the next 17 pulses by puffing H2, and the last 16 pulses by puffing D2.
This study concerns the modelling of the D/H retention in the WEST W divertor during this D/H/D changeover experiment using the MHIMS code. A pure W divertor is considered with a MHIMS model parametrized with laboratory experiment [2]. After validating the background plasma calculated by SOLEDGE3X-EIRENE [3] with the Langmuir Probe data in the divertor, the H/D implantation properties (fluxes, energies, angle of incidence) are given as input to MHIMS. Finally, the outgassing fluxes of the MHIMS simulations are transformed into partial pressures of H2, HD and D2 [4,5] and compared to the mass spectrometer signal during the waiting phase between each pulse of the changeover session.
The outgassing fluxes calculated by MHIMS and the one measured in WEST after the discharges shows similar t-α exponential decay with α around 0.8 in the simulations and 1.0 in the experiment. However, the pressure given by the outgassing from the divertor only is about 5 times lower than the experimentally observed pressure, suggesting outgassing from other components less exposed to the plasma contributes to the total vacuum pressure. Regarding the dynamics of the calculated H and D inventory, they follow the sequence of the changeover as the plasma and the divertor implants and recycles fuel particles. However, during the H plasmas, the H isotopic ratio in the plasma grows up to 0.7 while it stays below 0.6 in the material. Indeed, the analysis of the H/D depth profiles shows that the 17 H plasmas are able to remove the D up to the first 100 µm while 700 s of cumulated H plasma exposure is not enough to reach D trapped deeper. Thus, the changeover is an efficient tool to recover hydrogen isotopes but focused near the plasma-exposed surface.

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