Contribution ID: **92** Type: **Oral**

Global tungsten erosion and impurity migration modeling for the DEMO with the ERO2.0 code

Thursday, 30 November 2023 14:00 (30 minutes)

Dedicated computer codes are used to address the physics of plasma-wall interaction and related issues of wall lifetime and long-term tritium retention in fusion devices. The Monte-Carlo code ERO2.0 is such an example, which allows numerical modeling of realistic three-dimensional device geometries based on its massive parallelization [1]. In addition to (net) erosion and re-deposition maps on plasma-facing components, the code yields volumetric information about impurity concentrations in the plasma. A fully kinetic approach is used to trace impurities throughout the background plasma, thereby also addressing atomic processes like ionization, recombination, and collisions along the particle trajectory. The code was validated against experimental data from the largest European fusion device JET in the past [2], and predictions were made regarding the wall lifetime for the next step international experimental fusion reactor ITER [3].

In the present contribution, recent code developments, such as the contribution of spatially inhomogeneous multi-species plasma backgrounds to gross erosion calculations will be presented. These developments will then be applied for the first time to modeling the full tungsten European demonstration reactor DEMO, which is currently in the design phase. The ERO2.0 simulations are based on the currently only available DEMO-specific plasma solution [4], which was generated on basis of the 2017 Baseline equilibrium. Due to gaps in the range of (15 - 80) cm between the last simulated plasma grid-point and the first wall, special emphasis will be put on extrapolation assumptions of plasma parameters to the wall and their impact on the transport of tungsten in the scrape-off-layer plasma. The simulations also reveal charge-exchange neutrals to be the driven source of main chamber erosion, while the divertor erosion is mainly driven by seeded Argon ions and tungsten self-sputtering. Beyond, the importance of energy- and angular-resolved charge-exchange spectral characteristics for main chamber erosion calculations will be discussed in detail.

[1] J. Romazanov et al., Physica Scripta T170, 014018 (2017)
[2] J. Romazanov et al., Nuclear Materials and Energy 18, 331-338 (2019)
[3] J. Romazanov et al., Contributions to Plasma Physics 60, e201900149 (2019)
[4] F. Subba et al., Nuclear Fusion 61, 106013 (2021)

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Session Classification: MOD/1 fusion devices