6th Asia-Pacific Conference on Plasma Physics, 9-14 Oct, 2022, Remote e-conference

Plasma-surface interaction and impurity transport simulations with the three-dimensional Monte-Carlo code ERO2.0

J. Romazanov[1], S. Brezinsek[1], A. Kirschner[1], R. A. Pitts[2], M. Navarro[3], S. Rode[1], H. Xie[1,4,5], D. Matveev[1], M. Krikbou[1], C. Baumann[1], T. Dittmar[1], M. Groth[6], H. Kumpulainen[6], R. Mäenpää[6], D. Brömmel[7], M. Shoji[8], G. Kawamura[8], S. Di Genova[9], G. Alberti[10], Ch. Linsmeier[1]

[1] Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung – Plasmaphysik, Partner of the Trilateral Euregio Cluster (TEC), 52425 Jülich, Germany; [2] ITER Organization, Route de Vinon-sur-Verdon, CS 90 046, 13067 St.-Paul-lez-Durance Cedex, France; [3] Department of Engineering Physics, University of Wisconsin Madison, Madison, Wisconsin 53706, United States of America; [4] Institute of Plasma Physics, Chinese Academy of Sciences, Hefei, Anhui 230031, China; [5] Advanced Energy Research Center, Shenzhen University, Shenzhen, 518060, China; [6] Association EURATOM-Tekes, Aalto University, Espoo, Finland; [7] Forschungszentrum Jülich GmbH, Institute for Advanced Simulation, Jülich Supercomputing Centre, D-52425 Jülich, Germany 5; [8] National Institute for Fusion Science, National Institutes of Natural Sciences 322-6 Oroshi-cho, Toki 509-5292, Japan; [9] M2P2, Aix-Marseille Univ, CNRS, Centrale Marseille, 13013 Marseille, France; [10] Politecnico di Milano, Department of Energy, Milan, 20133, Italy

e-mail (speaker): j.romazanov@fz-juelich.de

Plasma-facing components (PFCs) in fusion reactors are eroded during plasma discharges due to sputtering by energetic ions or charge-exchange neutrals. Such steady-state erosion not only reduces PFC lifetime, but also significantly contributes to fuel retention via co-deposition of eroded impurities. Moreover, contamination of the core plasma with heavy impurities like tungsten should be prevented, since those exhibit strong radiative cooling. Therefore, understanding and controlling erosion and related plasma-surface interaction (PSI) processes is key to the successful realization of magnetic confinement fusion power production.

For this aim, the ERO2.0 code has been developed. This code allows PSI studies with a realistic three-dimensional (3D) description of PFC geometries as well as importing 3D plasma backgrounds produced by codes such as EMC3-EIRENE. Due to massive parallelization, it is possible to simulate the entire plasma boundary of a fusion reactor including all relevant PFCs. To study the transport and redeposition of eroded material, trajectories of eroded particles are followed in a kinetic description, including the chain of ionization or molecular dissociation. The outcome of the simulations is the erosion and redeposition pattern on the PFCs, together with volumetric data on the impurity concentrations in the plasma. To allow comparison with experimental data e.g. from spectroscopy, the code implements a range of synthetic diagnostics.

In this contribution, the ERO2.0 code is described along with the underlying physics and technical implementation. The code capabilities are illustrated on the example of recent application to the prediction of beryllium erosion and transport in the JET [1] and ITER [2] tokamaks. Results include for instance the beryllium net erosion and deposition patterns, as shown in Figure 1. Next, the ongoing application to carbon erosion and transport simulations in the Wendelstein 7-X is discussed. This includes in particular also the simulation of ^{13}C tracer injection experiments and comparison with post-mortem analysis. Finally, a summary of other recent or ongoing code applications and improvements is presented.

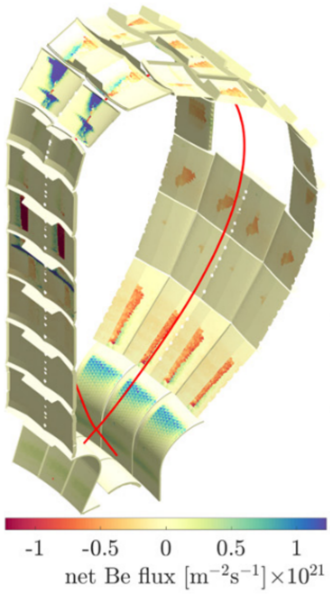

Figure 1. Simulated beryllium net erosion (-) and deposition (+) patterns in an ITER $Q = 10$ D-T plasma.

References

[1] J. Romazanov et al. "Beryllium global erosion and deposition at JET-ILW simulated with ERO2.0". In: *Nucl. Mater. Energy* 18 (2019), pp. 331–338.

[2] J. Romazanov et al. "Beryllium erosion and redeposition in ITER H, He and D–T discharges". In: *Nucl. Fusion* 62.3 (2022), p. 036011.