Langevin approach for plasma-surface interaction: turbulent sputtering and surface morphology

D. Reiser

Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung – Plasmaphysik, 52425 Jülich, Germany

The eminent role of plasma instabilities and related turbulent effects in fusion research is well known. Prominent examples relevant for future experiments and reactor operation are the anomalous transport degrading confinement properties and the Edge Localized Modes (ELM's) leading to intermittent expulsion of particles and heat onto the divertor plates.
However, an integrated simulation taking into account the temporal evolution of the multi-scale plasma dynamics and the interaction of the plasma with plasma-facing components is currently not within reach due to limitations in computational resources.
On the other hand, if the focus of research is not that much on the detailed origin of the plasma turbulence but rather on the interaction with material boundaries, a half-empirical approach is available via the use of so-called synthetic turbulence models. Such models can be employed to mimic the basic statistical features of the plasma dynamics known from more detailed simulations and/or from experiment. With the knowledge of spatiotemporal correlations and amplitudes the plasma turbulence can be parametrized and its time evolution can be modelled by means of fast algorithms. This approach has been successfully adopted already for the analysis of plasma-wall interaction in linear devices [1]. The extension to tokamak geometries is straightforward and might be applied to the studies of impurity transport in the presence of ELM's. Moreover, this approach can be extended consistently by implementing additionally a Bradley-Harper-like model [2] for the morphological changes in the plasma-facing material, which is based on similar numerical methods like the generation of synthetic plasma turbulence. In this work we present a Langevin computational model for the linear device PSI-2 [3, 4] based on this combination of plasma turbulence with impurity sputtering and morphological changes of the target material. Scans through relevant parameter ranges of PSI-2 operational conditions are presented.

References

[1] D. Reiser et al., Phys. Scr. **2017**, 014039 (2017).

[2] V. O. Kharchenko and D. O. Kharchenko, Condensed Matter Physics **14**, 23602 (2011).

[3] A. Kreter et al., Fusion Sci. Technol. **68** (1), 8-14 (2015).

[4] A. Kreter, Fusion Sci. Technol. **59** (1), 51-56 T (2011).