Integrated modelling: coupling of surface evolution and plasma-impurity transport

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During the interaction of the scrape off layer (SOL) plasma with the first wall the evolution of both the plasma and the wall are tightly coupled: The wall material is eroded by sputter or chemical erosion and enters the plasma as an impurity species leading to a certain impurity density n_Z in the plasma. These plasma impurities migrate and after a number of (re-) erosion / (re-) deposition steps they form layers at locations where their non-reflected influx Γ^{IN} exceeds their re-erosion flux Γ^{ERO}. These layers then act as new sources of impurities, which again undergo migration thus changing both n_Z in the plasma and their Γ^{IN} at the wall. The changes in Γ^{IN} result in variations of n_Z and of the layer growth rate. The changes in n_Z also affect the plasma parameters temperature Te and density n_i via line radiation and dilution. These changes in T_e and n_i in turn again affect Γ^{ERO} through changes in the incident particle energy and background main ion plasma flux.

Elaborate models have been developed to describe each of the processes separately: The SOL plasma with a fixed first wall composition is modelled by SOLPS [1] or EMC3 [2]. The migration of impurities on a fixed plasma background is modelled by e.g. DIVIMP [3] or ERO [4]. The surface evolution due to erosion deposition for a fixed incident particle spectrum is modelled by dynamic TRIM codes [5] like SDTrim.SP. To describe the coupling and feedback between these processes one can parameterize the codes output and setup continuity equations to derive the time evolution of Γ^{IN}, Γ^{ERO} and n_Z as is in done in the WallDYN [6] approach. This WallDYN approach requires simplified models, but allows for a computationally efficient, non-iterative solution of the coupled problem. The WallDYN approach has been successfully applied to JET-ILW and ASDEX-Upgrade, showing that the key process in modelling Γ^{IN} and n_Z is to take the multiple re-erosion and re-deposition steps of the migrating impurity into account.

This presentation will first describe the WallDYN approach of parameterization of surface evolution and impurity migration in the plasma by analytical models which describe dynamic TRIM and trace impurity transport code output. It will then show the importance of surface dynamics in correctly predicting the impurity sources and resulting plasma impurity concentrations. Finally, first results on the 13C migration in W7X, obtained with the recently developed extension of WallDYN to 3D geometries [7], will be presented.

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