Measurement and Modelling of Impurity Transport in Radiating Boundary Discharges in ASDEX Upgrade

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Radiative cooling of the plasma boundary by controlled injection of medium Z impurities has been demonstrated to yield drastic reductions of the power flow onto the target plates as required for future reactors. An important key number for such scenarios is the fuel dilution and central radiation loss caused by an increased central density of the added impurity, which depends on the radial transport parameters of the impurity in the plasma bulk. When using a transport description by anomalous diffusivity $D$ and drift velocity $V_d$, the radial equilibrium distribution of the impurity density in the source free region is purely determined by the dimensionless drift parameter $\alpha = V_d D$ while transient effects depend on the absolute values of $D$ and $V_d$.

Radiating boundary discharges in the ASDEX Upgrade tokamak with neon as radiating species were analyzed and the impurity transport in the plasma bulk was investigated by several means. The signals of a soft x-ray pinhole camera measuring in the energy range above 1 keV and the time evolution of bremsstrahlung measurements in the visible range ($\lambda = 536 \, \text{nm}$) were compared to calculated radiation fluxes from the 1-D impurity transport/radiation code STRAHL to get information about the quasistatic profiles of neon and to deduce the corresponding drift parameter. Charge exchange recombination spectroscopy was used to measure the time evolution of the radial helium profiles after a short helium gas puff and the transport parameters were taken from linear regression analysis of the time behaviour of normalized densities versus normalized fluxes at various radial positions.

While the measurements on helium show flat density profiles, the neon density profiles are either peaked or flat depending on the confinement regime. In CDH-mode a pronounced peaking of the neon density develops. During the development of the peaked neon profile an $m=1$ mode with increasing amplitude is detected. The mode amplitude and the peaking reach a stable level after about 1 s. No sawtooth activity can be measured. When the bulk radiation is too high the plasma falls back into L-mode. Long L-phases with radiating boundary could be produced for scenarios with high $H$ mode threshold, i.e. $D \rightarrow D^+$ discharges with $\nabla B$ drift away from the X-point or $H \rightarrow H^+$ discharges, and in both cases no peaking of the neon density and no sawtooth suppression are observed. When the impurity puff is not strong enough to cause a transition from the H-mode to the CDH-mode, that means for an H-mode with high boundary radiation and type-I ELMs with reduced frequency, the neon density is again flat and sawteeth are present. In order to decide whether the suppression of sawteeth causes the neon peaking CDH-discharges with central ICRH heating are planned and will be presented.