Transport analysis of high radiation and high density plasmas at ASDEX Upgrade


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Future fusion reactors will operate under more demanding conditions compared to present devices. They will require high divertor and core radiation by impurity seeding to reduce heat loads on divertor target plates. In addition, high core densities are required to reach adequate fusion performance. These scenarios are extensively addressed in the ASDEX Upgrade tokamak. Here we present the transport analysis of such scenarios.

Plasmas with high radiation fraction by impurity seeding: radiative cooling experiments at ASDEX Upgrade show a confinement improvement with nitrogen seeding despite the high radiated power [1]. The transport analysis, carried out taking into account the radiation losses, exhibits no change in the core transport while an enhancement of the confinement time induced by higher pedestal pressure is observed. To assess the radiation profile, a non coronal radiation model was developed and compared to the bolometric measurements in order to provide a reliable radiation profile for the transport calculations. Non coronal effects mostly lead to a radiation enhancement at the plasma edge. In order to investigate the physics mechanisms governing the non coronal regime, a modeling of the evolution of impurities and radiation in the pedestal is ongoing using the ASTRA transport code coupled to the impurity transport code STRAHL.

High density plasmas with pellets: at ASDEX Upgrade pellet injection allows the plasma to reach densities up to 1.5 \( n_{GW} \) without confinement degradation. The transport analysis shows that \( \tau_E \) remains constant despite the density increase: a density dependence \( \tau_E \sim n_e^{0.11-0.22} \) is more adequate than the ITER98 scaling \( \tau_E \sim n_e^{0.41} \) to describe this regime. These results can contribute to further improvement of the scaling for the energy confinement time at high densities. Furthermore the kinetic profiles reveal a transient phase at the start of the pellet train due to a drop of the temperature and a slower density build up compared to the temperature decrease. The recovery of the stored energy follows the density build up.