Divertor Power Load Studies in ASDEX Upgrade and TCV

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In recent years the focus of tokamak fusion research onto power exhaust increased showing that first wall power load is one of the major challenges in realizing a power plant. Unmitigated divertor power loads in next step fusion devices like ITER are projected to exceed material limits making significant impurity seeding necessary. Furthermore, scenarios without large type-I edge localized modes (ELMs) are desired for a future reactor. Two possible regimes, among others, are the operation with negative triangularity and type-I ELM suppression or mitigation using an external magnetic perturbation (MP) field. Shaping the plasma to negative triangularity was pioneered at TCV showing improved core confinement in L-mode, a natural ELM free regime, compared to positive triangularity. ELM suppression by an external MP is studied in most of today's tokamaks. However, steady state power exhaust under these conditions is an open field of research. The divertor power load characterization in both regimes is presented.

Experiments in TCV were conducted in L-mode performing a scan of the upper triangularity from -0.28 to 0.47 with both magnetic drift directions and in deuterium and helium. These experiments exhibit a correlation between upper triangularity and scrape-off layer power fall-off length. With decreasing triangularity a narrowing of the power fall-off length is observed with the smallest values at negative triangularity. This shows that the power fall-off length is possibly narrower in a negative triangularity reactor than expected from multi-machine scaling laws derived from data with positive triangularity and without dedicated triangularity variations. A recently established empirical scaling from ASDEX Upgrade L-mode is extended towards TCV. No direct effect of the machine size on the power fall-off length is observed.

Experiments in ASDEX Upgrade were conducted characterizing the effect of an external MP on divertor power load. The application of a non-axisymmetric MP leads to a toroidal variation of heat flux in both L- and H-mode plasmas. It is shown that the toroidally averaged heat flux profiles are described by a 1D diffusive model and are comparable to heat flux profiles without MP. Plasma discharges with an increased density have a reduced toroidal heat flux variation. The local decrease of plasma temperature in the divertor caused by the increased density is the identified reason. Also, previous studies reported that heat load caused by ELMs correlates with pedestal pressure. This correlation is confirmed in presence of a MP. However, the external MP affects the toroidal position of the heat load caused by ELMs.

*See appendix of "A. Kallenbach 2017 Nucl. Fusion 57 102015"

†See author list of "S. Coda et al 2017 Nucl. Fusion 57 102011"

‡See author list of "H. Meyer et al 2017 Nucl. Fusion 57 102014"