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Experimental and numerical progress in the assessment of alternative divertor configurations in TCV and extrapolations towards higher power conditions

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We will present recent progress of alternative divertor geometry studies in TCV, focusing primarily on the effects of total flux expansion (Super-X), outer target poloidal flux expansion (X-Divertor) and additional X-points near the target (X-Point Target) or near the primary X-point (Snowflake-Minus-LFS). These geometrical features are combined with improved divertor closure using the new TCV baffles and studies are directed towards operation at the highest available power levels.

The first baffled Snowflake L-mode experiments [1] show significant reductions in peak target heat fluxes due to both geometry and baffles. With nitrogen seeding, the X-point radiator present in comparable Single-Null discharges can be displaced outside the confined plasma, sitting stably between the primary and secondary X-point. This does not, however, provide benefits in terms of core confinement or core impurity screening, a behavior which is currently being interpreted using EMC3-EIRENE simulations and extended to higher power/SOL opacity conditions in both simulations and experiments. The beneficial effects of total flux expansion in Super-X L-mode plasmas fall short of Two-Point Model predictions, yet less so in the presence of baffles. These results are consistent with SOLPS-ITER simulations in an idealized setup [2] and more recent SOLEDGE2D-EIRENE runs closely matching the experimental setup [3], both highlighting the need for high-levels of divertor neutral trapping for optimized Super-X operation. Most high-power, H-mode detachment studies on TCV have focused on NBI heated X-Divertor and X-Point-Target divertors, both compared to a more conventional Single-Null. Stable, inter-ELM detachment is achieved with nitrogen seeding, with H98⊠1 throughout and little difference in core properties as divertor geometry is varied [4]. Inter-ELM, outer target heat fluxes are reduced by factors ⊠2 in the X-Divertor and X-Point-Target and, when combined with baffles and seeding, are shown to drop by ˜95% as compared to the unbaffled, unseeded Single-Null. These experiments are currently being extended to small-ELM regimes and discharges combining the maximum level of NBI and ECRH heating on TCV and first results will be presented.

In addition to the use of transport codes to interpret and extrapolate these experimental findings, we will also discuss recent progress on TCV in the validation of first-principles turbulence simulations, insights gained on divertor turbulence and transport, and first studies on their dependence on divertor geometry.

[1] S. Gorno et al., "Power exhaust of the baffled SF-LFS divertor in TCV", in preparation
[2] A. Fil et al., Plasma Phys. Control. Fusion 62 035008 (2020)
[3] C. Meineri et al., "Study of fully baffled super X L-mode discharges with PFR D2 fuelling on TCV", in preparation
[4] H. Raj et al., "Improved Heat and Particle Flux Mitigation in High Core Confinement, Baffled, Alternate Divertor Configurations in the TCV tokamak", in preparation
[5] D. S. Oliveira and T. Body et al., "Validation of edge turbulence codes against the TCV-X21 diverted L-mode reference case", in press

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