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Advanced divertor detachment in H-mode and baffled TCV plasmas

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Operating a tokamak fusion reactor in a highly dissipative detached divertor regime, whilst maintaining sufficient core confinement, remains a major challenge. It is likely that advanced divertor solutions will be required. Proof of principle experiments of such ideas, as well as the underlying physics processes, are being explored on the TCV tokamak. Previous studies in L-mode revealed a lower detachment threshold with increasing divertor leg length, ascribed mainly to changes in the SOL width, and deeper detachment and improved control of the CIII radiation front with increasing poloidal flux expansion (fx). In the Snowflake minus, as predicted by simulations, the position of the X-point radiator could be displaced outside of the core plasma, although benefits in terms of core confinement could not be demonstrated. Increasing the outer target major radius (Rt) by 70%, seemingly the most direct way towards improved detachment characteristics, did not reveal the expected benefits. These studies have now been extended to neutral beam heated, ELMy H-mode [1,2]. For a fixed core shape and X-point position, the L-H power threshold was found to be weakly dependent on divertor geometry. Partial detachment of the outer target could be achieved, although only at levels of nitrogen seeding that are marginally compatible with H-mode confinement. More resilience of the H-mode regime to seeding and a stronger reduction in target particle flux was observed when increasing fx by a factor 4, while a 40% increase in Rt revealed approximately 20% slower upstream movement of the CIII front. The overall dependences on divertor geometry are, however, found to be relatively modest in these plasmas.
These studies are expected to strongly benefit from the ongoing installation of divertor baffling structures on TCV. These baffles, which are compatible with a large variety of advanced divertor geometries [3,4], are expected to increase fuel and impurity compression in the divertor by an order of magnitude [4,5], which should facilitate detached H-mode operation. Furthermore, the baffles will aid in equalizing neutral trapping between different divertor magnetic geometries, found in recent SOLPS-ITER simulations to be necessary to isolate the effect of magnetic geometry, and in particular to recover the benefits expected of increasing Rt [6]. First results in baffled, advanced divertor geometries and comparisons to these predictions will be presented.

[1] J. Harrison et al., PPCF 61, 065024 (2019)
[2] C. Theiler et al., 27th IAEA-FEC, Gandhinagar, India (2018)
[3] H. Reimerdes et al., Nucl. Mat. Energy 12, 1106-1111 (2017)
[4] A. Fasoli et al., NF (2019), submitted
[5] M. Wensing et al., PPCF, https://doi.org/10.1088/1361-6587/ab2b1f, (2019)
[6] A. Fil et al., PPCF, ready to submit

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