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Investigation of detachment in Double-Null configurations in the TCV tokamak

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Plasma exhaust is a crucial issue for future fusion reactors. The high-power level across the separatrix needed to ensure H-mode operation and the narrow Scrape-off Layer (SOL) width make the task of staying within acceptable target heat loads extremely challenging, probably necessitating operation in a detached regime. In the past few years, significant efforts have been devoted towards the development of advanced divertor configurations that could facilitate access to such a regime. In particular, the double-null (DN) configurations may be an interesting and promising candidate. By magnetically separating the outer and the inner legs, DN configurations may allow the exhausted power to be shared between two outer legs, and, possibly, at two radiation fronts. Advanced geometries can then be applied to both active legs, together or separately, to increase the expected benefits.

In this work, we investigate detachment on TCV in DN geometries for a range of outer leg positions, including a double Super-X configuration, where the two outer strike points are located at high major radius. Measurements of the CIII emission front position along the lower outer leg show a movement at the front towards the X-Point at a lower line-integrated density $\langle n_e \rangle$ in the DN configurations, as compared to equivalent Lower Single Nulls (LSN), indicating a lower detachment threshold. This is further supported by Langmuir probe measurements at both outer strike-points. Bolometric measurements indicate that, for the same $\langle n_e \rangle$, a higher fraction (10% - 50%, depending on shape and $\langle n_e \rangle$) of the input power is radiated in these DN configurations. However, this enhanced accessibility of the detached regime appears to come at the price of a reduced detachment window. The double-null configurations disrupt at lower (between 10% - 20%) line-averaged densities than the equivalent LSN, after a swifter movement of the CIII front towards the X-Point. The sensitivity of these results to the magnetic balance of the double-null will also be discussed.

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