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SOL transport and detachment in alternative divertor configurations in TCV L- and H-mode plasmas

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The effect of magnetic geometry on scrape-off layer (SOL) transport and detachment behavior is investigated on the TCV tokamak with the goal of assessing the potential of alternative divertor geometries and for the validation of theoretical models. L-mode experiments reveal that increasing connection length and hence divertor volume by either increasing poloidal flux expansion or divertor leg length have different effects on the boundary plasma. In attached conditions, the SOL heat flux width l_q inferred from target infrared thermography measurements is weakly dependent on poloidal flux expansion but increases approximately with the square root of the divertor leg length. The divertor spreading factor S shows no clear trend with leg length but decreases with flux expansion. TOKAM3X turbulence simulations of the leg length scan are in qualitative agreement with the experiment and can explain observations by a strongly asymmetric (ballooning) transport at and below the X-point. Evidence for increased transport in the region of low poloidal field is obtained in the Snowflake minus geometry. The presence of an additional X-point in the low-field side SOL increases the effective SOL width by approximately a factor two.

Increasing flux expansion and leg length both result in enhanced divertor radiation levels, with the effect being much larger in the latter case. This behavior, together with the observed trend in l_q, is consistent with a substantial drop in the density threshold for divertor detachment with increasing leg length and a weak variation with flux expansion. Novel spectroscopic techniques reveal that the drop in target ion current and access to detachment is caused by a reduction of the divertor ionization source due to power starvation, while volume recombination is only a small contributor. This interpretation is confirmed by SOLPS modeling.

TCV alternative divertor studies are being extended to neutral beam heated H-mode plasmas. The H-mode power threshold is found to vary weakly between standard, X-, and Super-X geometries. In all cases, ELMy H-mode is obtained at intermediate current, while the discharges are ELM-free at high current. Signs of detachment have so far only been observed in the latter case. Ongoing experiments further investigate H-mode detachment in these plasmas and will be extended to Snowflake configurations.

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