Experimental characterization of divertor filamentary dependencies in TCV and comparison with first-principles turbulence simulations

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Plasma filaments at the tokamak outboard midplane are known to represent the dominant Scrape-Off Layer (SOL) cross-field transport mechanism. To predict the heat and particle flux distribution at the target plates, however, a detailed understanding of filament dynamics in the divertor, particularly around the magnetic X-point, is also required. Experimental investigations in TCV have been carried out by employing a recently installed suite of Gas Puff Imaging (GPI) systems [1] accessing the outboard midplane, the vicinity of the magnetic X-point and the divertor legs. In the divertor near-SOL, high frequency and circular Divertor-Localized Filaments (DLF) are observed, with spatial scales of ~15-20 ion sound Larmor radii and disconnected from upstream [2]. The radially outwards motion (v_r~ 0.4km/s) of the DLF is found to contribute significantly to cross-field particle transport. Consistent with this observation, 2D probe measurements show a broadening of the electron density profile in the region where DLFs appear. This detailed divertor fluctuation characterization is extended to a large parameter space [3], including scans in plasma current, safety factor, field direction and collisionality. DLFs appear as a generally observed feature but the poloidal location at which they occur depends on q_{95} through the magnetic shear impacting the decorrelation of upstream and divertor turbulence. Collisionality increases the amplitude, radial size and velocity of DLFs up until detachment onset, where DLFs disappear but the overall fluctuation level significantly increases in the divertor. These detailed measurements, combined with a new, synthetic helium GPI diagnostic [1], are used to compare size, velocity and poloidal distribution of SOL filaments between experiment and real-size, 3D turbulence simulations with the GBS code [4]. Velocity and poloidal distribution are shown to match reasonably well while filament sizes appear overestimated in the simulations. The effect of recent simulation improvements, such as the inclusion of a kinetic neutral population, will be discussed.

[1] N. Offeddu and C. Wüthrich et al., RSI **93**, 123504 (2022)
[2] C. Wüthrich et al., NF **62**, 106022 (2022)
[3] C. Wüthrich et al. 2023, in prep.
[4] D.S. Oliveira and T. Body et al., NF **62**, 096001 (2022)