The dynamics of filaments in attached and detached SOL conditions using 3D simulations

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Filaments are field aligned density and temperature perturbations, which provide a significant flux of particles and heat from the last closed flux surface to the far scrape-off layer (SOL). In order to design next generation tokamaks operating in high density regimes, it is beneficial to make robust predictions of wall fluxes, which requires understanding of these non-diffusive transport mechanisms in the presence of detached conditions.

We have carried out non-linear, three-dimensional simulations in a slab geometry, including neutral-plasma interactions, using the STORM [1, 2] module for BOUT++ [3], including self-consistent collisional parameters and fluid neutrals, that are co-evolved with the filament. The filaments are around the critical size, which is the perpendicular size for which filaments observe the highest radial velocity. The heat and particle influx is varied, generating self-consistent 1D parallel profiles without radial dependence. The high density simulation reproduce detached divertor conditions, featuring both a significant total pressure drop and target flux rollover.

Filaments were seeded on the backgrounds, and the resulting filament motion was studied. In attached conditions we found a strong target temperature dependence [2, 4] which is caused as the filament connects electrically with the target. In detached conditions the filament was found to be electrically insulated from the sheath, caused by a high resistivity in the cold area adjacent to divertor target.

A decreasing trend of the radial filament velocity with increasing density is observed, which is temporarily broken on the onset of divertor detachment, due to the filament becoming electrically insulated from the divertor target. This results in faster filaments, at least for filaments of critical size and larger. Further, the critical size increases with detachment, as sheath currents are suppressed. Detachment has been observed to coincide with shoulder formation [5], which could be explained by the increased radial velocity, and the associated decreased parallel transport caused by detachment.