SOL profile and fluctuations in different divertor recycling conditions in H-Mode plasmas

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Plasma Exhaust and Plasma Wall Interaction (PWI) are subjects of intense studies in the context of fusion energy research for the understanding of the amount of heat loads and the lifetime of different Plasma Facing Components. On this context in order to ensure reliable predictive edge modeling, it is mandatory to determine the transport properties of the Scrape Off Layer (SOL), a region which is largely influenced by the presence of turbulent filaments which contribute to particle and energy losses in both L and H mode. From the ITER divertor perspective, to keep the power fluxes acceptable for target material, high neutral pressure and partial detachment are needed to ensure maximum tolerable loads [1]. Thus experimental investigation of SOL transport needs to be extended to these regimes. In present experiments the regimes matching ITER divertor operational point are obtained with high gas throughput leading to high density regimes. In L-Mode these operational conditions are associated to the appearance of a *density shoulder* i.e. progressive flattening of the density scrape off layer profile at high density [2–4]. It has been proved that density shoulder appear starting from high-recycling regimes and become broader after target density rollover [5], even though differences have been observed depending on divertor geometry [6], or if high recycling conditions are achieved through impurity seeding rather than high fuelling [6, 7]. The density shoulder is actually accompained by an increase of the filamentary activity [4, 5, 7], together with an increase of their associated convective transport [4]. Preliminary investigations suggested that similar inter-ELM SOL density profile broadening is observed in H-mode as well [4, 5, 8], with a stronger dependence on the neutral pressure [5]. The possible increase of convective heat and particle fluxes to the wall poses serious issues in term of acceptable sputtering yeald of the first wall. In H-mode, in case of highly dissipative divertor with high gas throughput, the plasma changes its stability properties moving towards a small-ELM regime [9] where a clear increase of the SOL density decay length

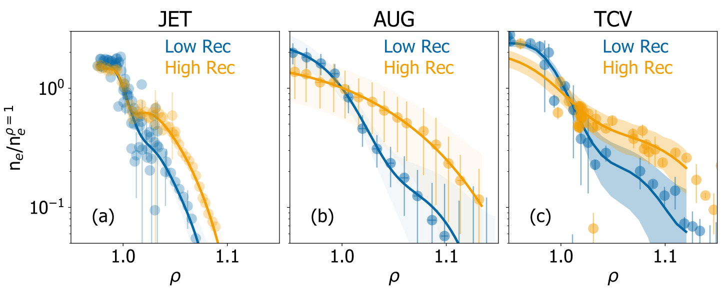

Figure 1: Upstream profiles, normalized with respect to values at the separatrix in different recycling conditions for JET (a), AUG (b) and TCV (c). In all the cases symbols represent raw data whereas the solid line represent a Gaussian Process Regression fit

is observed. Despite the large experimental effort, a comprehensive understanding of the mechanism leading to an H-mode shoulder formation is presently lacking and this motivated a joint experimental effort within Eurofusion framework. The present contribution will report results obtained in a coordinated effort within 3 different devices, JET, ASDEX-Upgrade (AUG) and TCV focusing on the SOL profile evolution in different divertor recycling states, correlating the observed profile modification with different turbulent SOL plasma transport.

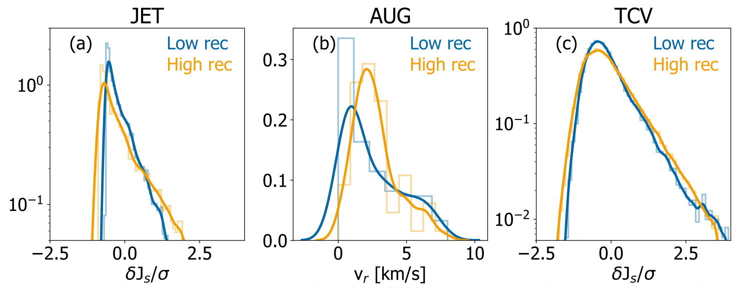

Figure 2: Fluctuation properties in different recycling states for the 3 devices:(a) PDF of Jsat fluctuations at the wall on JET (b) inter-ELM filament velocity in the far SOL from THB diagnostic (c) PDF of Jsat fluctuations at the wall on TCV

In JET, 2MA/2.3T low δ plasma with 16 MW of applied NBI power were analyzed, with different level of fueling exploring different divertor shapes in order to tackle the dependence of different neutral compression as well [10]. On AUG 0.8MA/2.5T scenarios at different power levels (from 3 to 17 MW) and different fuelling schemes were analyzed in order to explore a wide range of divertor parameters and recycling state. Finally on TCV high-δ low current (0.18 MA) discharges were investigated with an additional 1 MW of NBI heating with different fueling levels and locations. In all the devices we have been able to identify conditions where inter-ELM density profiles at different recycling states exhibit a clear profile broadening as shown in figure 1. In order to access possible contribution of SOL turbulence induced convective transport in modifying SOL profile, fluctuation in the main SOL and at the wall have been investigated using different diagnostics in the various machine as shown in 2. For AUG, filaments velocities of inter-ELM filaments have been determined using the Thermal Helium Beam diagnostic [11] and compared with the fluctuation observed in high-recycling state during the small-ELM regime. The comparison of the distribution function of these velocity is shown in 2 (b) and a clear increase of the filament velocity during high recycling state is observed. For TCV and JET we show the Probability Distribution Function (PDF) of the ion saturation current density J_s as measured at the wall by mean of embedded langmuir probe respectively in panels (a) and (c) of figure 2. In high density/high recycling state more skewed PDF are observed for both the machines suggesting an increase of the fluctuation induced convective transport towards the first wall. The contribution will provide a complete characterization of the explored conditions in all the 3 devices in terms of divertor properties, upstream profiles, SOL fluctuation and pedestal evolution in order to improve the understanding of SOL transport in ITER divertor relevant condition.

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