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

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Plasma Exhaust and Plasma Wall Interaction are subjects of intense studies in fusion energy research for the understanding of the amount of heat loads and the lifetime of Plasma Facing Components. In order to ensure reliable predictive edge modeling in this context, it is mandatory to determine the transport properties of the Scrape Off Layer (SOL), a region largely influenced by the presence of turbulent filaments which contribute to particle and energy losses in both L and H modes. 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. Presently the regimes matching the ITER divertor conditions are obtained with high gas throughput and high density. In L-Mode these conditions are associated with a *density shoulder* i.e. progressive flattening of the density scrape off layer profile at high density [2–4]. It has been shown 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], with an increase of their associated heat and particle transport [4]. Preliminary investigations suggested that similar inter-ELM SOL density profile broadening is observed also in H-mode [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 terms of acceptable sputtering yield of the first wall. In H-mode, with highly dissipative divertor, the plasma changes its stability moving towards a small-ELM regime [9] where a clear increase of the SOL density decay length is observed. Despite the large effort, a comprehensive understanding of the mechanism leading to an H-mode shoulder formation is presently lacking and this motivated a joint experimental program within the Eurofusion framework. The present contribution will show an unique com-

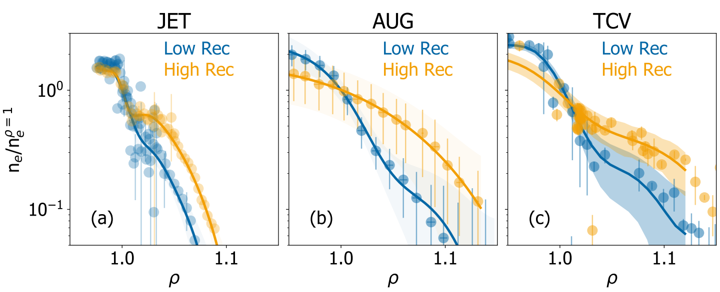

Figure 1: Upstream profiles, normalized with respect to values at the separatrix in different recycling conditions for JET (a), AUG (b) and TCV (c). In all the cases symbols represent raw data whereas the solid line represent a Gaussian Process Regression fit

parison of H-Mode SOL density shoulder properties across 3 different devices, JET, ASDEX-Upgrade (AUG) and TCV focusing on the SOL profile evolution in different divertor recycling states, correlating the profile modification with different turbulent SOL plasma transport.

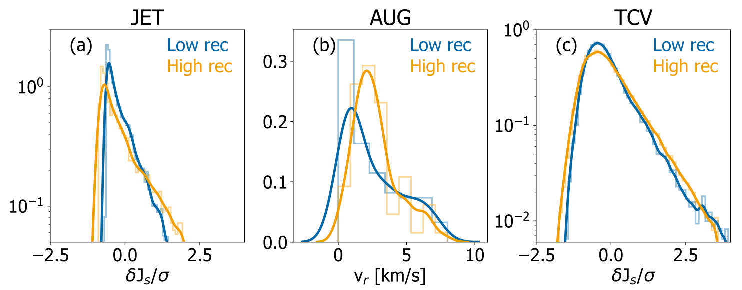

Figure 2: Fluctuation properties in different recycling states for the 3 devices:(a) PDF of Jsat fluctuations at the wall on JET (b) inter-ELM filament velocity in the far SOL from THB diagnostic (c) PDF of Jsat fluctuations at the wall on TCV

On JET, 2MA/2.3T low δ plasma with 16 MW of applied NBI power were analyzed, with different levels of fueling exploring different divertor shapes in order to tackle the dependence of 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 states. Finally on TCV high-δ low current (0.18 MA) discharges were investigated with 1 MW of NBI heating with different fueling levels and locations. In all the devices we have identified conditions where inter-ELM density profiles exhibit a clear profile broadening as shown in figure 1. To access the contribution of SOL turbulence in modifying the SOL profile, fluctuations in the main SOL and at the wall have been investigated as shown in 2. On AUG, filaments velocities of inter-ELM filaments have been determined using the Thermal Helium Beam diagnostic and compared with the fluctuations observed in high-recycling state during the small-ELM regime. The comparison of the Probability Distribution Function (PDF) of these velocities 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 PDF of the ion saturation current density J_s as measured at the wall respectively in panels (a) and (c) of figure 2. In high density/high recycling state more skewed PDFs are observed for both the machines suggesting an increase of the fluctuation induced convective transport towards the first wall. These experimental results form an excellent basis to benchmark SOL modelling under various conditions in differently sized machines, providing a more complete characterization of the explored conditions in terms of divertor properties, upstream profiles, SOL fluctuation and induced transport and pedestal evolution. These observations consequently will strongly contribute to improve the understanding of SOL transport in conditions relevant fo the ITER divertor operation.

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