SOL profile and fluctuations in different divertor recycling conditions in H-Mode plasmas: a cross-machine comparison

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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, tritium retention, and the lifetime of different Plasma Facing Components. On this context in order to ensure reliability of predictive edge modeling capability, it is mandatory to determine the transport properties of the Scrape Off Layer (SOL) in condition close to the operational point foreseen for ITER and future devices. From the ITER divertor perspective, to keep the power fluxes densities acceptable for target material, high neutral pressure and partial detachment are needed to ensure maximum tolerable loads based on avoidance of W recrystallization [1]. Thus experimental investigation of SOL transport needs to be extended also to these operational regimes. The SOL properties results from a competition between sources and losses parallel and perpendicular to the magnetic field: it is strongly dominated by the presence of turbulent filaments, which contribute to particle and energy losses both in L- and H-mode 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 condition 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]. Furthermore in case

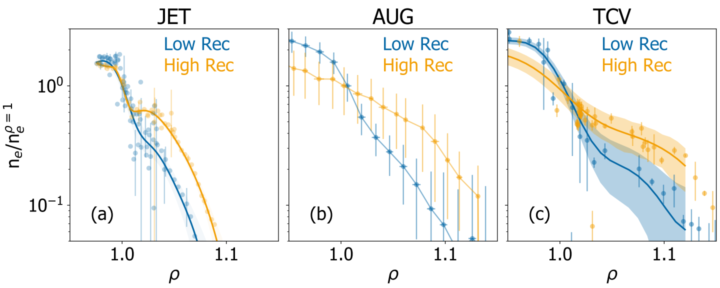

Figure 1: Upstream profiles, normalized with respect to values at the separatrix in different recycling conditions.(a): JET profiles, from Li-Be and HRTS data superposed to a Gaussian Process Regression fit. (b) AUG, profiles gathered using Li-Be diagnostic. (c) TCV, where symbols representes raw data as obtained combining Thomson Scatering and reciprocating probe whereas the solid line represent a Gaussian Process Regression fit

of highly dissipative divertor with high gas throughput the pedestal profile modification move the plasma towards a small-ELM regime [9] where a clear increase of the SOL density decay length 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.

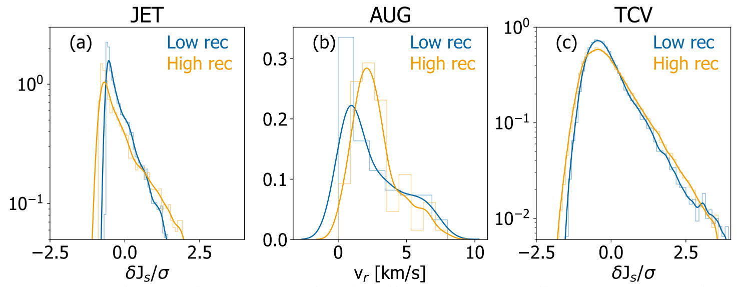

Figure 2: Fluctuation properties in different recycling states for the 3 devices:(a) PDF of Jsat fluctuations at the wall on JET (b) inter-ELM filament velocity in the far SOL from THB diagnostic (c) PDF of Jsat fluctuations at the wall on TCV

In JET, 2MA/2.3T low-δ plasma with 16 MW of applied NBI power were analyzed, with different level of fueling both exploring different divertor shapes in order to tackle the dependence of different neutral compression as well [10]. On AUG 0.8MA/2.1T 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 where different fueling levels and fueling schemes (main chamber or divertor fuelling) were used. 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 figgure 2. Clearly 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.

Acknowledgment

This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014 - 2018 and 2019 - 2020 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.

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