Density and temperature profiles in the Scrape-Off Layer interpreted through filament dynamics

F. Militello, J. Omotani, L. Appel, T. Farley, N. Walkden, J. Harrison, A. Kirk, B. Lipschultz, D. Moulton and A. Wynn

We developed a new theoretical framework to clarify the relation between radial Scrape-Off Layer density profiles and the fluctuations that generate them. The framework provides an interpretation of the experimental features of the profiles and of the turbulence statistics on the basis of simple properties of the filaments, such as their radial motion and their draining towards the divertor. L-mode and inter-ELM filaments are described as a Poisson process in which each event is independent and modelled with a wave function of amplitude and width statistically distributed according to experimental observations and evolving according to fluid equations. We will rigorously show that radially accelerating filaments, less efficient parallel exhaust and also a statistical distribution of their radial velocity can contribute to induce flatter profiles in the far SOL and therefore enhance plasma-wall interactions. A quite general result of our analysis is the resiliency of this non-exponential nature of the profiles and the increase of the relative fluctuation amplitude towards the wall, as experimentally observed. According to the framework, profile broadening at high fueling rates can be caused by interactions with neutrals in the divertor or by a significant radial acceleration of the filaments. The framework assumptions were tested with 3D numerical simulations of seeded SOL filaments based on a two fluid model. In particular, filaments interact through the electrostatic field they generate only when they are in close proximity (separation comparable to their width in the drift plane), thus justifying our independence hypothesis. In addition, we will discuss how isolated filament motion responds to variations in the plasma conditions, and specifically divertor conditions. Finally, using the theoretical framework we will reproduce and interpret experimental results obtained on JET, MAST.