Simulation of SOL turbulence in the ISTTOK tokamak

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Understanding scrape-off layer (SOL) turbulence is crucial for the success of the entire fusion program. SOL dynamics determines the overall confinement and performance of future tokamaks (such as ITER), governs the heat load on the vessel wall, regulates the impurity dynamics, the plasma refueling, and the removal of fusion ashes. While the use of numerical simulations has recently allowed some important advancements in the understanding of the plasma SOL dynamics, such as the identification of the mechanisms regulating the turbulence amplitude and the SOL width and the main turbulent regimes [1-4], our theoretical understanding still needs to be completely assessed by comparing it with a large set of experimental results.

In the SOL, the collision frequency is usually large, justifying the use of a fluid model. The amplitude of the fluctuations is comparable to the one of the background profiles, and occurs on scale lengths that are larger than the ion Larmor radius. As a matter of fact, the SOL region can be modeled by the drift-reduced Braginskii equations [5], which we solve by using the GBS code [6]. This evolves the evolution of the SOL plasma dynamics in three-dimensions, without separation between perturbations and equilibrium. Therefore, GBS is able to model the self-consistent formation of the plasma profile resulting from the plasma and heat outflowing from the core to the SOL, cross-field transport arising from turbulence driven by a number of instabilities, plasma flow along the field lines that is ultimately lost at the sheaths.

In this work, the GBS code has been ported to the SOL configuration of the ISTTOK tokamak. Experimentally, the ballooning character of turbulence in the SOL has been observed, with a clear distinction between LFS and HFS, including a poloidal variation of the parallel flow [7]. Because of its diagnostics, the ISTTOK tokamak allows a detailed comparison between simulations and experiments, and the assessment of our understanding of the plasma dynamics in this region.

Thanks to the use of GBS simulations, the evaluation of the linearly unstable modes and analytical investigations, we have theoretically investigated the turbulent regimes, the saturation mechanisms and the formation of the SOL profile in ISTTOK. Our theoretical predictions have then been compared with the ISTTOK experimental measurements.

[1] P. Ricci, et. al., *Physics of Plasmas* **20** 010702 (2013)
[2] F.D. Halpern, et. al., *Nuclear Fusion* **53** 122001 (2013)
[3] S. Jolliet, et. al., *Physics of Plasmas* **21** 022303 (2014)
[4] A. Mosetto, et. al., *Physics of Plasmas* **20** 092308 (2013)
[5] A. Zeiler, et. al., *Physics of Plasmas* **4** 2134 (1997)
[6] P. Ricci, et. al., *Plasma Phys. Control. Fusion* **54** 124047 (2012)
[7] C. Silva, et. al., *Plasma Phys. Control. Fusion* **53** 085021 (2011)