Investigation of transport barrier formation in edge turbulent simulations

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The formation of a transport barrier around the separatrix is a ubiquitous feature observed experimentally on tokamaks at high power forming the so-called H-mode characterized by an increased confinement of the energy and a reduction of the SOL width. ITER performances rely on this high confinement mode which is not yet fully understood. A key ingredient invoked to explain the formation of the barrier is the partial suppression of turbulent structures by sheared ExB flows localized near the separatrix whose intensity is controlled by the power. The sheared flows generated by the turbulence itself, the so-called zonal flows, could also play a role on the onset of the bifurcation from the low confinement L-mode to the H-mode. Today, in addition to the experimental observations, the understanding of the L-H transition relies on a tremendous effort to simulate numerically the formation of a transport barrier in a turbulent plasma. In these numerical investigations, different physical models are tested, fluid or kinetic, to find out which physical ingredients are necessary to trigger the L-H bifurcation.

In this contribution, we present the latest results obtained with the code SOLEDGE3X developed in the past few years relying on a drift-fluid description of the edge plasma. SOLEDGE3X is coupled to the kinetic code EIRENE to take recycling neutrals into account. The code has been used to simulate a power scan in a diverted plasma. At low power, a well-developed turbulence is observed with turbulent structures propagating freely from the closed field line region to the SOL. At higher power, a net suppression of turbulence is observed near the separatrix associated with an increase of the ExB shear. Radial oscillations of the radial electric field are also recovered in the closed field line region, reminiscent of experimental observations of stationary zonal flows during the barrier formation [1]. The dynamic of the formation of the barrier is discussed as well as the turbulence properties before and after the barrier formation.

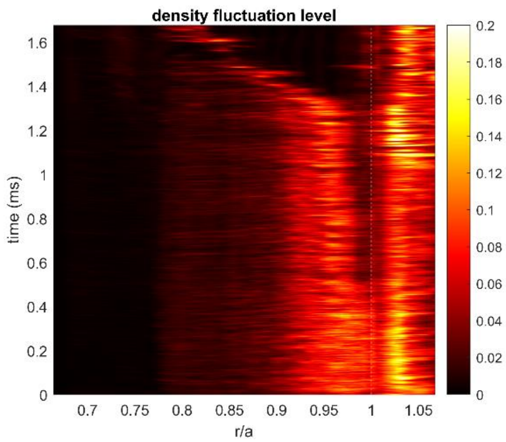

Figure 1: density fluctuations as a function of space and time. At t = 0.6ms, a hole in density fluctuations appears at the separatrix. For t > 1.2ms, the barrier characterized by a suppression of fluctuations propagates inward, from the separatrix to the core.

[1] J. C. Hillesheim et al., “Stationary Zonal Flows during the Formation of the Edge Transport Barrier in the JET Tokamak”, PRL 116, 065002 (2016)