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Impact of the transition from open to closed field lines on turbulent transport in tokamaks

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The edge of tokamak plasmas is characterized by large density and temperature gradients. The transport in this region is critical since it governs the energy content of the plasma, hence determining its overall performance in terms of fusion gain. In some cases, turbulent transport is locally reduced in the edge, leading to enhanced plasma confinement. The transition from a low confinement (L-mode) to a high confinement (H-mode) is routinely observed in most tokamak plasmas. The L to H mode transition is correlated with the deepening of the radial electric field well, possibly governing the shearing of turbulent structures and the subsequent reduction of turbulent transport. The origin of this sheared radial electric field is not fully understood yet, nor the precise mechanisms by which it impacts turbulent transport. However, the transition from closed to open field lines is clearly identified as a key ingredient for the formation of the electric field well at the edge.

In this presentation, the impact of the transition from closed to open field lines on the plasma is studied by means of global flux-driven simulations performed with the GYSELA code [1]. In the closed field lines of these simulations, trapped electrons and ions are treated kinetically whereas passing electrons are treated adiabatic. This model allows simulating a part of the electron response at a limited numerical cost. The interaction with the wall (limiter) is modeled via immersed boundary conditions in the gyrokinetic equation together with the consistent modification of the quasi-neutrality. In the scrape-off layer, electrons whose trajectories are touching the limiter are considered as adiabatic, with a Bohm response whereas the other electrons are treated kinetically.

In these simulations, a sheared radial electric field is observed to develop at the transition between closed and open field lines. The development of the electric field and of the edge turbulence depends on the position of the limiter (cf figure). This is in qualitative agreement with simulations obtained considering all electrons as adiabatic [2]. However, the particle transport allowed by considering a part of kinetic response for electrons, makes the simulations more challenging than the adiabatic electron simulations.

During the presentation, the model allowing these simulations will be detailed. The impact of these boundary conditions on edge turbulence will be discussed.

References
[1] V. Grandgirard *et al* Computer Physics Communications 207 (2016) 35–68
[2] G. Dif-Pradalier *et al.*, accepted in Communications Physics

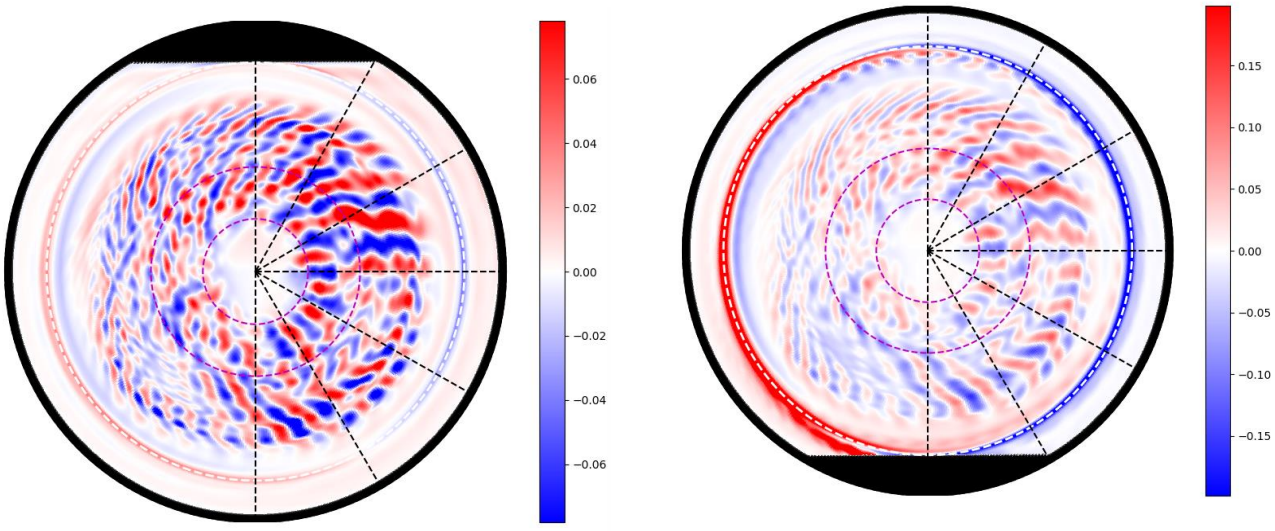

Figure: Electric potential fluctuations in presence of a limiter at the top or at the bottom of the plasma.