Impact of plasma shaping and negative triangularity on edge plasma turbulence and equilibrium in TOKAM3X simulations

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A better understanding of particles and energy transport at the edge of tokamak devices is mandatory for the design of future machines for both estimation of confinement time and wall interaction problematics. Future machines plan to adopt a strong shaping of the plasma to improve confinement and control of the pedestal. In particular, negative triangularity is currently considered as a possible option to obtain ELMs free H mode. However, this strong shaping is also observed to impact a critical parameter for heat deposition on the wall λ_q [1]. The recent development of 3D codes offers the possibility to address this question in a more systematic way.

In this contribution, we use the fluid edge electrostatic 3D code TOKAM3X to study the impact of plasma shaping on edge transport. This 3D turbulent code includes the physics suspected to play a significant role in the particle and energy transport (diffusion, drifts convection, turbulence) in arbitrary axisymmetric magnetic geometry [2]. Although TOKAM3X can handle full divertor geometry, we chose to study the separated impact of elongation κ and triangularity δ in limiter configuration as a first step towards the complexity of a full realistic geometry.

We start by analysing an elongation scan (κ = 1, 1.4, 1.7). For the same particle and energy fluxes imposed at the inner boundary of the domain, we observed that the total particle and energy content increases when elongation is raised due to an increase of radial gradients in the edge. Correlatively, this scan exhibits a decrease of λ_q at the outer target when elongation is increased in agreement with experimental results (e.g. on TCV [1]). A decrease of the radial turbulent transport of both particles and energy in the edge explains this trend. This reduction is mainly linked to a reduction in the fluctuation amplitude of potential and density fluctuations while their relative phase does not change in a significant way. Also, a higher radial shear of poloidal ExB velocity closer to the separatrix is observed for higher elongation cases.

A triangularity scan (δ = -0.5, -0.3, 0.0, 0.3, 0.5) has also been performed. Globally, triangularity is found to have a small impact on the plasma content compared with elongation. Moreover, the trend is much less regular. While negative triangularity leads to non negligible modifications in plasma turbulence and equilibrium, positive triangularity simulations exhibit a much milder trend. Negative triangularity reduces the radial turbulent transport of electron energy mostly in the scrape-off layer with, correlatively, a stronger radial shear of poloidal ExB velocity closer to the separatrix in comparison with the pure circular geometry. Consequently, λ_q at the outer target is reduced by 34% in comparison with the circular case. The trend is less important when we scanned positive triangularity: neither clear increase of turbulent transport nor increase of λ_q is observed. Finally, we discuss the correlation between confinement and λ_q in our database of simulations.

[1] F.Nespoli et al., NF **57** (2017)
[2] P.Tamain et al., JCP **321**, p.606-623 (2016)