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# Effect of triangularity and collisionality in global gyrokinetic simulations

P. Donnel[1], S. Brunner[1], L. Villard[1], C. Gheller[1], O. Sauter[1] and the TCV team[1]

[1] École Polytechnique Fédérale de Lausanne (EPFL), Swiss Plasma Center (SPC)

Pioneered in TCV [1] and confirmed in DIII-D [2], studies have experimentally observed that negative triangularity plasmas have a heat confinement time approximately doubled compared with plasmas with similar parameters but a positive triangularity. The fact that this improved confinement has been observed in two different devices is suggestive of its robustness. Negative triangularity tokamaks are therefore an interesting alternative to present tokamak geometries.

From a theoretical point of view, the improvement of the confinement in negative triangularity plasmas is not perfectly understood yet. Flux-tube gyrokinetic simulations performed with different codes [3, 4] have shown a reduction of the level of turbulence in the edge while almost no difference was predicted by these local codes in the core. This is due to the weak radial penetration of triangularity in the core of the plasma. The prediction of local gyrokinetic codes is different from the improvement of confinement on the whole plasma observed experimentally. A conjecture [5] has been proposed to explain the modification of confinement between positive and negative triangularity in the core. The reasoning is that negative triangularity indeed only improves confinement in the edge and that this improvement "propagates" in the core due to the profile stiffness. This hypothesis has already been studied with flux-tube simulations [4], but it is of interest to revisit the problem with flux-driven global gyrokinetic simulations. Experimental [1] and numerical [4] studies have also underlined the critical role of collisions on the improvement of confinement in negative triangularity plasmas.

In this context, a multi-species nonlinear collision operator has recently been derived and implemented in the global gyrokinetic code ORB5. This operator relies on an expansion of the distribution function in fluid moments to compute the Rosenbluth potentials. The operator is implemented using a Langevin approach to solve the Fokker-Planck equation corresponding to the collisional evolution of the distribution function. This numerical approach results in a light computational cost of the collision operator and a straightforward parallelization. This collision operator has been successfully benchmarked against neoclassical physics.

The ORB5 code enhanced with this collision operator has now been applied to assess the combined impact of triangularity and collisionality on turbulence. The preparation of the code for this study and the status of results obtained so far will be presented.

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