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TH/P7-09: Towards Turbulence Control via EGAM Excitation & Vorticity Injection

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Any means towards turbulence control would be highly beneficial to fusion reactors. Experimentally, fusion plasmas can exhibit spontaneous transitions towards high confinement regimes characterized by local reduction of turbulent transport. The resulting transport barriers exhibit complex dynamics: they can expand and/or move adiabatically, but they can also experience sudden relaxations, either quasi-periodic like Edge Localized Modes or definitive. The shear of the radial electric field dE_r/dr, by tearing apart convective cells, is one of the generic mechanisms which are advocated for such transport bifurcations. However, first principle gyrokinetic models do not reproduce these experimental evidences so far. Such inherently multi-scale physical mechanisms clearly require global simulations.

In this paper, we report on important progresses in this direction obtained by means of flux-driven global gyrokinetic simulations. The 5D gyrokinetic GYSELA code is used, which evolves the entire ion distribution function coupled to quasi neutrality. Importantly, no scale separation assumption is assumed, so that equilibrium profiles and fluctuations evolve self-consistently. All electrostatic branches of the Ion Temperature Gradient (ITG) driven turbulence are modeled with adiabatic electrons.

Two experimentally relevant turbulence control mechanisms are unveiled. First of all, vorticity injection efficiently generates a sheared radial electric field, which leads to a barrier for both heat and momentum transport. Interestingly enough, this barrier exhibits an oscillatory relaxation dynamics, which bears some analogy with ELM-like events (Edge Localized Modes). Secondly, a heat source specifically designed to generate a fast particle population is found to durably excite EGAMs (Energetic Geodesic Acoustic Modes), even in the saturated turbulent regime. The resulting dE_r/dr is then shown to impact both neoclassical transport and ITG turbulence.

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