Role of intrinsic and external torque in ion profile de-stiffening and transport barrier formation: A gyrofluid simulation study

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The challenge presented by the projected core profile stiffness in ITER is re-kindling interest in ITB dynamics and 'profile de-stiffening' at zero or low external torque. This naturally forces us to confront questions pertinent to intrinsic rotation physics in these regimes. Recent gyrofluid simulations clearly demonstrated the importance of intrinsic rotation to torque free, reversed shear ITB dynamics [1]. In particular, we noted that the intrinsic toroidal velocity shear is the largest contribution to the total ExB shear, even at high heating power. Here, we extend the analyses by including an external torque. First, we demonstrate the importance of turbulence-driven intrinsic torque by applying an opposite direction external torque and observing the subsequent barrier destruction. Second, we study the relative efficiency of external and intrinsic torques in barrier formation and maintenance by comparing profile structure and barrier evolution for different τ_{ext}/P_{in} ratios (τ_{ext} : external torque, P_{in} : input heating power). The results here are likely to depend on q-profile structure and the target density profile. Care must be taken to distinguish between a 'true ITB' resulting from a clear, feedback-driven transport bifurcation as opposed to a regime of reduced profile stiffness. Quantitative tests to distinguish these two limits include studies of stiffness exponents and coefficients, as well as identification of highly localized regime of abrupt change in the profile slope (i.e. profile corners). For all these reasons, we give special attention to regimes of flat q. In this work, we address these questions by performing global gyrofluid simulations with varying external power, torque, and q-profiles. We aim to quantify relevant physical quantities which are responsible for the effectiveness of ITB (or reduced profile stiffness) development.

[1] S. S. Kim et. al., Intrinsic rotation, hysteresis and back transition in reversed shear internal transport barriers, submitted to Nucl. Fusion.