Modeling of L-mode plasma intrinsic rotation in ASDEX Upgrade

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In tokamak plasmas, finite toroidal rotation velocities are observed also in the absence of external sources of torque. This phenomenon is known as intrinsic rotation and can be shown to arise from a component of the stress tensor not related to either viscosity or convection, which appears when the plasma poloidal symmetry is broken. In L-mode diverted plasmas in ASDEX Upgrade, the intrinsic rotation reverses the direction in the core twice, from co- to counter-current and backwards, with increasing electron density [1, 2].

In this work we investigate the effect of non-zero averaged parallel wavenumbers of plasma turbulence like TEM and ITG as a consequence of finite tilting angles of turbulent structures. We model L-mode plasma experiments in the ASDEX Upgrade tokamak with the ASTRA code [3, 4], coupled to the TGLF transport model [5] and the drift-kinetic solver NEO [6]. Using TGLF linear turbulent spectra, we estimate the values of the tilting angles and the averaged parallel wavenumbers necessary to match the experimental rotation profiles, and compare those to the results of global non-linear gyrokinetic simulations with the GKW code [7], as well as to analytical calculations. We show the reduction of turbulent heat fluxes at larger tilting angles, while the resulting temperature profiles are still in good agreement with the experiment. As reported previously [8], the impurity concentration is a critical parameter for ITG instability, so it is modelled carefully in this work. We set boron as the main impurity, since it is intrinsic to AUG, and define its average content with an experimental scaling. Our simulations show that its concentration profile evolves from noticeably hollow to almost flat during the density ramp-up.