Intrinsic toroidal rotation mechanisms tested against ASDEX Upgrade observations

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The quantitative prediction of intrinsic toroidal rotation caused by turbulent momentum transport presents one of the major current challenges in the theoretical understanding of tokamak plasmas. A combined theoretical and experimental effort of addressing a comprehensive and systematic comparison of the predictions of many intrinsic momentum generation mechanisms is made against dedicated ASDEX Upgrade experiments, will be presented. The database comprises of 190 observations of Ohmic L-mode plasmas [1]. These observations are compared with gyrokinetic turbulence simulations using the nonlinear gyrokinetic turbulence code GKW [2], which has been increasingly upgraded to include the symmetry breaking mechanisms that are most important for describing the turbulent momentum flux.

Global turbulence simulations run with kinetic electrons reproduce the large flow gradients and hollow flow profiles seen in the majority of experiments. It is shown that the dominant mechanism is profile shearing [3] and that the scaling of the turbulent flow with the ion gyroradius is weak. When an adiabatic electron model is used, flow profiles reverse and become peaked, contrary to observations.

In addition, quasilinear and nonlinear local simulations are used to study further symmetry breaking mechanisms that are well described in the flux tube model. These include neoclassical background flow effects, up-down magnetic equilibrium asymmetry, higher order poloidal derivatives and Coriolis effects. The sum of these symmetry breaking mechanisms predict mostly hollow rotation profiles, as observed, but sustain smaller gradients than those in the global simulations [4]. However, when added to the global results, the total predicted rotation gradients result in improved agreement with experimentally measured values.

References