Density Impact On Toroidal Rotation In Tore Supra: Experimental Observations And Theoretical Investigation

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Rotation reversals have been reported in several machines, the direction of this reversal depends on the tokamak configuration. From co- to counter-rotation direction with respect to the plasma current on diverted plasmas, such as in ASDEX-Upgrade [1], C-mod [2] or TCV [3]. However, in limited plasmas, the inversion is reported to occur from counter- to co-rotation, TCV [4]. The explanation for this abrupt switch on core toroidal rotation is not fully understood but has been linked to changes in density, plasma current, magnetic field and plasma shape. Specifically, rotation reversal would occur at the transition from LOC to SOC regime [5] and the change in turbulence would be the key factor. In ASDEX-Upgrade, the turbulence regime has been linked with this reversal occurrence when close to the transition between TEM and ITG [1]. Nonetheless, recent studies [6] indicate that changes in momentum transport do not correlate with changes in linear mode dominance.

To further clarify the above mentioned subjects, plasma rotation analysis has been performed for Tore Supra limited ohmic plasmas. The physical mechanisms behind the rotation bifurcation will be investigated, mainly the possible influence of sawtooth activity, a comparison with neoclassical predictions and the role of turbulence on such observations. This paper reports on the density impact on toroidal rotation studied during density ramps in Tore Supra ohmic plasmas combined with stationary density experiments. In Tore Supra, at all radii the rotation is in the counter-current direction, reduced when density increases. However, in the plasma core ($r/a<0.5$) the plasma accelerates at $n_l \sim 3 \times 10^{19} m^{-2}$ to break again at $n_l \sim 3.5 \times 10^{19} m^{-2}$. Experimental results showing toroidal rotation breaking at all radii is in agreement with neoclassical predictions including ripple-induced toroidal friction [7]. Nonetheless, the modification of the core rotation is not reproduced by neoclassical predictions. The core rotation behavior could not be correlated to sawtooth activity, which could suggest a probable change on the turbulence driven contributions to justify this deviation from neoclassical predictions. This possibility has been analyzed using quasi-linear gyrokinetic simulations by the QuaLiKiz code.

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