Experimental demonstration of an up-down asymmetry effect on intrinsic rotation in the TCV tokamak

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A new mechanism was recently proposed that generates a radial flux of parallel momentum in toroidal plasmas. Namely, by considering up-down asymmetric flux surfaces, the symmetry following the magnetic field can be broken and an additional contribution to the turbulent momentum flux arises. This mechanism was thoroughly investigated using the gyrokinetic flux-tube code GKW and shown to be large enough to potentially modify the rotation profile. These predictions were then tested with specific experiments on TCV. The intrinsic toroidal rotation profile from CXRS is shown in Fig. 1, showing that the central toroidal rotation is modified by roughly a factor of two between the asymmetric plasma shapes. More precisely, the toroidal rotation gradient changes in the outer part of the plasma, where the flux surface asymmetry is highest, whilst remaining constant at the plasma centre where the flux surfaces are up-down symmetric. Note that, to within experimental uncertainty, the edge rotation is identical for the two configurations, excluding an effect of possibly different boundary conditions. The experiments were performed for all combinations of the toroidal magnetic field and plasma current directions, \( s_b = \pm 1 \) and \( s_j = \pm 1 \) respectively, and plasma shapes, \( s_s = 1 \) (blue) and \( s_s = -1 \) (red) as shown in Fig. 1. The localisation of the effect in the outer part of the plasma, its rate of decrease towards the centre and the dependence on \( s_b, s_j, \) and \( s_s \) are all consistent with the predictions of the gyrokinetic simulations. Furthermore the magnitude of the effect is also in the range predicted by linear simulations. A non-negligible dependence of the up-down asymmetry flux on the wave vector of the micro-instabilities, will necessitate nonlinear simulations for more quantitative comparisons.

Figure 1: Up-down asymmetry and toroidal rotation profile.