Characterisation of the core poloidal flow structure at ASDEX Upgrade

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In tokamaks, the toroidal rotation (υtor) is essentially a free parameter that is usually, i.e. in H-modes with neutral beam injection (NBI) heating, dominated by the external momentum input from the NBI sources. The poloidal rotation (υpol), on the other hand, is strongly damped due to the motion of the particles from the low-field-side (LFS) to the high-field-side (HFS) and the associated magnetic pumping effect [1,2].

Recent studies on DIII-D show that at low collisionalities υpol is significantly higher in the plasma core than expected from neoclassical theory [3]. At higher collisionalities, however, a rather good agreement between experiment and theory has been found at TCV [4], which is qualitatively in good agreement with previous observations of υpol in the edge of ASDEX Upgrade [5]. The poloidal rotation enters directly the radial force balance (see equation (1)) and, is, therefore, a critical parameter for understanding the transport in the core of tokamak plasmas [6].

\[ E_r = -\frac{\nabla p_\alpha}{e Z_\alpha n_\alpha} - \upsilon_{pol,at} B_{tor} + \upsilon_{tor,at} B_{pol} \] (1)

One diagnostic providing a direct measurement of all terms necessary for the measurement of the radial electric field (Er) is Charge eXchange Recombination Spectroscopy (CXRS). It measures the line radiation of low-Z impurities in the plasma enabling a measurement of the impurity temperature (Tα), density (nα) and rotation (uα). The direct observation of upol, however, rather difficult due to the dependency of the charge exchange cross-sections on the collision energy leading to an apparent rotation in the poloidal plane [7,8].

According to neoclassical theory, the general plasma flow can be expressed as the sum of a component parallel to the magnetic field and a purely toroidal rigid body rotation: \( \hat{u} = \hat{u} \hat{B} + \omega R \hat{\omega}_{tor} \), where \( \hat{u} \) and \( \omega \) are two flux functions. By measuring the toroidal rotation on two distinct points on the same flux surface, the whole plasma flow can be measured and, hence, providing an indirect measurement of upol [9] which is not affected by atomic physics effects. This technique enables a very accurate measurement of upol with an error of \( \pm 1 \) km/s [4,10].

This poster will present a recently built poloidal rotation database showing that the observed upol values at ASDEX Upgrade agrees with Neoclassical predictions over a wide parameter range. Additionally the evolution of upol and the resultant Er profile will be shown in interesting plasma scenarios like the reversal of the intrinsic rotation in Ohmic L-modes plasmas and during MHD events (like sawteeth and internal transport barriers).