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EX/2-1: Connections Between Intrinsic Toroidal Rotation, Density Peaking and Plasma Turbulence Regimes in ASDEX Upgrade

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Recently, ASDEX Upgrade has made significant contributions to momentum transport studies thanks to the upgrade of the core charge exchange recombination spectroscopy system, which now produces much higher quality ion temperature and toroidal rotation profiles. This upgrade enabled the development of an intrinsic rotation database that contains over 200 observations. The edge rotation on AUG is always co-current, while the core rotation can be either co- or counter-current directed. The latter results in a null point in the profile at finite rotation gradient, which is clear evidence of a localized residual stress momentum flux. Moreover, the Mach number in the center of the plasma appears to be determined largely by the normalized gradient of the toroidal rotation at mid-radius, u'. This correlation holds for all of the observations regardless of plasma confinement regime or type of auxiliary heating. Further examination of the database reveals that u'exhibits the strongest correlation with the local logarithmic electron density gradient, R/Lne: hollow rotation profiles coincide with peaked n_e profiles, while co-current rotation corresponds to low R/Lne. The known relationship between density peaking and plasma turbulence suggests a connection between the turbulence and the intrinsic rotation behavior as well. A study based on local linear gyro-kinetic calculations found good quantitative agreement between the predicted and measured values of u'through the imposition of a finite tilting angle of -0.3 radians on the turbulent mode structure. The mechanism expected to produce such a tilting is a combination of ExB and profile shearing residual stress. These database results are also consistent with observations of residual stress in non-intrinsic rotation scenarios. Flat to hollow rotation profiles are observed concomitant with peaked electron density profiles when sufficient ECRH power is added to NBI heated H-modes causing the turbulent regime to transition from ITG to TEM. Momentum transport analyzes of these plasmas show that the observations can only be explained by the presence of a core localized, counter-current directed, residual stress induced torque of the same order of magnitude as the applied NBI. These results have important implications for torque modulation experiments, which often assume that the residual stress is negligibly small.

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