NBI Modulation Experiments to Study Magnetic Field Induced Ripple Torque and Momentum Transport on JET

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Accurate and validated tools for torque calculation, including the magnetic ripple, are necessary to make reliable predictions of toroidal rotation for current and future experiments. We use discharges from a dedicated experimental session on JET where neutral beam modulation technique is used to create a periodic perturbation both to torque and rotation profile. Comparing two otherwise similar plasmas except one with normal JET ripple (δ=0.08%) and one with enhanced ripple (δ=1.5%), one can deduce the torque profile induced by the NBI fast ion losses caused by the ripple. This method allows us to benchmark the time dependent torque calculations from the ASCOT code [1]. Good agreement in the NBI torque profile between the calculation and experimentally deduced torque is found, indicating the effect of ripple on NBI fast ion induced torque is calculated accurately in ASCOT.

The second topic of this paper, also based on NBI modulation experiment is to study the parametric dependencies of the inward momentum pinch and the Prandtl number in JET plasmas. Parametric scans to study the magnitude of the inward momentum pinch on the density gradient length R/L_n, collisionality, q-profile and L- versus H-mode are presented. Neither the pinch (Rv_{pinch}/χ_ϕ) nor the Prandtl number is found to depend on collisionality, consistent with the linear gyro-kinetic simulations with GS2 code [2]. The most pronounced dependence of the momentum pinch is on R/L_n from which one obtains the following scaling: $Rv_{pinch}/\chi_\phi = 1.2R/L_n + 1.4$. This trend with R/L_n is qualitatively consistent with linear GS2 and GKW [3] simulations. There is small decrease in Rv_{pinch}/χ_ϕ with increasing q, but the dependence is practically within the error bars. In L-mode plasmas, the Prandtl number averaged over $0.4 < r/a < 0.8$ is typically above 2 while it is below 2 in H-mode plasmas.

[1] J.A. Heikkinen *et al.*, Journal of Computational Physics **173**, 527 (2001).
[2] N. Kluy *et al.*, Phys. Plasmas **16**, 122302 (2009).
[3] A.G. Peeters *et al.*, Comp. Phys. Comm. **180**, 2650 (2009).