Analysis and prediction of momentum pinch in spherical tokamaks

W. Guttenfelder[1], A.R. Field[2], T. Tala[3], S.M. Kaye[1], J.-K. Park[1], M. Peters[4], Y. Ren[1], W.M. Solomon[1]

[1]Princeton Plasma Physics Laboratory, Princeton NJ 08543, USA
[2]CCFE, Culham Science Centre, Abingdon, Oxfordshire OX14 3DB, UK
[3]VTT, P.O. Box 1000, FIN-02044 VTT, Espoo, Finland
[4]Indiana University, Bloomington, IN 47405, USA

E-mail: wgutten@pppl.gov

Previous perturbative measurements in NSTX H-modes indicated the existence of an inward momentum pinch. Assuming that $\Pi_\varphi = nmR^2(-\chi_\varphi \nabla\Omega + V_\varphi \Omega)$, where Ω is the measured toroidal angular rotation rate, Π_φ is the momentum flux determined from TRANSP and V_φ is the pinch velocity, the pinch parameter was found to be RV_φ/χ_φ = (-1) – (-7) [1]. Local, quasi-linear gyrokinetic predictions of ITG instability including the Coriolis drift [2] provide a reasonable explanation of the momentum pinch in conventional tokamaks [3]. However, the Coriolis effect predicts near zero or outward pinch for the NSTX H-modes (in contrast to experiment) due to ballooning modes at relatively high beta (β_T=12-16%) [4].

To provide an additional test of momentum pinch theory at low aspect ratio, similar experiments were performed in MAST L-mode plasmas at relatively low beta, thereby eliminating the complexity of electromagnetic effects at high beta. These experiments were conducted during the final MAST campaign (2013) using applied n=3 RMP fields to perturb the plasma rotation. The time-dependent response of the rotation after the RMP field is removed is used to infer both momentum diffusivity and pinch. The inferred pinch values, RV_φ/χ_φ=(-2)-(-11), are similar to those found in conventional tokamaks and NSTX H-modes. Gyrokinetic predictions are beginning to determine if a discrepancy in predicted momentum pinch is found at these lower beta conditions. A similar L-mode experiment is planned for NSTX-U in 2016. This work is supported by US DOE contract DE-AC02-09CH11466, and the RCUK Energy Programme and EURATOM.

[1] W. Solomon et al., Phys. Rev. Lett. **101**, 065004 (2008); Phys. Plasmas **17**, 056108 (2010); S.M. Kaye et al., Nucl. Fusion **49**, 045010 (2009).
[2] A.G. Peeters et al., Phys. Rev. Lett. **98**, 265003 (2007); Nucl. Fusion **51**, 094027 (2011).
[3] T. Tala et al., IAEA FEC ITR/P1-19, San Diego (2012).
[4] W. Guttenfelder et al., APS-DPP, NP8/15, Denver, CO (2013).