Analysis and prediction of momentum pinch in spherical tokamaks

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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 $RV_\varphi/\chi_\varphi = (-1) - (-7)$ [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 kinetic ballooning modes that are predicted to be unstable at relatively high beta (β_T=12-16%) [4].

To provide an additional test of momentum pinch theory at low aspect ratio, plans were made to perform similar experiments 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 the upcoming run.

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