Dependence of intrinsic rotation on collisionality in MAST*

J. C. Hillesheim[1], F.I. Parra[2], M. Barnes[2,3], M. Carr[1], N. A. Crocker[4], H. Meyer[1], W. A. Peebles[4], R. Scannell[1], A. Thornton[1], and the MAST Team[1]

[1]*Culham Centre for Fusion Energy, Culham Science Centre, Abingdon, Oxon OX14 3DB, United Kingdom*
[2]*Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford, UK*
[3]*University of Texas, Austin, Austin, Texas 78712, USA*
[4]*University of California, Los Angeles, Los Angeles, California 90095,USA*
jon.hillesheim@ccfe.ac.uk

Abstract. Tokamak plasmas rotate intrinsically, even when there is no external injection of momentum. Experimentally, the toroidal rotation due to intrinsic rotation can be of similar magnitude as the rotation induced by a neutral beam injection source, which can stabilize instabilities like resistive wall modes and affects turbulent transport through rotation shear. A sixteen channel Doppler backscattering (DBS) system has been installed on MAST, enabling the study of intrinsic rotation in Ohmic plasmas. DBS measurements were obtained over a range of Ohmic plasma conditions, where spectroscopic measurements were not available. This included observations of intrinsic rotation reversals coincident with relatively small changes to line-averaged density, which is the first time this phenomenon has been seen in a spherical tokamak. A database with good DBS data covering line-averaged densities 1.0 $< \overline{n_e}/(10^{19}\ m^{-3}) < 4.0$ and plasma currents 400 kA $< I_p <$ 900 kA was obtained at B_t=0.5 T. The data set includes both asymmetric lower single null and balanced up-down symmetric plasmas, as well as both L-mode and H-mode plasmas. The intrinsic rotation reversal densities were observed to scale linearly with I_p, similar to conventional tokamaks. We compare the data to a 1D analytical model, which captures the collisionality dependence of the radial transport of toroidal angular momentum due to finite drift orbit effects on turbulent fluctuations. The model is able to accurately reproduce the change in sign of core toroidal rotation, using experimental profiles from shots with rotation reversals as inputs and no free parameters fit to experimental data. The result of comparing the model over the MAST Ohmic intrinsic rotation database shows reasonably good agreement, with the model correctly predicting the sign of core rotation in about 80% of cases where a clear comparison was possible.

* This work was supported by the RCUK Energy Programme under grant EP/I501045, the European Union's Horizon 2020 programme, and the US Department of Energy under DE-FG02-99ER54527. The views and opinions expressed herein do not necessarily reflect those of the European Commission.