JET Intrinsic Rotation Studies and predictions for ITER

M.F. F. Nave[1], T. Johnson[2], L.-G. Eriksson[3] , C. Giroud[4], M.-L. Mayoral[4], J. Ongena[5], R. Sartori[6], F. Rimini[8], T. Tala[7], M. Tsalas[8], P. de Vries[9], A. Salmi[7], JET-EFDA Contributors[8]

JET-EFDA, Culham Science Centre, OX14 3DB, Abingdon, UK

[1]Associação EURATOM/IST, Inst. de Plasmas e Fusão Nuclear-Laboratório Associado, Inst. Superior Técnico, Lisbon, Portugal
[2]Association EURATOM - VR, Fusion Plasma Physics, EES, KTH, Stockholm, Sweden
[3]European Commission, Research Directorate General, B-1049 Brussels, Belgium
[4]UKAEA/Euratom Fusion Association, Abingdon, U. K.
[5]ERM-KMS, Association EURATOM-Belgian State, Brussels, Belgium
[6]Fusion For Energy Joint Undertaking, Barcelona, Spain
[7] VTT Association Euratom-Tekes, VTT, Finland
[8]EFDA-JET CSU-Culham, Abingdon, U.K.
[9]FOM Institute for Plasma Physics, Rijnhuizen, Association EURATOM-FOM, the Netherlands
[8]See the Appendix of F. Romanelli et al., Proc. 22nd Fusion Energy Conf. Geneva, Switzerland, 2008

Intrinsic rotation is considered to play a key role in the performance of toroidal plasma reactors where the momentum input will be small. Using the unique capability of JET to monotonically change the amplitude of the toroidal magnetic field ripple, without modifying other relevant equilibrium conditions, the effect of the ripple on the angular rotation frequency of the plasma column was investigated under the conditions of no external momentum input. In order to separate ripple fast-ion effects from thermal ion effects and to test existing ripple transport models, plasma rotation was measured in Ohmic and in ICRF heated plasmas with ripple levels varied from 0.08% to 1.5%. In both cases the ripple causes counter rotation, indicating a strong torque due to non-ambipolar transport of thermal ions and in the case of ICRF also fast ions. JET intrinsic rotation measurements in H-mode plasmas do not fit the multi-machine intrinsic rotation scaling law of [1] that has previously predicted a substantial intrinsic co-current rotation for ITER.

With the standard low ripple value of 0.08%, JET plasmas with large ICRF heating power and normalized $\beta \approx 1.3$, have a very small co-current rotation, in clear contradiction with the scaling law of [1] that would extrapolate to roughly 10 times a higher Alfven-Mach number for the same β value. At ITER-relevant ripple values of 0.5%, JET H-mode plasmas with ICRF heating are hardly rotating, while at 1% ripple, H-modes were observed to counter-rotate (see figure). JET results suggest that ripple can have a large impact in the rotation in ITER and, it should be taken into account in extrapolation from present data.

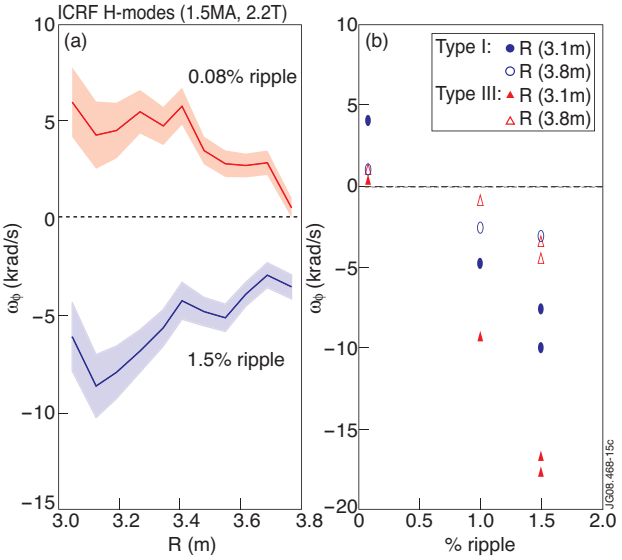

Fig (a) -C toroidal rotation angular frequency profiles for ICRF heated H-mode plasmas.
(b)- C toroidal rotation angular frequency as a function of ripple for ICRF heated H-modes.

[1] J.E.Rice et al, Nuclear Fusion 47 (2007) 1618