The influence of Toroidal Field Ripple on the formation and performance of Internal Transport Barriers at JET

P.C. de Vries[1], E. Joffrin[2], X. Litaudon[3], C.D. Challis[1], K-D. Zastrow[1] J. Brzozowski[4], J. Hobirk[5], M Brix[1], N.C. Hawkes[1], C. Giroud[1], Y. Andrew[1], M. Beurskens[1], K. Crombé[6], T. Johnson[4], J. Lönnroth[8], V. Yavorskij[9] and JET EFDA Contributors[§]

[1]EURATOM/UKAEA Fusion Association, Culham Science Centre,. OX14 3DB, Abingdon, UK
[2]EFDA-JET CSU, Culham Science Centre, ABINGDON, Oxfordshire, OX14 3DB, UK
[3]Association EURATOM-CEA, DSM/DFRC, CEA Cadarache, 13108, St. Paul lez Durance, France
[4]Association EURATOM - VR, Fusion Plasma Physics, EES, KTH, Stockholm, Sweden
[5]Max-Planck-Institute für Plasmaphysik, Euraton Association, 85748, Garching, Germany
[6]Departement of Applied Physics, Ghent University, Ghent, Belgium
[7]VTT Technical Research Centre of Finland, EURATOM-Tekes, Espoo, Finland
[8]Association Euratom-Tekes, Helsinki University of Technology, P.O. Box 4100, 02015 TKK, Finland.
[9]Institute for Theoretical Physics, Association EURATOM-OEAW, University of Innsbruck, Austria
[§]See Appendix of M.L. Watkins, et al., Fusion Energy 2006 (Proc. 21th Int Conf. Chengdu) IAEA (2006)

The toroidal field (TF) ripple of ITER will differ from JET due to a lower number of TF coils. Ferrite material will be mounted between the ITER coils in order to reduce the ripple. Nevertheless, the estimated TF ripple in ITER is in the order of δ~0.5% (i.e. the toroidal variation of the magnetic field at the outer separatrix) which is higher than that at JET (δ~0.08%). The question arises if a larger TF ripple may affect the formation and performance of internal transport barriers (ITBs). Firstly, because a larger TF ripple is expected to reduce the toroidal rotation and consequently affecting the rotational shear. Secondly, the TF ripple may act on the H-mode pedestal and edge Localised Modes (ELMs) which have been found to degrade ITBs.

TF ripple amplitude at JET was varied by independently powering the odd and even-numbered toroidal field coils. The imbalance current between the two coil-sets can be changed arbitrarily increasing the toroidal field ripple up to δ~3%. A series of experiments has been carried out analysing the effect of TF ripple on ITBs. Two types of scenarios have been studied: ITBs formed with negative or reversed magnetic shear and those formed in low positive shear profiles.

Smaller ELMs were observed in discharges with larger TF ripple however this did not have a clear beneficial effect on the ITB. An Increased TF ripple led to a modification of the toroidal rotation profile. In these cases the outer part of the plasma was found to rotate in counter current direction, while in the core still rotated in the direction of the NBI (co-direction). The area of counter rotation reached up to ρ=0.5 for δ~1%, which was close to the ITB position in these discharges and the rotation gradient was reduced in this area.

The initial formation of an ITB (trigger) was observed in all discharges with reversed shear. However, high performance ITBs with steep temperature gradients developed only in discharges with small TF ripple (δ<0.5%). This suggests that the ITB trigger in discharges with reversed shear is not strongly dependent on toroidal rotation (gradient) while the further development might be. The formation of ITBs in low positive shear discharges was found to be more difficult for higher TF ripple values. The question arises if this was due to lower absorbed power or due to the alteration of the toroidal rotation. The paper will also address the analysis of the absorbed power and TF ripple induced losses for these pulses.

This research was partly funded by EURATOM and the UK EPSRC.