Predictive modelling of ripple-induced effects in ELMy H-mode plasmas

V. Parail[1], P. de Vries[1], T. Johnson[2], J. Lonnroth[3], N. Oyama[4], G. Saibene[5], A. Salmi[3], R. Sartori[5], S. Wiesen[6], H. Urano[4], Y. Andrew[1], C.S. Chang[7], Y. Kamada[4] and EFDA-JET collaborators[*]

** See appendix of M Watkins et al., Fusion Energy 2006 (Proc. 21st Int. Conf. Chengdu, 2006) IAEA Vienna (2006)*

1. Euratom/UKAEA Fusion Association, Culham Science Centre, Abingdon, OX14 3DB, UK

2 Association EURATOM-VR, Alfven Laboratory, Royal Institute of Technology, 10044 Stockholm, Swede;

3. Association EURATOM-TEKES, Helsinki University of Technology, P.O. Box 2200, FIN-02015 HUT, Finland

4. Japan Atomic Energy Agency, Naka, Ibaraki-ken, 311-0193 Japan

5. EFDA Close Support Unit, Garching, 2 Boltzmannstrasse, Garching (DE) Germany

6. *Institute fur Plasmaphysik, Forschungszentrum Julich GmbH, Euratom Association, Trilteral Euregio Cluster, D-52425 Julich, Germany*

7. Courant Institute NY University, NY, USA

e-mail address: Vassili.Parail@jet.uk

Abstract

The recently completed experiment on a variable level of ripple at JET brought to light some interesting and not always expected results, which still require explanation from theoreticians and modellers. It was shown that plasma rotation reduces dramatically after application of even a moderate level of toroidal ripple so that toroidal rotation even changes sign to counter-current near the plasma edge at 1% ripple amplitude despite co-current NBI injection. Secondly, even small (<1%) ripple significantly increases the ELM frequency and reduces the ELM size. This might be considered as a positive effect but for the accompanying reduced plasma performance. This reduction in performance appears not only as a reduction of the energy confinement time but also in a noticeable decrease in overall particle content. The latter could be restored in JET by additional gas puffing although gas puffing failed to increase the density in similar experiments in JT-60U.

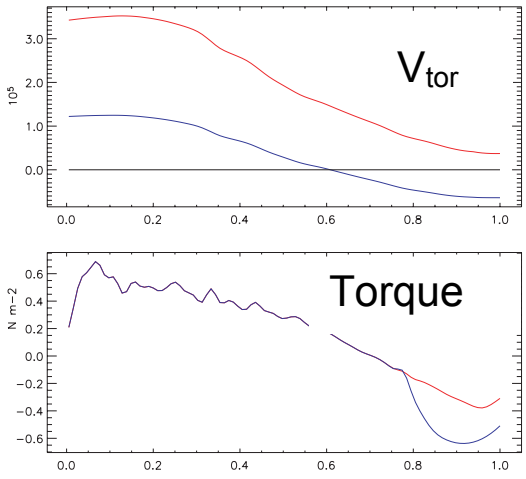

Fig. 1. a) Simulated toroidal velocity in JET: red- without losses of thermal ions, blue- with losses;b) NBI torque: red- without losses of thermal ions, blue- with losses

A suite of transport codes (JETTO and EDGE2D) as well as Monte Carlo orbit following codes OFMC, ASCOT and XGC-0 were extensively used in an attempt to explain the above-mentioned observations. ASCOT modelling combined with JETTO has shown that loss of plasma rotation and the observed reversal of edge rotation velocity cannot be explained by losses of momentum by fast beam ions only. Additional directional losses of thermal ions were required to reverse the edge rotation (see Fig. 1). Analysis by ASCOT shows that extra directional losses come from losses of thermal ions. Predictive modelling of the plasma dynamics using JETTO, EDGE2D and COCONUT showed that the observed increase in ELM frequency can arise from additional convective losses, triggered by finite ripple. Extra convective losses, which lead to the observed density pump-out during application of finite ripple, is probably the least expected effect. We try to attribute this pump-out effect to non-ambipolar losses of fast and thermal ion due to finite ripple. These non-ambipolar losses should create a 2-D electric field (in the r,θ plane), which would lead to enhanced convective losses of both electrons and ions through the separatrix due to ExB drift. Monte Carlo orbit following codes ASCOT and XGC-0 were used to simulate this effect. The result of this modelling, which confirms the importance of this effect will be presented. Work partly supported by EURATOM and the UK EPSRC'