Predictive modeling of external kink modes with low toroidal mode numbers

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In Tokamak experiments with high edge pressures, long-lived MHD modes with toroidal mode numbers n=1-2 have been observed coinciding with ELM-free periods. Examples are the edge harmonic oscillations (EHO) observed in DIII-D quiescent H-modes (QHM) [1], in JET experiments with counter-NBI designed to obtain QHM [2] and the outer-mode (OM) observed in JET high performance plasmas [3]. Observations indicate that both the DIII-D EHO and the JET OM are likely to be external kink modes. The conditions for obtaining low amplitude saturated external kink modes with low toroidal mode numbers and their interaction with ELMs has been studied using the transport code JETTO coupled to a quasi-linear model for ELMs. Modelling assumptions have been verified using the MHD stability code MISHKA.

In the code JETTO, ELMs occur when marginal stability conditions for either ballooning or external kink modes (also known as “peeling modes”) are violated. Transport enhancement caused by the ELM is assumed to be proportional to the MHD mode growth rate [4]. The ELM duration and repetition frequency is strongly dependent on how the marginal stability conditions depend on plasma edge parameters as well as on the level of edge transport enhancement. ELM dynamics in JET ELMy H-mode plasmas has been previously studied [4] using the external kink marginal stability condition from Connor et al. [5]. With this expression, derived for large toroidal mode numbers, the external kink stability depends strongly on stabilizing effect of the edge pressure gradient as well as on the destabilizing effect of the edge current density. This expression has been found to be inappropriate for the modelling of JET plasmas where long-lived n=1 modes are observed. Edge stability performed with the code MISHKA does not indicate a strong dependence on the pressure gradient. Here we discuss results from modelling edge stability of JET QHM experiments. ELM dynamics using in JETTO three different expressions for the external kink marginal stability are compared: (a) Using the expression of Connor et al as in JETTO default version; b) Connor et al expression modified for low toroidal mode numbers (Here the marginal stability of external kinks depends on edge values of ∇p, j and q) and; (c) Marginal stability as determined from MISHKA that depends on j only. Continuous external kink modes with mode number n=1, lasting 1-1.5 seconds as observed in the JET QHM plasmas have been obtained.

[1] P. West et al. NF 45 No 12 (2005) 1708
[2] W. Suttrop et al. NF 45 No 7 (2005) 721
[3] M.F.F. Nave et al. NF No 39 (1999) 1567
[4] J. Lonnroth et al. PPCF No 46 (2004) 1197
[5] J. Connor et al, PoP No 5 (1998) 2687