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Power balance analysis of JET-ILW L-H transition in Deuterium plasmas

P. Vincenzi[1], E. R. Solano[2], E. Delabie[3], C. Bourdelle[4], J. Citrin[5], G. Snoep[5], A. Baciero[2], P. Carvalho[6], M. Chernyshova[7], J.C. Hillesheim[8], A. Huber[9], S. Menmuir[8], F. I. Parra[10] and JET contributors*

[1] Consorzio RFX, [2] Laboratorio Nacional de Fusión, CIEMAT, [3] Oak Ridge National Laboratory, [4] CEA, IRFM, [5] DIFFER—Dutch Institute for Fundamental Energy Research, [6] Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, [7] Institute of Plasma Physics and Laser Microfusion, [8] CCFE, Culham Science Centre, [9] Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung-Plasmaphysik, [10] Rudolf Peierls Centre for Theoretical Physics, University of Oxford, * See the author list of E. Joffrin et al 2019 Nucl. Fusion 59 112021

e-mail (speaker): pietro.vincenzi@igi.cnr.it

The understanding of the physics governing the transition from low (L) to high (H) -mode confinement and of the existence of a plasma density, $n_{e,min}$, at which the power to access H-mode is minimum, has strong implications for ITER operation and DEMO design. Studies in the last decades on different tokamaks have sometimes shown a flattening or even a minimum of the L-H power (P_{LH}) threshold as a function of density. On JET C-wall, the roll-over of the power threshold at low density was not observed in all divertor geometries, it reappeared only with the installation of the JET-ILW (ITER-like wall) [1]. In JET, both the power threshold and the value of $n_{e,min}$ (when observed) depend on toroidal field and plasma shape. Results from ASDEX-Upgrade (AUG) and Alcator C-mod (C-mod) experiments suggested that the variation of the ion heat flux with density, dominated by equipartition in electron heated plasmas, can explain the non-monotonic density dependence of the L–H threshold power [2], [3].

Based on data from dedicated L-H transition experiments in JET-ILW with Deuterium plasmas heated by Neutral Beam Injection (NBI), interpretative numerical simulations have been run with JINTRAC suite of codes [4] to carry out a power balance analysis, estimating in particular the power coupled to ions at the L-H transition. The NBI power deposition is estimated with ASCOT Monte Carlo code [5]. For pulses where core ion temperature (T_i) measurements were not available, the quasilinear gyrokinetic transport model QuaLiKiz-JETTO [6] is used to predict core T_i. Since the position of the divertor strike points strongly influences P_{LH}, each plasma shape has been considered as a separate dataset. For the JET discharges analyzed (B_{tor}=3 T, I_p= 2.5 MA), ion heating is dominated by direct NBI heating, and the electron-ion equipartition power term is generally lower in magnitude than NBI power to ions. This result is exemplified in fig. 1, referring to 3 discharges, at different average densities, of high-triangularity "Horizontal Target" (HT) plasmas, having the outer strike point located in a tilted, almost horizontal, divertor tile. Similar results are found for the other sets analyzed, namely a low-triangularity HT dataset, and a "Vertical Target" dataset, with plasmas having both inner and outer strike points on vertical target tiles. For these L-H transitions in JET, the existence of a minimum ion heat flux, at given plasma density, seems to be in agreement with results from NBI-heated AUG discharges, while it appears different from radio-frequency heated plasmas, where such a minimum was not observed. Similarities and differences with other devices are discussed, in particular with respect to AUG and C-mod results. Modelling of the L-mode edge prior to the transition is also presented, focusing on the micro-turbulence analysis performed at various densities with the gyrokinetic code GENE [7].

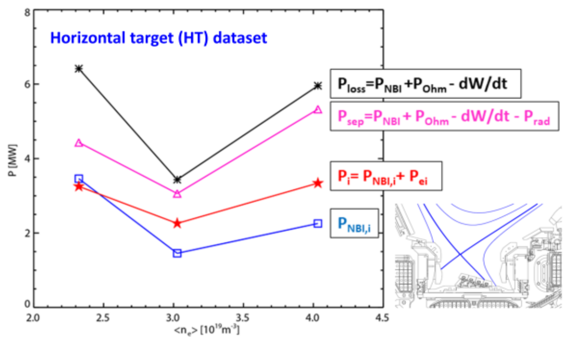

Fig. 1: Power balance terms for high-triangularity JET D-plasmas at different volume-averaged densities in the divertor configuration named "Horizontal Target" (shown in the right-bottom corner).

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