Investigation of the role of ETGs in electron heat transport in TCV plasmas

A. Mariani*[1], P. Mantica[1], N. Bonanomi[1,2], S. Brunner[3], M. Fontana[3], A. Karpushov[3], C. Marini[3], L. Porte[3], O. Sauter[3], and the TCV Team and the EUROfusion MST1 Team†

[1] *Istituto di Fisica del Plasma IFP-CNR, Via R. Cozzi 53, 20125 Milano, Italy*
[2] *Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, D-85748 Garching, Germany*
[3] *Swiss Plasma Center (SPC), EPFL, 1015 Lausanne, Switzerland*

Recent studies have shown both experimentally and theoretically that Electron Temperature Gradient (ETG) micro-turbulence modes can impact on electron heat transport in tokamaks in conditions when ion-scale turbulence is close to marginality and electron heating is significant [1, 2]. In these conditions, due to reduced ion-scale zonal flows, radial streamers can form, substantially increasing electron heat transport and leading to multi-scale interactions. Given the relevance of these mechanisms for ITER scenarios, a new study has been carried out on the Tokamak a Configuration Variable (TCV) at the Swiss Plasma Center (SPC) of the EPFL (Lausanne, CH), which is equipped with both ECH and NBI heating, allowing to investigate the relevance of ETG transport for different ratios of electron to ion heat fluxes.

The main drive of ETG modes is the electron temperature logarithmic gradient R/L_{Te}, and their threshold has been shown to increase with increasing effective ionisation degree Z_{eff} and with increasing electron to ion temperature ratio T_e/T_i [3]. An experimental characterisation of the electron threshold at mid-radius was carried out in TCV by using different proportions of on- vs off-axis ECH power to reconstruct the shape of the electron heat flux in gyro-Bohm units $q_{e,gb}$ versus R/L_{Te} with/without NBI heating. Three dedicated TCV discharges have been performed under the EuroFusion MST1 experimental campaign (2017) to explore this topic. Each discharge features different time intervals, corresponding to NBI only, mixed NBI/ECH, ECH only phases. ECH was injected both steady and modulated in different time intervals, in order to gain additional information from heat wave propagation analysis.

A preliminary experimental analysis of the three TCV discharges shows reduced R/L_{Te} values in presence of NBI, which is consistent with a reduced ETG threshold due to lower T_e/T_i. The electron stiffness in the pure ECH case is found to be very high, which may also be a signature of ETG transport, since TEMs are generally characterised by very low stiffness. Linear local (flux-tube) gyrokinetic simulations have been performed with the GENE code [4], to compare the theoretical dependence of the ETG threshold on $Z_{\text{eff}}T_e/T_i$ with the experimental findings. Non-linear single scale gyro-kinetic simulations are in progress to perform a comparison between experimental and theoretical stiffness level, with the option of performing a multi-scale simulation in case the ion-scale electron flux is found to be too small to account for the total experimental electron heat flux. The simulations have been run considering both a two species electron-deuteron plasma and taking into account the main impurity, that is carbon, as a third active gyrokinetic species.

*mariani@ifp.cnr

†See the author list of H. Meyer et al., Nuclear Fusion 57 (2017) 102014

"This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission."

References

[1] N. Bonanomi et al. 2017, 44th EPS Conf. on Plasma Physics
[2] N. Howard et al. 2017, Plasma Phys. Control. Fusion **60**
[3] F. Jenko et al. 2001, Phys. Plasmas **8**
[4] F. Jenko et al. 2000 Phys. Plasmas **7**