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Electron Heat Transport in JET from Ion to Electron scales: Experimental Investigation and Gyro-kinetic Simulations

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The TEM driven electron heat transport has been investigated experimentally in JET C-wall L-mode plasmas with dominant ICRH electron heating, by flux scans at constant total electron power and power modulation using ICRH in (3He)-D mode conversion scheme. The dependence of the TEM threshold on s and q has been studied by implementing ad hoc time waveforms of the plasma current in order to extend the range of s explored and to decouple it from q. Linear simulations have been made using the gyro-kinetic code GKW. A strong dependence on s has been identified in the experiments and no dependence on q, in agreement with linear GKW results. The experimental estimate of the electron stiffness in these plasmas is however significantly higher than predicted by non-linear TEM gyro-kinetic simulations. This discrepancy is even worse in plasmas with comparable electron and ion heating (ICRH+NBI), in which the electron stiffness increases and a macroscopic drop of R/L_Te is observed with respect to pure ICRH plasmas. Non-linear simulations using GENE show that in both cases it is not possible to account for the experimental electron flux by just considering the ITG-TEM turbulence. Therefore, the idea that electron scale ETG turbulence could account for the missing flux has been explored, supported by the fact that the ETG threshold is predicted to decrease with the increasing T_i/T_e due to NBI heating. A first study of the ETG contribution to the heat flux, using linear and non-linear local GENE simulations, was based on separate simulations of ion and electron scales. For the ETG saturation, either an ad hoc external flow shear or electron scale zonal flows were used. In both ICRH and ICRH+NBI cases it was found that a non-neglibile electron heat flux can be carried by the ETG modes, explaining the observations. However, a high sensitivity of the results on multiple parameters was found. In addition, recent studies show that multi-scale simulations with real electron to ion mass ratio are needed for a proper ETG study. Computationally heavy multi-scale simulations have then been started using GENE for these JET shots. The results will help to clarify if and when the electron scale instabilities can carry significant electron heat flux in JET plasmas, also in view of extrapolations to ITER scenarios, where the electron channel will be key for fusion performance.

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