Role of small-scale turbulence and multi-scale interactions in electron heat transport in JET

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JET L-mode plasmas with Ion Cyclotron Resonance Heating (ICRH) power deposited on electrons and with and without significant ion heating by Neutral Beam Injection (NBI) are studied with gyrokinetic simulations performed with the GENE code in the local limit [1]. The simulations cover both the electron and the ion scales and take into account also the multi-scale interactions. In the ion scale simulations, where the dominant modes are the Trapped Electron Modes (TEM) and the Ion Temperature Gradient (ITG) modes, despite the numerous confidence tests on the main parameters (such as R/L\textsubscript{Te}, R/L\textsubscript{Ti}, R/L\textsubscript{n}, s), it was impossible to reproduce the electron heat fluxes and especially the electron stiffness found experimentally. Furthermore, both higher electron stiffness and lower values of R/L\textsubscript{Te} are observed in plasmas with significant NBI heating than in plasmas with pure ICRH heating, for the same normalized electron heat flux [2]. This could not be reproduced in the simulations. A possible explanation of the missing electron heat fluxes and of the difference between the discharges with and without NBI heating was found in the Electron Temperature Gradient (ETG) modes. In recent works, these modes and their interactions with ion scale modes are found to be responsible of a large amount of the heat flux in certain regimes [3-5]. A database of JET discharges, created in order to study the electron heat transport, shows a strong correlation between the level of the electron turbulent transport and the parameter $\tau = Z_{\text{eff}}T_{e}/T_{i}$, which is a key parameter for the ETG threshold. The ETG threshold in the discharges with lower $\tau$ is lowered [6], confirming the possibility of a greater influence of ETGs in plasmas with $T_{e}/T_{i}$. Nonlinear simulations on electron scales were performed using high values of the external flow shear in order to avoid streamers dominating the box-scale. Using a simple addition of the fluxes due to TEM/ITG and due to ETG, the experimental electron and ion heat fluxes could be reproduced quite well. Also, in the discharges with only ICRH heating, the electron stiffness was reproduced [6].

A first multi-scale simulation was carried out with GENE using the experimental parameters, two kinetic species, real ions/electrons mass ratio, and Miller geometry. The multi-scale simulation shows that ETGs can be important for the electron heat transport at JET, especially in conditions where the ITGs are marginal stable. A comparison between the GENE and the experimental results and the TGLF model with the new saturation rule accounting for multi-scale interactions [7], both stand alone and implemented in the ASTRA code, is also addressed.

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