Towards self-consistent runaway electron modelling

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Reliable runaway electron (RE) mitigation after disruptions is one of the most important challenges for safe ITER operation [1]. A proper understanding of the generation and losses of REs is therefore essential. A full MHD simulation of the disruption is a complex and computationally demanding task. Therefore reduced dimension fluid-type models are employed to describe the evolution of plasma parameters during disruptions with reasonable accuracy. One of these codes is GO [2], which uses a self-consistent, one-dimensional model to calculate the evolution of electric field, plasma parameters and runaway current and is also capable of taking into account impurity injection using a collisional-radiative model based on ADAS data. GO has already been applied to various tokamaks to better understand the runaway evolution during mitigated or unmitigated disruptions [1, 2], and its physics model is being continuously extended.

There are several applications however, that demand the knowledge of the electron distribution function. Accurate estimates of wall damage, calculation of the interaction with partially ionised high-Z materials, calculation of synchrotron or bremsstrahlung emission (for diagnostic purposes), possibilities for particle-wave interactions, even constraining equilibrium reconstructions requires an energy- and pitch resolved distribution. We use the 2 dimensional Fokker-Planck solver CODE [3] to calculate the momentum-space distribution of runaway electrons for time-evolving plasma parameters. As the next step in self-consistent runaway modelling, we are coupling GO with CODE to obtain the 3 dimensional evolution of the $f_e(p_\parallel, p_\perp, r, t)$ electron distribution. In the future, coupling with more sophisticated solvers (e.g. the 3 dimensional LUKE [4]) is planned.

In this paper we report on the recent progress and the complexities involved with implementing such self-consistent calculations. We also present the implications of the coupled model and its components in the view of recent experimental results [5].

References


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