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Runaway dynamics in disruptions: sliding and screening

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Runaway electrons (REs) are a pressing issue for ITER due to their significant potential to cause damage. Improved knowledge of RE formation mechanisms, their dynamics and characteristics, as well as transport or loss processes that may contribute to RE suppression and control, will benefit the fusion community and contribute to a safe and reliable operation of reactor-scale tokamaks.

We review recent results on runaway electron dynamics obtained with the relativistic finite-difference Fokker-Planck code CODE [1] and its nonlinear counterpart NORSE [2]. The latter includes a fully nonlinear relativistic collision operator, making it possible to consider scenarios where the electric field is comparable to the Dreicer field (or larger), or the electron distribution function is otherwise far from a Maxwellian, which can be the case already in present-day runaway experiments. Using NORSE, the transition to a regime where the entire electron population experiences continuous acceleration, so-called electron slide-away can be investigated. We will show that Ohmic heating and the rate of heat loss play an important role in the transition to slide-away, with the latter affecting the average energy reached by the runaways by several orders of magnitude.

We will also describe the dynamics of fast electrons in plasmas containing partially ionized impurity atoms, where the reduced-screening effect of bound electrons must be included [3]. We show that the enhancement of both collisional drag and pitch-angle scattering due to reduced screening lead to significant runaway current decay. This has important implications for the understanding of important phenomena, such as the energy spectrum of runaways and the effective critical electric field for runaway electron generation.

References

[1] Landreman et al, Comp. Phys. Comm. 185, 847 (2014); Stahl et al, Nucl. Fusion 56, 12009 (2016)
[2] Stahl et al, Comp. Phys. Comm. 212, 269 (2017)
[3] Hesslow et al, Phys. Rev. Lett. 118, 255001 (2017)