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Runaway seed formation during the thermal quench and the effects of radial transport of fast electrons

One of the most important open questions in runaway-generation research concerns the formation and survival of a seed population of fast electrons following the thermal quench of a tokamak disruption. Because of the large plasma current in future tokamaks such as ITER, such a seed current can multiply via the knock-on mechanism which may result in a significant fraction of the total plasma current being converted into an ultra-relativistic runaway current. An experimentally validated predictive model of runaway generation during disruptions is yet to be achieved, but is needed to inform the design and operation of the ITER disruption mitigation system.

In this contribution we report on ongoing efforts to model runaway electrons generated during tokamak disruptions. We present a novel reduced kinetic model for runaway hot-tail generation which eliminates the pitch angle dynamics via a strong-pitch-angle scattering expansion. By comparison to numerical solutions of the electron Fokker-Planck equation we explore the domain of validity of the approximate model, and demonstrate that it can accurately predict runaway seed formation in high-Z plasmas. We use the hot-tail model to investigate the impact of a one-dimensional model of electron radial transport on seed survival during a thermal quench.

During the current quench and runaway-plateau phase of a disruption, magnetic perturbations can induce electron losses which may suppress the runaway avalanche multiplication or enhance the rate of decay of runaway current. We describe a fluid method of calculating these losses assuming given energy-dependent radial transport coefficients, which generalizes a previous calculation to account also for collisional screening effects in the presence of partially ionised impurities as well as radiation reaction forces.

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