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Formation and Termination of Runaway Beams in Tokamak Disruptions and Implications for ITER

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Large runaway electron (RE) currents could be formed during the current quench (CQ) phase of ITER disruptions. Although the main interest of studying REs is related to their final deposition on the plasma facing components (PFCs), much less attention has been paid to their termination phase, when the current and the REs are lost. During this phase, conversion of magnetic energy of the runaway plasma into runaway kinetic energy can occur which can increase substantially the energy fluxes deposited by the REs on the PFCs. In this work, an inter-machine comparison for various devices (JET, DIII and FTU) has been performed which, together with simple 0D modeling of the termination phase, has allowed to identify the physical processes determining the magnetic into kinetic energy conversion. It is predicted that, in ITER, for fast RE losses, below 1 ms, it is essentially the plateau runaway kinetic energy that will be deposited on the PFCs. For long enough RE losses, the avalanche generation of runaways will play an important role, increasing the energy deposited by the REs onto the PFCs, and energies up to 300 MJ for a plateau RE current of 10 MA are predicted. With the aim of improving our understanding of the physics underlying the runaway heat loads onto the PFCs in ITER disruptions, an integrated analysis in which the results of the modeling of the disruption CQ and runaway formation provide the basic inputs for the termination phase of the disruption, is carried out for selected ITER scenarios. This is done by means of simplified models, but retaining the essential physical processes, including the effect of the main runaway generation mechanisms expected in ITER, effects associated with current profile shape during the formation and termination of the runaway current, as well as, in the case of high impurity content, corrections to the runaway dynamics to account for the collisions of the REs with the partially stripped impurity ions. The ultimate goal is to provide a guidance for the most severe foreseen ITER scenarios as well as for the most suitable schemes for the minimization of the effects of runaway impact on the ITER first wall.

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