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Current profile shape effects on the formation and termination of runaway beams in tokamak disruptions and implications for ITER

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Runaway electrons (REs) generated during disruptions are usually found to deposit their energy in very short pulses and on localized areas of the plasma facing components (PFCs). In ITER, there is serious concern about the potential that large amounts of MeV REs generated during the disruption current quench (CQ) have for erosion / melting of the PFCs. Although zero-dimensional (0-D) modeling has shown to provide a rather complete physics picture of the CQ and termination phases of the disruption, there is evidence indicating that current profile shape effects could be important. In this work, a one dimensional model (1-D) beyond the 0-D model is used to evaluate effects associated with the evolution of the plasma and RE current profiles during the disruption. The model predictions are found to be in agreement with measurements of the plasma internal inductance for 2 MA JET disruptions with RE current plateau formation. The resulting runaway plasma is more peaked in the plasma center than the pre-disruption plasma current. The peaking decreases when the RE current increases and is also found to be dependent on the runaway seed profile shape, increasing with the internal inductance of the seed current. These results can have important implications for ITER as: (1) due to the increase in the plasma internal inductance, for the same RE current magnitude, the magnetic energy of the RE plasma would be substantially larger; (2) the post-CQ plasma current profile might be MHD unstable as plasmas with peaked current profiles can be prone to the tearing-mode instability. Moreover, the magnetic energy does not scale linearly with the square of the RE current. In order to investigate these effects, an integrated 1-D analysis of the runaway beam formation and termination during disruptions in ITER has been carried out, and including the essentials of the involved physical processes such as the main RE generation mechanisms expected in ITER as well as corrections to the RE dynamics to account for the collisions of the RE electrons with the partially stripped impurity ions.

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