Runaway electron confinement modeling for rapid shutdown scenarios in DIII-D, Alcator C-Mod and ITER

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Abstract

MHD simulations of rapid shutdown scenarios by massive particle injection in DIII-D, Alcator C-Mod and ITER are performed in order to study runaway electron transport during mitigated disruptions. The simulations include a runaway electron (RE) confinement model using drift-orbit calculations for test particles. A comparison of limited and diverted plasma shapes is studied in DIII-D simulations, and improved confinement in the limited shape is found due to both spatial localization and reduced toroidal spectrum in the nonlinear MHD activity. C-Mod simulations compare shutdown scenarios in which impurity (Ar) fueling is concentrated in the edge versus the core, and find the confinement of REs in the core is maintained until the onset of the $m = 1/n = 1$ mode, which is delayed in the case of edge deposition, relative to core deposition. But, the overall RE loss fraction is 100% regardless of Ar fueling profile. A comparison of simulations across the three devices points to a trend of increased RE confinement with increasing device size, wherein all REs are lost in C-Mod, all are confined in ITER, and a partial loss is observed in DIII-D. This trend is related to a reduction in the fluctuating field amplitude near the plasma edge during the thermal-quench-induced MHD activity. The result bodes poorly for RE mitigation strategies in ITER that rely on MHD deconfinement of runaway electrons.

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