Runaway Electron Production in DIII-D Killer Pellet Experiments, Calculated with the CQL3D/KPRAD Model

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May 23, 2000

Abstract. Runaway electrons are calculated to be produced during the rapid plasma cooling resulting from “killer pellet” injection experiments, in general agreement with observations in the DIII-D tokamak. The time-dependent dynamics of the kinetic runaway distributions are obtained with the CQL3D collisional Fokker-Planck code, including the effect of small and large angle collisions and stochastic magnetic field transport losses. The background density, temperature and $Z_{\text{eff}}$ are evolved according to the KPRAD deposition and radiation model of pellet-plasma interactions. Three distinct runaway mechanisms are apparent: (1) prompt “hot-tail runaways” due to the residual hot electron tail remaining from the pre-cooling phase, (2) “knock-on” runaways produced by large-angle Coulomb...
collisions on existing high energy electrons, and (3) Dreicer “drizzle” runaway electrons
due to diffusion of electrons up to the critical velocity for electron runaway. For electron
densities below $\approx 1 \cdot 10^{15} \text{ cm}^{-3}$, the hot-tail runaways dominate the early time evolution,
and provide the seed population for late time knock-on runaway avalanche. For small
enough stochastic magnetic field transport losses, the knock-on production of electrons
balances the losses at late times. For losses due to radial magnetic field perturbations in
excess of $\approx 0.1\%$ of the background field, i.e., $\delta B_r/B \geq 0.001$, the losses prevent late-time
electron runaway.

PACS Nos. 52.20.Fs, 52.25.Dg, 52.55.Fa, 52.65.Fr