1998 International Sherwood Fusion Theory Conference
March 23–25, 1997, Atlanta, Georgia

Runaway Electron Production in DIII-D Experiments Calculated with the CQL3D/KPRAD Fokker-Planck/Radiation Model

R.W. Harvey,* V.S. Chan, S.C. Chiu,◊ T.E. Evans,
M.N. Rosenbluth,† and D.G. Whyte‡

General Atomics
San Diego, California

Rapid temperature drops in tokamaks due to impurity pellet injection or disruptions, can lead to a massive generation of runaway electrons. This is caused by the large induced electric fields which keep the plasma current constant on time scales short compared to the resistive time. The CQL3D bounce-averaged Fokker-Planck (FP) code [1] provides a ready means for calculation of the 2D-in-momentum-space distribution of runaway electrons generated at each flux surface in such time-varying plasmas. In addition to the nonlinear, relativistic, Coulomb collision FP operator, we have implemented a ''knock-on'' collision model giving exponential ''avalanche'' of runaways [2], a constant current algorithm and a loss function to model transport physics. For modeling runaway generation in DIII–D due to impurity pellet injection, CQL3D uses $n_e(t)$, $T_e(t)$, and $Z_{eff}(t)$ profiles obtained with the KPRAD [3] pellet ablation, ionization, and radiation code. The principle calculated results for high-Z pellet injection in DIII–D are:

(1) Complete conversion of the plasma current to runaways occurs if losses are neglected.

(2) The residual tail electrons remaining after the rapid temperature drop lead to a prompt population of ''hot tail electrons'' which either provides complete, prompt conversion (''hot tail runaway''), or provides a large seed which quickly avalanches to full conversion.

(3) When magnetic fluctuation losses are included using experimentally measured levels arising during pellet injection [$\delta B/B = 1\%$] [4], the runaway electrons are lost before full conversion of plasma to runaway current. This is in accord with the experimental results and shows the importance of transport losses in the model.

This is a report of research sponsored by the U.S. Department of Energy under Grant No. DE-FG03-95ER54309.

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*CompX, Del Mar, California. ◊Sunrise R&M, Inc., San Diego, California.
†ITER JTC, San Diego, California. ‡University of California, San Diego, California.

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