1997 International Sherwood Fusion Theory Conference
April 23–26, 1997, Madison, Wisconsin

Fokker-Planck Simulations of Knock-on Runaway Electron Generation in Tokamaks

S.C. Chiu, V.S. Chan, R.W. Harvey,† and M.N. Rosenbluth‡

General Atomics
San Diego, California

The ability to tolerate disruptions is an important issue in high current tokamaks. To minimize the thermal and electro-mechanical stresses that can be produced during current quench in a disruption, it has been proposed to inject pellets or jets to quench the plasma thermally and thus allow a rapid current decay. A serious concern for this method is that high electric fields produce long-lived high energy runaway electrons [1]. Specifically, the presence of trace amount of high energy electrons can produce secondary runaways through large angle knock-on collisions with the bulk electrons and produce an avalanche of runaways in a fraction of a second. This work is the first numerical study that attempts to accurately evaluate the phenomena including realistic effects. To simulate this phenomena, the bounce averaged Fokker-Planck code CQL3D is used. Effects such as trapping, synchrotron radiation and bremsstrahlung are included. Secondary knock-on production is modeled by a source term using Moller cross-section and an approximation that the primary runaways have negligibly small pitch-angles. It is shown that even when the electric field is small for production of Dreicer runaways, knock-on collisions can cause the runaways to exponentiate at a characteristic time constant typically a fraction of a second, and then saturate when the electric field decreases to near or below the critical electric field. The growth rate is shown to be in good agreement with Rosenbluth's analytic theory [1]. Simulations of pellet injection indicate that sufficiently low Z pellets can effectively quench runaways. We will present results of evolution of the electric field and runaways at constant current, as the temperature and density change abruptly during pellet injection. The effect of magnetic fluctuations on runaways and the consequence of removing the approximation of negligible pitch angle for the runaway distribution in calculating the source term will be discussed.

This is a report of research sponsored by the U.S. Department of Energy under Contract No. DE-AC03-89ER51114.

---

†CompX, Del Mar, California.
‡ITER Design Center, San Diego, California.

[1] M.N. Rosenbluth *et al.*, IAEA Int. Conf., Montréal (1996), paper F1-CN-64/FP-26.