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Radiation effects on the runaway electron avalanche[1]

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Runaway electrons are a critical area of research into tokamak disruptions. A thermal quench on ITER can result in avalanche production of a large amount of runaway electrons and a transfer of the plasma current to be carried by runaway electrons. The potential damage caused by the highly energetic electron beam poses a significant challenge for ITER to achieve its mission. It is therefore extremely important to have a quantitative understanding of the avalanche process, including (1) the critical energy for an electron to run away to relativistic energy and (2) the avalanche growth rate dependence on electric field, which is related to the poloidal flux change required for an e-fold in current. It is found that the radiative energy loss of runaway electrons plays an important role in determining these two quantities. In this talk we discuss three kinds of radiation from runaway electrons, synchrotron radiation, Cerenkov radiation, and electron cyclotron emission (ECE) radiation. Synchrotron radiation, which mainly comes from the cyclotron motion of highly relativistic runaway electrons, dominates the energy loss of runaway electrons in the high-energy regime. The Cerenkov radiation from runaway electrons gives an additional correction to the Coulomb logarithm in the collision operator, which changes the avalanche growth rate. The ECE emission [1] mainly comes from electrons in the energy range $1.2 < \gamma < 3$, and gives an important approach to diagnose the runaway electron distribution in momentum and pitch angle. To study the runaway electron dynamics in momentum space including all the radiation and scattering effects, we use a novel tool, the adjoint method [2] to obtain both the runaway probability and the expected slowing-down time. The method is then combined with kinetic simulations to calculate the avalanche threshold and growth rate.

[1]C. Paz-Soldan et al., Nucl. Fusion 56, 056010 (2016).
[2]C. Liu, D.P. Brennan, A. Bhattacharjee, and A.H. Boozer, Phys. Plasmas 23, 010702 (2016).

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