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Runaway Electron Transport and Disruption Mitigation Optimization on Alcator C-Mod[1]

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Experiments and modeling on Alcator C-Mod have provided new insights into the physics of runaway electron transport and disruption mitigation optimization, both critical issues for ITER. Avalanche amplification of runaway current in disruptions is a concern for ITER since the amplification gain scales exponentially with plasma current. While stochastic transport losses of the fast electrons can effectively eliminate the amplification, such losses have not previously been quantified. C-Mod has investigated runaway production and transport by seeding a suprathermal electron tail using Lower Hybrid heating and then promptly terminating the discharge with a massive gas injection (MGI). This innovative combination assures, through the Dreicer mechanism, a sufficient "seed" population of runaways, $\sim$0.1 of the initial plasma current, such that their amplification and transport can be measured. In the experiment electrons accelerate to relativistic velocities but are all lost due to transport on a timescale less than a millisecond, effectively resulting in runaway electron suppression before the current quench. The runaway loss mechanism is confirmed to be stochastic transport by using electron tracing in 3-D resistive MHD simulations (NIMROD), which have also shown the importance of MHD activity in MGI disruption mitigation. Large parallel electric fields and stochasticity appear simultaneously in the model, suggesting that the development of strongly stochastic regions through sufficient impurity radiation cooling is key to both mitigation and runaway avoidance. Particle delivery, mitigation effectiveness, runaway avoidance and overall response time of the system is optimized using mixed-gases of a fast low-Z gas carrier with a trace high-Z radiating species. Mitigation options and optimization for ITER are discussed.

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