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ITPA Joint Experiment to Measure Threshold E-fields and Densities for Runaway Electron Onset and Suppression

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Recent results from an ITPA joint experiment to study the onset, growth, and decay of relativistic electrons (REs) indicate that energy loss mechanisms other than collisional damping may play a dominant role in the dynamics of the RE population. Understanding the physics of RE growth and mitigation is motivated by the theoretical prediction that disruptions of full-current ITER discharges could generate ~10 MA of REs (10-20 MeV) through an avalanche growth process [M. Rosenbluth, S. Putvinski, Nucl Fusion 37 (1997) 1355]. A necessary condition for avalanche growth is that the Coulomb acceleration due to the toroidal electric field has to be at least high enough to counter the collisional drag on background electrons, i.e. $E>E_c$, where E_c is the critical E-field derived in [J. Connor, R. Hastie, Nucl Fusion 15 (1975) 415]. E_c scales linearly with electron density, n_e, so one way to suppress avalanche growth is to quickly raise n_e sufficiently high, but this is problematic on ITER. However, if there are other energy loss mechanisms in addition to collisions, then the actual threshold E-field will be greater than E_c, i.e. REs become more difficult to generate and sustain due to the additional loss mechanism(s). Due to the importance of E_c to the issue of REs in ITER, the ITPA MHD group is conducting a joint experiment to measure the threshold E-field on a number of tokamaks under steady-state, low Z_{eff} conditions in which V_{loop}, n_e, and REs can be well-diagnosed, and compared to theory. The analysis must take into account the RE growth time, which can be comparable to the discharge timescale. Data from DIII-D, C-Mod, TEXTOR, and FTU have been obtained so far, and the consensus to date is that the threshold E-field is significantly higher than E_c, or conversely, the n_e required to damp REs is significantly less than predicted, suggesting that other loss mechanisms are involved. Implications for RE mitigation in ITER will be discussed.