Progress on studies of runaway electrons formed during tokamak disruptions*

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A brief overview of the present status of research on tokamak disruption runaway electrons (REs) is given. Understanding the physics of RE formation, amplification, and transport is considered crucial for large next-generation tokamaks due to the potential of wall damage due to uncontrolled RE-wall strikes following a disruption. REs are thought to form during the end of the disruption thermal quench (TQ) due to either Dreicer, hot-tail, or reconnection mechanisms [1], although the dominant mechanism is not clear from presently available data. RE seeds which form during the TQ appear to be largely lost to the divertor strike points, possibly due to rapid parallel transport along flux surfaces destroyed by the TQ MHD; this is supported by MHD simulations of RE transport during the TQ [2]. This role of TQ MHD on the RE prompt loss is supported by an apparent increase in RE prompt loss with increasing plasma elongation. REs which survive this TQ prompt loss phase are predicted to amplify during the current quench (CQ) via the knock-on avalanche process. Accurate comparisons of RE avalanche rates with theory are challenging because of uncertainties in the RE seed term magnitude, the RE loss rate, and the plasma composition; however, present data appears to qualitatively agree with the presence of amplification due to knock-on avalanche during the CQ [3]. The final loss of large RE beams after the CQ to the plasma wall appears to be due to either vertical loss due to control system loss of the narrow RE beam and/or due to the sudden onset of an instability in the RE beam. This final loss instability shows strong toroidal peaking, suggesting an ideal kink, although this has not been confirmed, partially due to lack of data on the RE channel current profile. The final loss RE-wall strike has been shown to be quite localized, with RE energies of order 20-30 MeV consistent with estimates of energy gain from the toroidal loop voltage and energy loss due to synchrotron radiation. Energy balance measurements of RE-wall strikes have been made and suggest that significant fractions of the RE beam magnetic energy can be converted to kinetic energy in some RE-wall strikes [4].

[1] H. Dreicer, Phys. Rev. **117**, 329 (1960); H. M. Smith and E. Veerwichte, Phys. Plasmas **15**, 072502 (2008); P. V. Savrukhin, Plasma Phys. Control. Fusion **48**, B201 (2006).
[2] V. Izzo, et al., Phys. Plasmas **15**, 056109 (2008).
[3] E. Hollmann, et al., to be submitted to Nucl. Fusion (2011).
[4] A. Loarte, et al., submitted to Nucl. Fusion (2011).

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