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Toroidal modeling of post-disruption runaway beam by MHD instabilities in DIII-D.[1]

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Understanding various potential mechanisms for relativistic runaway electrons (REs) mitigation or suppression is crucial, since REs can potentially cause severe material damage in ITER. A recent DIII-D experiment, where ~1 MA level of post-disruption runaway current was achieved, shows that fast-growing magneto-hydrodynamic (MHD) instabilities occur when the plasma edge safety factor drops to around 2, and these large MHD perturbations in turn suppress the runaway beam. The MARS-F stability computations identify these instabilities as resistive kink modes with a mixture of both internal and external eigenmode structures. A new drift orbit model for relativistic test electrons has been developed to study RE confinement in the presence of MHD perturbations. The updated code shows that a fast growing resistive kink instability of ~100 Gauss level induces a significant fraction of RE loss. The RE beam is completely lost as the instability grows up to 1 kG level, consistent with experiment. The key loss mechanism is the prompt drift orbit loss due to radial expansion of RE trajectory in the presence of 3D fields. The 3D field induced loss increases with the perturbation amplitude but decreases with the particle energy, while generally being not sensitive to the initial particle pitch angle. The particle velocity change, due to electric field acceleration/deceleration, small angle scattering, synchrotron radiation and Bremsstrahlung, further perturbs the RE trajectory but plays a minor role in prompt RE loss within microsecond time scale. The RE orbit model will also be applied to study RE confinement with 3D resonant magnetic perturbation fields. The idea of using RMP to excite/amplify MHD modes for RE control will also be exploited.

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