Runaway dynamics in disruptions with current relaxation events

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The safe operation of tokamak reactors requires a reliable modeling capability of disruptions, and in particular the spatio-temporal dynamics of associated runaway electron currents. In a disruption, instabilities can break up magnetic surfaces into chaotic field line regions in a fast magnetic reconnection event, causing current profile relaxation, as well as a rapid radial transport of heat and particles. Modeling fast reconnection—an inherently three-dimensional phenomenon—has posed a major numerical challenge. At the same time, there is a need to explore the vast parameter space characterizing off-normal events, requiring computationally efficient reduced models of low dimensionality.

Using the mean field helicity transport model of Ref. [1] implemented in the new 1D2P disruption runaway modeling framework DREAM [2], we calculate the dynamics of runaway electrons in the presence of current relaxation events. Particular focus is devoted to scenarios where flux surfaces remain intact in parts of the plasma, with skin currents induced at the boundary of the intact field line regions.

We find that the final runaway current density profile can be significantly affected by the current relaxation event. If the reconnection extends to the entire plasma, the runaway current density will be more weighted towards the edge. If there is an intact region in the plasma, the associated skin current may turn into a sizable radially localized runaway beam, or, depending on heat transport, could turn into a hot ohmic current channel. In the presence of an intact edge, a reverse runaway beam carrying an appreciable current might develop from the skin current region.

References

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