Runaway electron beam termination and impact in ITER

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Post-disruption relativistic runaway electron (RE) beams are expected to be a major risk in ITER and future fusion-grade tokamak devices. Most of the existing strategies for RE beam mitigation (e.g. deuterium 2nd injection) rely on obtaining a plasma state that would lead to a benign termination of the RE beam. In this work, using massively-parallel 3D non-linear magnetohydrodynamic (MHD) simulations, we investigate the co-evolution of the RE beam and background plasma MHD, and its role in causing a benign termination. The extended reduced MHD model in the JOREK code [1, 2] has been used for these studies. Runaway electrons are modeled as an RE fluid [3] that is electromagnetically coupled to the background plasma. The model applied to the JET experimental shot 95135 (in which a benign termination was observed after deuterium 2nd injection [4]) revealed that a low density plasma with a hollow current-density could lead to fast MHD growth, magnetic stochastization and a beam termination accompanied by a distributed loss of REs. Simulation results showed a good match with the experiment, and the observed dynamics provide a possible pathway to benign terminations in general.

Imminent vertical motion of the elongated plasma column (and associated shrinking of plasma size) and relatively slow RE decay during the plateau phase leads to a natural decrease in the edge safety factor q_{95}. A low q_{95} obtained via this process can potentially destabilize the plasma and opens the possibility of a termination with distributed loss of REs. Our model was used to study the possibility of benign RE beam terminations in a low-q_{95} ITER plasma [5]. Insights resulting from the 3D simulations will be presented, along with implications on first-wall thermal loads and propensity for re-avalanching.

References

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†See the author list of Joffrin E 2024 Nuclear Fusion 10.1088/1741-4326/ad2be4