Hybrid kinetic-MHD simulations of runaway electron beam termination events in realistic 3D tokamak geometry

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Disruption events and the associated generation of highly energetic *runaway electrons* (REs) remain one of the largest threats to future high current tokamak reactor designs like ITER and DEMO. Studies have indicated that even with systems in place to mitigate these events, a multi-MA RE beam may be unavoidable during the nuclear phase of ITER operation. The transport of REs in 3D MHD fields is however difficult to model and presents one of the largest uncertainties for these estimates, since it can have a substantial impact on the beam formation and the details of the ensuing termination. This is in part due to the fact that REs dominate the dynamics of the bulk plasma at these stages, meaning they cannot be treated separately from the MHD. To account for this, codes like JOREK and M3D-C1 have developed coupled models where REs are treated in the fluid picture. While allowing for a more complete treatment of the MHD, such models fail to capture details of the RE drift orbits, changes in the major-radial force balance, influence of drift orbits onto MHD stability limits, and accurate transport in stochastic fields.

Based on earlier work with kinetic RE test particles in JOREK, we present here a hybrid 3D model in fully realistic tokamak geometry where kinetic REs and MHD co-evolve self-consistently using a full-f particle-in-cell approach. Analytical validation shows that the model accurately captures drift orbits and major-radial force balance. At first, results from a RE beam termination scenario in JET will be shown, as it occurs due to a burst of 3D MHD activity, and be compared to previous RE fluid results. In addition we present predictive results for the beam termination in ITER, including an assessment of the RE deposition on the 3D walls (these results will be based on the new model if time permits; otherwise a postprocessing of RE fluid results using kinetic particles will be shown). Finally initial results regarding the implementation of RE sources in the kinetic model will be included.