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Runaway electron formation and termination in mitigated ITER disruptions

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Uncontrolled termination of post-disruption relativistic runaway electron (RE) current can cause deep localized melting of the plasma facing components and poses a serious challenge to the successful operation of fusion grade tokamaks, including ITER. While RE deconfinement depends on the timescale of flux-surface reformation, the magnetohydrodynamic (MHD) plasma stability itself is affected by the runaway current. Therefore MHD-RE interaction is highly non-linear and determines the eventual impact-profile of REs on the components. This is the motivation of the present work, aimed at studying RE-MHD co-evolution in disruptions using the 3D MHD code JOREK [1,2].

We present numerical predictions for the formation and termination of RE current in vertically unstable plasmas in mitigated ITER disruption scenarios. The REs are modeled as a separate fluid species [3], subjected to field-parallel and drift transport along with an avalanche source including the effect of partially-ionized impurities [4]. The back-reaction of REs on MHD is treated via a current-coupling, while the impurities are assumed to be in coronal-equilibrium. Electrically conducting structures such as the vacuum-vessel and various coils are included via coupling to the STARWALL code. Starting with a 15MA elongated free-boundary X-point plasma equilibrium, a pseudo thermal-quench followed by first injection of Ne+D causes a current-quench and subsequent vertical motion along with a multi-MA RE beam formation.

Through axisymmetric simulations, we investigate the effect of first injection quantities, current-profile flattening, Neon 2nd injection and Neon-flushout via Deuterium 2nd injection. Within the constraint for the current-quench time for ITER (50ms < t_{CQ} < 150ms) and assuming an RE seed current of 0.1A, our simulations predict a multi-MA RE beam for any combination of Ne/D injection quantities, with the RE beam current increasing (upto I_{RE} ~ 9.5MA) with Neon quantity. This is in qualitative agreement with 1D predictions of the GO code [5]. The second injection of Neon causes both a faster decay of RE current, and a correspondingly faster vertical plasma motion towards the wall. However, 2nd injection of Neon is found to be ineffective in reducing the undissipated RE energy deposited onto the wall. Commensurate increase in the poloidal magnetic energy channeled to REs (due to bound-electrons acting as additional avalanche targets), is seen to offset the additional dissipation of RE energy.

In general, vertical plasma motion and scrape-off causes a net decrease in the edge safety factor ($q_{95}\ a^2/I_p$). Through full 3D simulations, we demonstrate that accessing lower q95 can trigger the fast growth of MHD instabilities leading to magnetic stochastization. This opens up a possible pathway for benign termination of RE beams in ITER via distributed RE losses onto the wall, even without executing a Neon flushout. Dynamics of this process and its sensitivity will be discussed.

[1] G.T.A. Huijsmans et al., Nucl. Fusion 47.7, 659 (2007).
[2] M. Hoelzl et al., Nucl. Fusion 61, 065001 (2021).
[3] V. Bandaru et al., Phys. Rev. E 99, 063317 (2019).
[4] L. Hesslow et al., Nucl. Fusion 59, 084004 (2019).
[5] O. Vallhagen et al., J. Plasma Phys. 86, 475860401 (2020).

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