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# Prediction of runaway electron avalanche in ITER mitigated disruptions via 3D MHD modelling

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Disruptions are the rapid termination of discharges in tokamaks [1], usually composed of a rapid thermal quench (TQ) and a subsequent current quench (CQ). The avalanche of runaway electrons (REs) during ITER disruptions could potentially generate several mega-amperes of RE current, which might damage the plasma-facing components [2]. On ITER, the disruption mitigation system will use shattered pellet injection (SPI) of impurity and/or hydrogen to prevent the potential damages caused by disruptions, including those from REs. Previous studies have suggested that avoiding the formation of such a large RE current would be extremely difficult in ITER disruptions because of its high plasma current up to 15 MA and the extra nuclear RE seed in deuterium-tritium operations [3]. However, before the number of REs increases to a large value, some REs might be lost due to the magnetic stochasticity from the growth of MHD instabilities such as tearing modes [4]. In our work, MHD-induced RE deconfinement in CQ is modeled with the JOREK code, using a 3D reduced MHD model coupled to a fluid description of REs [5]. Tracing particles are used to evaluate the transport of REs in the magnetic field calculated by the MHD model.

Considering that the post-TQ (pre-CQ) plasma scenario is not well known, the initial conditions of the CQ simulations in this work include a scan over the current density profiles. More realistic scenarios based on the TQ dynamics in the simulations of SPI-mitigated ITER disruptions [6] are also used in our CQ modelling. During the scan, the MHD stability shows high sensitivity to the initial current profile. High edge current gradient in the profiles with a flat core region tends to drive strong instabilities on edge rational surfaces, which rapidly trigger global magnetic stochasticity. A complete RE loss is expected to happen in these scenarios (**Fig.1** left). In contrast, a peaked current profile in the absence of edge drive may only have broken flux surfaces (FS) on the peripheral layers (**Fig.1** right). A strong RE current can still be generated in the confined region in the core. The same trend is found in further CQ simulations based on the post-TQ profiles taken from corresponding ITER SPI simulations, where the level of current flattening caused by the perturbation from the pellets is different.

After the global magnetic stochasticity, some FSs might recover, and the REs can re-avalanche from seeds. However, together with other mechanisms like the scraping-off effect [7] and optimized mitigation injection, even temporary or partial deconfinement could facilitate the RE avoidance on ITER. Simulations to the end of the CQ with an improved RE-MHD interaction model are ongoing to investigate this.

References

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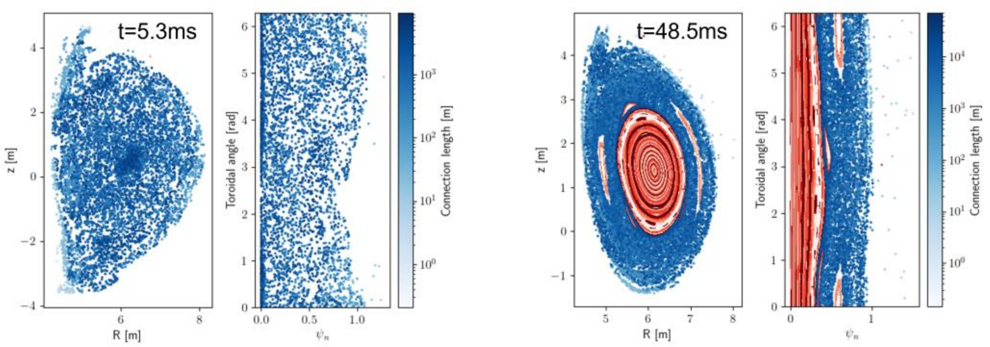


**Figure 1.** Poincaré plots from the RE particle tracing in two simulations with unstable (left) and stable (right) pre-CQ current profiles. The traces of two hundred 10MeV RE are calculated. The connection length in the plot represents the distance a RE need to travel before it hits the wall. In the red regions REs are well confined.