Contribution ID: **136** Type: **Contributed**

Non-linear simulation of benign RE beam termination in JET D2 second-injection experiment

Understanding the MHD activity leading to runaway electron (RE) beam termination might allow a path to avoid localized first-wall damage in fusion-grade tokamaks such as ITER. Recent experiments at JET demonstrated the possibility of benign termination of RE current [1], when deuterium pellets were injected (via SPI) onto a plateau-phase RE beam with argon impurities in the background plasma. This is the motivation of the present work, wherein through non-linear MHD simulations, we aim to obtain some physical insight into the instabilities in the respective JET experiments.
In this contribution, we present results of JOREK [2] simulations, that focus on the non-linear interaction of resistive tearing modes with REs. Runaway electrons are modeled as a fluid that is subjected to parallel transport and is electromagnetically coupled to the background plasma [3]. It is observed that the hollow current-profile of the equilibrium is conducive to the linear growth of the unstable (m, n) = (4, 1) modes at the two q = 4 rational surfaces. In the non-linear phase, this in turn leads to the growth of successively higher toroidal modes, eventually stochastising the magnetic field in a large portion of the plasma cross-section and the corresponding expulsion of REs. Both the timescales and the main qualitative dynamics in the simulations show close resemblance to the experiment. The effect of runaway electrons and their transport velocity on the linear and non-linear phases of this process is discussed.

References

[1] C. Reux et al., Manuscript in preparation (2020).
[2] G.T.A. Huijsmans et al., Nucl. Fusion 47.7, 659 (2007).
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Track Classification: Mitigation