The effect of high-Z material injection on runaway electron dynamics

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Developing a disruption & runaway electron (RE) mitigation strategy that robustly scales to ITER and beyond is a major challenge. The dynamics is governed by a complex interplay of effects such as the atomic physics and penetration of the high-Z material injected for mitigation, quench dynamics (MHD), kinetic physics, and quantum mechanics. The EUROfusion consortium is executing a coordinated research program to better understand the generation[1,2], control[3] and mitigation[4] of disruption-born REs following massive material injection.

RE studies on ASDEX Upgrade and TCV are carried out using massive gas injection (MGI) of neon, argon and krypton. The injection of high-Z materials mixed with deuterium is a promising mitigation strategy for ITER. A 1:4 argon-deuterium mixture has prevented RE beam formation in the commonly used RE scenario on ASDEX Upgrade. TCV demonstrated RE beam control up to a pre-disruption elongation of $\kappa \simeq 1.5$. Our results indicate that increasing elongation has no significant impact on RE physics and the main challenge is position control.

The scaling of the initial runaway current on plasma- and injection parameters, as well as the subsequent dissipation is analysed using 1D disruption-runaway simulations[5,6] along with state-of-the-art full-f kinetic models[7]. The high-Z dissipation model[7] was validated using experimental data from multiple European tokamaks. Full-f kinetic simulations were carried out for the first time for the complete duration of the thermal & current quench. These simulations show that an abrupt delivery of high-Z material (e.g. executed by SPI) is expected to significantly decrease the RE generation rate compared to slower injections methods (such as MGI).

References

[1] G. Pautasso et al. Plasma Physics and Controlled Fusion, **59** (1):014046 (2017).

[2] J. Mlynar et al. Plasma Physics and Controlled Fusion, **61** (1):014010 (2019).

[3] D. Carnevale et al. Plasma Physics and Controlled Fusion, **61** (1):014036 (2018).

[4] G. Papp et al. IAEA-FEC, **IAEA-CN-234-0502**:EX/9 (2016).

[5] G. Papp et al. Nuclear Fusion, **53** (12):123017 (2013).

[6] E. Fable et al. Nuclear Fusion, **56** (2):026012 (2016).

[7] L. Hesslow et al. Plasma Physics and Controlled Fusion, **60** (7):074010 (2018).