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Physics, control and mitigation of disruptions and runaway electrons in the EUROfusion Medium Size Tokamaks science programme

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EUROfusion dedicates a significant effort to disruption and runaway electron (RE) research in its Medium Size Tokamaks (MST) Task Force, which coordinates the European activities in ASDEX-Upgrade (AUG), MAST-U and TCV. The MST disruption and RE programme addresses prediction, avoidance and mitigation.
Experiments on disruption mitigation utilize Massive Gas Injection (MGI) systems in AUG and TCV. AUG focused on the amount of injected gas and on the search for the minimum quantity for mitigation. The minimum amounts of gas used in the AUG MGI for successful mitigation is now up to two orders of magnitude smaller than the maximum values used before. The toroidal asymmetry of the radiation distribution in plasmas disrupting because of locked modes is being studied by exploiting the AUG active coil system, which allows for reproducible relative positioning of the locked mode with respect to the MGI valves. The JOREK code is presently being applied to AUG and extended to impurity MGI, as well as being complemented by a test particle module for RE studies.
Scenarios for the reproducible generation of RE during disruptions have been developed both in AUG and TCV. In AUG, RE are produced by injecting Argon in a 0.8 MA, ECRH heated circular plasma. A RE beam, carrying current up to 420 kA for 480 ms is formed. A second Ar injection, 70 ms after the first Ar puff, is used to suppress the RE. The RE current decay rate grows with the amount of injected argon. RE control is attempted in AUG also by applying magnetic perturbation that could produce a stochastic magnetic field and eventually de-correlate RE, and by controlling the position of the RE beam via active ramp-down of the current.
Disruption avoidance through MHD stabilization via localized injection of Electron Cyclotron waves is studied in AUG at high beta or close to the density limit, complemented by applied magnetic perturbations to control the locked mode position or to entrain it.
Indications of unexpected or 'unhealthy' behaviour of the plasma that could be symptom of an incoming disruption are detected based on modelled plasma evolution and used as an input signal to a pulse supervision system. This is done with the RAPTOR code in AUG and TCV. The code gives detailed real-time information about profiles that are compared to known limits and to the expected plasma evolution providing an avoidance tool.

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