DPP17-2017-002004

Abstract for an Invited Paper
for the DPP17 Meeting of
the American Physical Society

Physics of the interaction between runaway electrons and the background plasma of the current quench in tokamak disruptions[1]

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Runaway electrons are created during disruptions of tokamak plasmas. They can be accelerated in the form of a multi-MA beam at energies up to several 10s of MeV. Prevention or suppression of runaway electrons during disruptions will be essential to ensure a reliable operation of future tokamaks such as ITER. Recent experiments showed that the suppression of an already accelerated beam with massive gas injection was unsuccessful at JET, conversely to smaller tokamaks. This was attributed to a dense, cold background plasma (up to several 10^{20} m^{-3} accompanying the runaway beam. The present contribution reports on the latest experimental results obtained at JET showing that some mitigation efficiency can be restored by changing the features of the background plasma. The density, temperature, position of the plasma and the energy of runaways were characterized using a combined analysis of interferometry, soft X-rays, bolometry, magnetics and hard X-rays. It showed that lower density background plasmas were obtained using smaller amounts of gas to trigger the disruption, leading to an improved penetration of the mitigation gas. Based on the observations, a physical model of the creation of the background plasma and its subsequent evolution is proposed. The plasma characteristics during later stages of the disruption are indeed dependent on the way it was initially created. The sustainment of the plasma during the runaway beam phase is then addressed by making a power balance between ohmic heating, power transfer from runaway electrons, radiation and atomic processes. Finally, a model of the interaction of the plasma with the mitigation gas is proposed to explain why massive gas injection of runaway beams works only in specific situations. This aims at pointing out which parameters bear the most importance if this mitigation scheme is to be used on larger devices like ITER. Acknowledgement: *This work has been carried out within the framework of the EUROfusion Consortium and has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053. The views and opinions expressed herein do not necessarily reflect those of the European Commission.*

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