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Advances in Numerical Modelling of MGI Mitigated Disruptions in ITER

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Disruption mitigation with use of the massive injection of noble gases (MGI) is widely used and experimentally validated on contemporary tokamaks. The disruption mitigation system (DMS) in ITER is aiming to subsequently or simultaneously achieve a solution for 3 main goals including mitigation of the heat loads on the plasma facing components during thermal quenches (TQs), keeping tolerable electro-mechanical loads on the conducting structures surrounding the plasma, and preventing the appearance of or suppressing the relativistic electron (RE) beams at the current quench (CQ) stage of the disruption. To assess the feasibility and operation domain of the ITER DMS, extended simulations are needed. The present report describes recent developments of the physical models for accurate and effective simulations of mitigated disruptions in ITER. The integrating core of these simulations is the Disruption Simulator based on the DINA code (DINA-DS). For specific conditions of impurity-dominated CQ plasmas, a special transport solver has been developed. Ionization of injected impurities due to interactions with REs is taken into account in the presented advanced transport model. MGI mitigated CQs are accompanied by fast vertical movement of the plasma column. A precise evaluation of the eddy currents induced in blanket modules and in the vacuum vessel has to take these dynamics into account. Representation of the ITER double wall vacuum vessel structure as 2 sets of 50 thin rings with rectangular cross-sections and relevant resistances for the inner and outer walls provides the necessary accuracy of the calculations. Recently, DINA has been updated to include parallel heat fluxes in the halo region for a complete energy balance. This provides the basis for a better estimate of the halo temperature and, therefore, plasma resistivity, affecting the resulting halo current amplitudes and CQ dynamics. The evolution of the RE distribution function in DINA-DS is simulated with the use of a recently developed analytical model. Knowledge of the RE distribution function instead of just RE current is of principal importance in assessing the total kinetic energy deposited to the first wall due to the loss of REs. Representative scenarios of mitigated disruptions in ITER simulated with updated models are presented. The operation domain for the ITER DMS based on MGI is discussed.

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