3D MHD simulations of unmitigated Vertical Displacements Events in ITER

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[3] *please refer to [M Hoelzl et al, Nuclear Fusion 61, 065001 (2021)]*

One of the high priority research needs for the ITER project is the development of a solid physics basis of plasma disruptions and their mitigation. Present predictions for the thermal and electromagnetic loads caused by unmitigated Vertical Displacement Events (VDEs) rely on experimental observations and axisymmetric simulations [1,2]. 3D effects, such as the sideways vessel force produced by toroidally asymmetric VDEs, must be understood to provide the basis for load validation in support of the ITER Research Plan and make predictions for full current operation. In this work, 3D simulations of such events are performed for an ITER 15MA/5.3T plasma with the MHD code JOREK coupled to the STARWALL wall code. The main goal of these simulations is to study different asymmetric features occurring during unmitigated VDEs that remain unclear for ITER. Among those features, the evolution of the distribution of the plasma and wall current density, the triggering time of the thermal quench, the distribution of the heat-fluxes onto the first wall, the minimum edge safety factor and the maximum sideway force and its toroidal rotation will be studied.

In these simulations, a VDE is triggered in an L-mode plasma by applying a current perturbation in the ITER in-vessel coils. Since the expected time scales for unmitigated VDEs in ITER are of the order of ~500 ms due to the long decay time of the ITER vessel currents, the main plasma and wall parameters are re-scaled by a given factor in order to reduce the computational cost to present computing capabilities (~million cpu.h). The influence of the re-scaling factor on the results will be studied together with convergence tests (e.g. for the toroidal resolution). In addition, the effect of the VDE direction (upwards or downwards), the parallel transport in the open field line region and the plasma viscosity will be studied. One of the main results obtained from this study is the confirmation that despite different assumptions, the thermal quench is triggered once the edge safety factor decreases to a value of 2 due to the reduction of the plasma volume during the VDE.

[1] Hender, T. C., et al. "MHD stability, operational limits and disruptions." Nuclear fusion 47.6 (2007): S128

[2] Lehnen, Michael, et al. "Disruptions in ITER and strategies for their control and mitigation." Journal of Nuclear Materials 463 (2015): 39-48.