Parametric dependence analysis of disruption forces in tokamaks

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Disruptions are among the fundamental issues to be tackled in future tokamaks [1]. With rapid transfer of the magnetic energy, they generate significant (eddy and halo) currents in the conducting structures. Interaction of these currents with the strong magnetic field present in the tokamaks is expected to produce substantial electromagnetic forces and torques, which might challenge even the integrity of the device elements. Consequently, theoretical and experimental studies on disruption modelling, prediction, avoidance and mitigation are currently in progress. In this paper, we investigate the dependence of the disruption-induced global electromagnetic forces on various parameters (resistive wall time, plasma current quench time, vertical instability growth rate and stability margin). This is a highly debatable area with contradictory indications and huge scatter of the results [2-5]. The modelling tool that we use is the CarMa0NL code [6], solving evolutionary axisymmetric equilibrium equations in the plasma, coupled to 3D volumetric conductors described by the eddy currents equations. This code is used here to provide predictions for ITER-relevant geometry and range of parameters, since it has been recently proven adequate to such studies [7]. Indeed, the CarMa0NL results have been found consistent with the counterintuitive, but theoretically founded property [8] that the total global electromagnetic force acting on a perfect conductor circumventing the toroidal plasma must be zero, neglecting plasma inertia. The simulations reproduced this property despite circulation of significant total current in such ideal wall (up to several MA in ITER) and strong local electromagnetic force density. Moreover, the results obtained suggested the proposal of an electromagnetic disruption force damper [7], able to “drain” global force from the conducting wall. Here we make next steps in analyzing the high-priority disruption issues.

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