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Global Forces on Tokamak Wall During Disruptions

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INTRODUCTION

- The COMPASS-U [1] is a high-field tokamak presently in the final design phase. It will operate at strong magnetic field (5 T) and large plasma current (2 MA), therefore, severe electromagnetic forces are expected on the tokamak wall during abnormal plasma terminations.
- Compared to conventional cases with simpler geometry, such analysis for the COMPASS-U is complicated by the presence of highly conductive passive stabilizing plates (PSPs) placed inside the vacuum vessel (VV) for improving of the plasma vertical stability (see Fig. 1a).
- Poloidal field (PF) coils are situated in close proximity of the VV and may strongly affect the eddy current dynamics.
- To cross-validate our results against analytical predictions [2] is one of the milestones in selecting a strategy for numerical computations of transient events for COMPASS-U considering PF coils and volumetric geometry of the wall with PSPs.

INITIAL EQUILIBRIUM

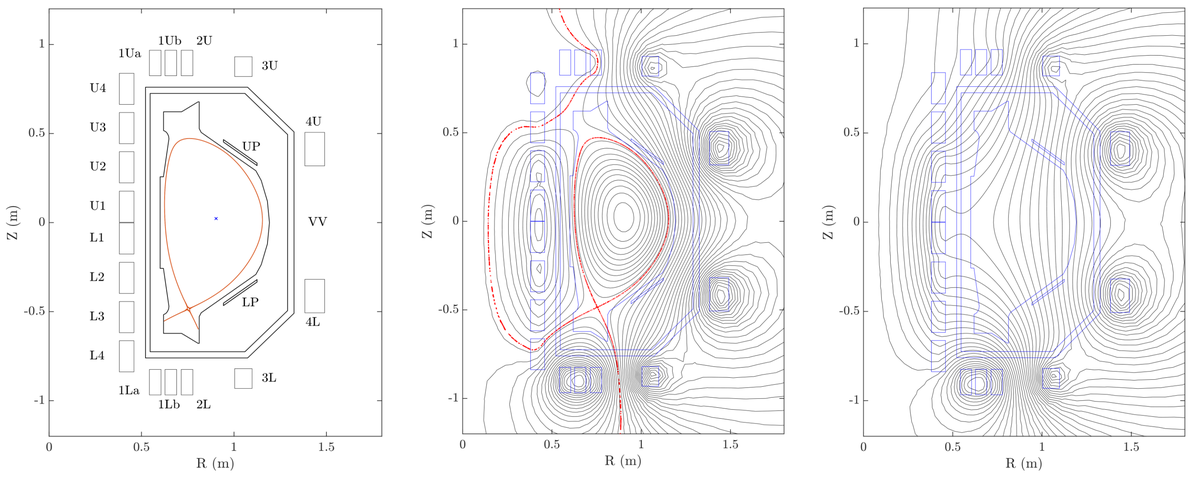

FIG. 1. Poloidal cross-section of COMPASS-U tokamak: poloidal field coils, vacuum vessel (VV), passive stabilizing plates (UP, LP) and first wall. The plasma magnetic axis (blue cross) and LCFS (a), plasma + vacuum (b) and vacuum only (c) flux maps for the single-null diverted baseline scenario ‘6400’.

CONFIGURATIONS OF CONDUCTORS UNDER CONSIDERATION

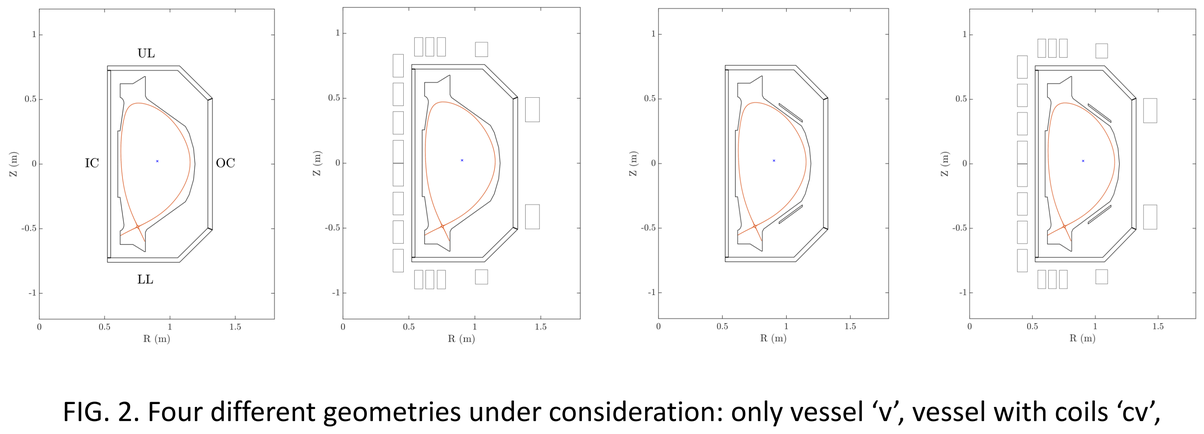

FIG. 2. Four different geometries under consideration: only vessel ‘v’, vessel with coils ‘cv’, vessel with plates (wall) ‘w’, and wall with coils ‘cw’. The vessel itself is segmented virtually for analysis in four parts: inner cylinder (IC), outer cylinder (OC), upper lid (UL) and lower lid (LL).

DISRUPTION SCENARIO AND CarMa0NL [3] RESULTS

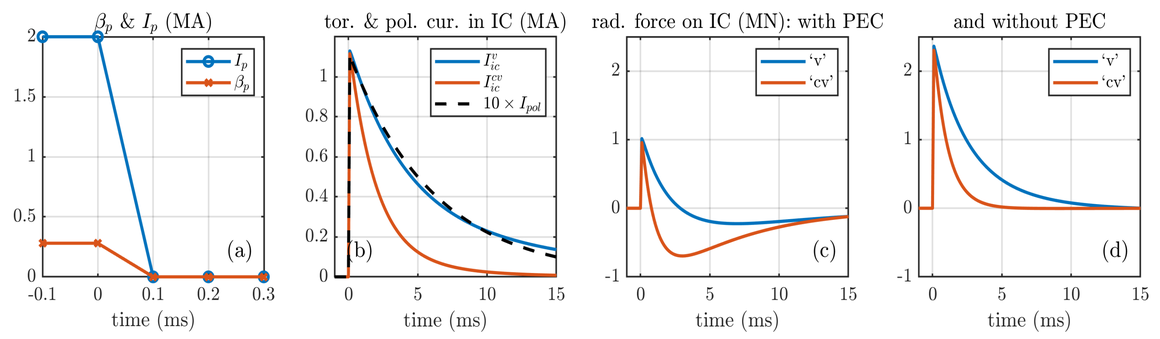

FIG. 3. Time evolution of the plasma current and poloidal beta during centered major disruption (a). Results for geometries ‘v’ and ‘cv’: time dependences of the toroidal (solid coloured) and poloidal (dashed black line) current in the IC (b), radial force on the IC for the case with (c) and without (d) poloidal eddy current.

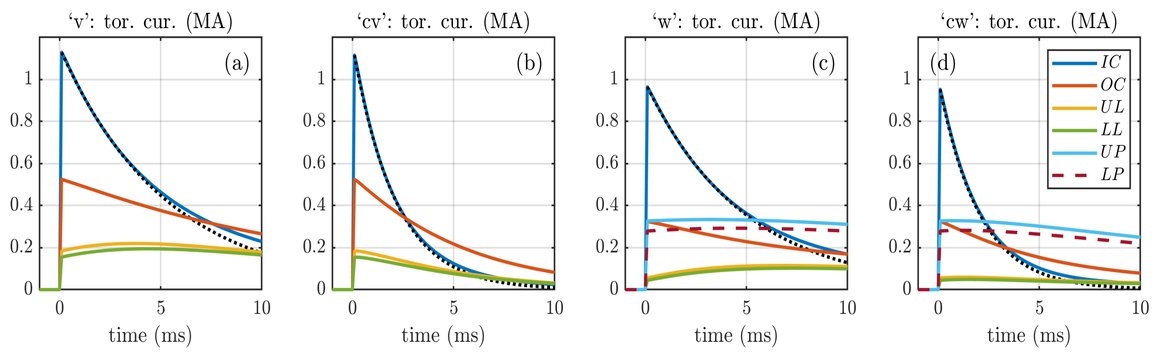

FIG. 4. Results for geometries ‘v’ (a), ‘cv’ (b), ‘w’ (c) and ‘cw’ (d): time dependences of the toroidal current in the inner cylinder (IC), outer cylinder (OC), upper lid (UL), lower lid (LL), upper plate (UP) and lower plate (LP).

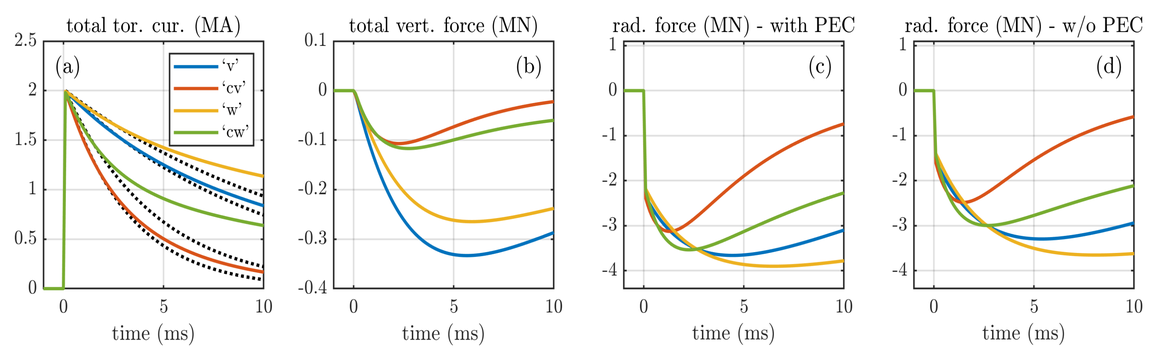

FIG. 5. Results for geometries ‘v’, ‘cv’, ‘w’, ‘cw’: time dependences of the total toroidal current in the wall (a), total vertical force on the wall (b), and total radial force for the case with (c) and without (d) poloidal eddy current.

CONCLUSIONS AND OUTLOOK

- The poloidal eddy current and its dynamics affects strongly the vertical and radial forces on the individual parts of the vessel, for example, when considered, the radial force on the IC is 2.4 times reduced and the vertical force on the UL is increased up to 43.0 times. This specifies previous analytical predictions for COMPASS-U (see Ref. [4] and references therein).
- The PF coils drain current from the wall, when taken into account, they reduce the maximum total vertical force on the wall by a factor of two.
- The total vertical force on the wall is found to be almost zero just after an abrupt CQ: this successful benchmarking with analytical predictions [2] increases credibility of CarMa0NL numerical calculations for COMPASS-U tokamak.

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ACKNOWLODGEMENTS

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