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Non-equilibrium perturbations of the vertically unstable mode in tokamaks

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The maximum allowable vertical displacement which can be recovered by the magnetic control system is a fundamental quantity for tokamak magnetic control (Gribov 2015 Nucl. Fusion 55 073021). This figure of merit is usually defined relying on a mass-less assumption, i.e. the reaction currents in wall structures are considered to vary in order to guarantee MHD equilibrium during the plasma perturbation. Recently we examined the consequences of considering also non-equilibrium perturbations of the vertical position via a simplified rigid filament model (Isernia 2023 Plasma Phys. Controlled Fusion 65 105007). In this case the reaction currents in wall structures are not determined anymore by the MHD equilibrium constraint during the perturbation. We illustrate the mapping of initial conditions between the full dynamic and the reduced mass-less model, emphasizing the role of the mass-less assumption on the definition of maximum allowable displacement. Moreover we show that the ratio between the perturbation time of the vertical position and the electromagnetic time of the unstable mode in the quasi-static limit $\Delta t/\tau_u$ governs the intensity of reaction currents at the end of the perturbation, hence the overall perturbation of the unstable mode.

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