Plasma stability in a tokamak with q~1 and forces acting on the conducting wall during disruption

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The stability of the tokamak plasma in the process of disruption and the sideways forces acting on the conducting wall due to the eddy currents are investigated. The plasma is considered to be isolated from the wall and halo currents are not taken into account. The basis for calculating the stability is the equilibrium configuration, obtained in the simulation of the disruption in ITER by the DINA code taking into account the generation of runaway electrons with the corresponding current profile [1]. A plasma with minor radius of 1 m and almost circular shape with a large current (> 5 MA) and the safety factor of $q \sim 1$ is close enough to the wall of the vacuum chamber at its top so that the ideal kink mode $n = 1$ becomes stable. Using the stability code KINX [2], the conditions for wall stabilization (stability gaps) at the Alfvén timescale are determined varying the current profile and the value of q at the plasma boundary. Taking into account a finite conductivity in the thin wall approximation, the growth rates of resistive wall modes (RWM), the plasma displacement structure and the currents induced in the wall are calculated. The sideways force acting on the wall is determined as the Ampere force from the surface current in a thin wall and the equilibrium field.

The results of the calculations show that for a peaked current density profile in the plasma there is a gap of ideal stability at $q > 1$ and a slow RWM can develop. The resonant harmonic $m = 1$ dominates the plasma displacement. The sideways force is almost completely determined by the interaction of the perturbed poloidal surface current and the toroidal field in the ITER (5.3T). The magnitude of this force with respect to the maximum of the perturbed radial field at the plasma boundary corresponds to the analytical model [3], despite the differences in the displacement structure. A possible development of the model with allowance for a plasma with open magnetic surfaces interacting with the wall is discussed.

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[2] L. Degtyarev et al. Computer Phys. Commun. 103 (1997) 10-27.

[3] D. V. Mironov, V. D. Pustovitov. Physics of Plasmas 24 (2017) 092508.