ON APPLICABILITY OF THE ANALYTICAL THEORY OF NON-CIRCULAR PLASMA EQUILIBRIUM TO THE ANALYSIS OF FAST TRANSIENTS IN TOKAMAKS [[1]](#footnote-1)\*)

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Modern tokamaks operating with vertically elongated plasmas are subject to Vertical Displacement Events (VDEs). The existing analytical theory of plasma equilibrium was developed mainly for circular plasma and does not allow their description. Two extensions are needed for that: incorporation of the non-circular shape and account of the electromagnetic reaction of the resistive wall to plasma evolution, including the current quench.

The plasma-wall interaction is based on both Faraday’s and Ohm’s laws, which include the time derivative of the poloidal flux. The latter should be found as a solution to the outer equilibrium problem. In the analytical theory, some progress had been achieved in a model of straight plasma column [1-4]. We argue that the results of [1-4] cannot be used in the evolution tasks for the toroidal plasma and propose a proper improvement.

The problems with cylindrical models arise from the fact that the boundary conditions for the poloidal flux become degenerate for a cylinder. These reduce to continuity of the poloidal flux on the plasma surface but leave unspecified the constant of integration of the reduced Grad-Shafranov equation. The constant remains a free parameter and sometimes is preset as zero [3, 4]. However, being directly related to the toroidal voltage, it cannot be arbitrarily prescribed in toroidal systems. In such a case, the constant should be determined carefully to calculate the response of the wall to fast transients.

Here, a method of the external equilibrium problem solution, based on the Green function formalism [5, 6], is discussed with intended application to the non-stationary equilibrium. Recently, this method allowed us to consider both toroidicity and plasma elongation [6]. This opens up the possibility to evaluate the constant of integration and then derive the equations of plasma motion applicable for the VDE analysis.

References

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