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ON ACCOUNT OF THE VACUUM VESSEL ELONGATION IN CALCULATION OF THE VDE GROWTH RATE IN A MODEL OF A TOKAMAK WITH NON-CONFOCAL WALL *)

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Tokamak plasma with vertically elongated cross-section is unstable with respect to sudden vertical motions called Vertical Displacement Events (VDE). It is known that the currents induced in the vacuum vessel can slow-down the VDE [1], so the process develops on times of the order of current decay time. Mathematical basis of account of the resistive wall effects in tasks with evolving plasma was developed in [2, 3] and involves the integral formulation of the magnetic flux diffusion equation on a thin resistive shell. This equation, if solved using perturbation method in terms of small vertical displacement ξ with initial equilibrium prescribed by R. Gajewski [4], predicts growing mode $\xi = \xi_0 \exp(t/\tau_{\mathrm{VDE}})$ with growth time

$$\tau_{\mathrm{VDE}} = \tau_w \oint_w c_b e^{2\mu_b} \,\mathrm{sh}(2\mu_b - \mu_w) \sin\theta_w \frac{G(\mathbf{r}, \mathbf{r}_w)}{R_w b_w z} d\mathrm{l}_w \,. \tag{1}$$

Here, τ_w is a resistive time of the wall with major and minor radii R_w and b_w, c_b is a linear eccentricity of a plasma boundary ellipse $\mu = \mu_b$ in coordinates $r = R_w - c_b \,\mathrm{sh}\,\mu \cos\theta$ and $z = c_b \,\mathrm{ch}\,\mu \sin\theta$, G is the Green's function of the Grad-Shafranov operator, and $d\mathrm{l}_w$ is the differential arc length of the wall poloidal contour, which acts as the integration domain. The subscript w marks the integration variable.

Previously, the VDE growth time was calculated for the wall with circular cross-section [5] to demonstrate the ability to evaluate the integral in (1) analytically. However, modern tokamaks vacuum vessels have significant vertical elongation $K_w > 1$, which should be accounted for in τ_{VDE}. In this work, we present a technique that allows to calculate τ_{VDE} using Eq. (1) for the wall with elliptical cross section. The method we develop include the Green's function transform in complex plain and integration over an elliptical contour using the residue theory.

References

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