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TH/P3-16: Rotational Stabilization of the Resistive Wall Modes in Tokamaks

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The paper is devoted to studying the combined effect of the mode rotation and energy dissipation in the resistive wall on the plasma stability. The problem is analyzed on the basis of the energy approach complementing the standard methods of the traditional MHD theory of plasma stability. The key element that makes our model different from this theory and commonly used thin-wall approaches to the stability analysis of the resistive wall modes (RWMs) is the incorporation of the skin effect. In the ideal MHD theory of plasma stability, the skin depth is, formally, zero. On the contrast, the thin-wall theory of the RWM stability assumes the skin depth much larger than the wall thickness. The presented model considers the intermediate case with a finite skin depth compared to the wall thickness. This corresponds to the modes in-between the typical RWMs and the ideal MHD modes, but the wall resistivity is still an important factor affecting the modes dynamics. It is shown that, in this region, the growth rates of the locked modes must be one-two orders larger that the calculated in the thin-wall models. On the other hand, the fast RWMs can be completely stabilized by the mode rotation above some critical level. Qualitatively, this corresponds to the rotational stabilization observed in the DIII-D tokamak and allowing the plasma operation above the no-wall stability limit [E. J. Strait et al., Phys. Plasmas 11, 2505 (2004)]. This is the main result of this study which is completely analytical with all dependencies explicitly shown. In particular, the dispersion relations for the fast RWMs and the critical frequency of the mode rotation necessary for the rotational stabilization are expressed through the quantities that depend on the plasma parameters or can be experimentally found by the magnetic measurements outside the plasma. Theoretical and experimental applications of the results are also discussed.

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