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Self-consistent modelling of energetic particle effects on RWM: anisotropy and finite orbit width[1]

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The resistive wall mode (RWM) is a macroscopic instability that can severely limit the achievable plasma pressure, and hence the eventual fusion power production, in present and future tokamak devices. Therefore, understanding the physics associated with this instability, and learning how to control it, is of critical importance in future devices such as ITER, in particular in the so called advanced tokamak scenarios. During recent years, it has been realized that kinetic effects, due to the mode resonance with drift motions of both thermal and energetic particles (EPs), can play a crucial role in stabilizing/destabilizing the RWM. The mode physics in such cases are well described by the MHD-kinetic hybrid approach. This contribution reports the recent new developments in the RWM theory, based on a non-perturbative, or self-consistent, approach for numerical modelling of the RWM stability in the presence of energetic particles. Two important aspects of the EPs effects are examined: (i) the anisotropy of the equilibrium distribution in the phase space, in particular along the particle pitch angle; and (ii) the finite orbit width (FOW) effect of EPs on the mode stability. Both effects have been studied within the so called perturbative approach. In particular, it has been found from a recent study, Ref. [1] below, that for the target plasma as envisaged in the ITER 9MA scenario, the RWM is fully stabilized by the kinetic effects from thermal and energetic particles. The FOW of EPs plays an essential role in the mode damping. Given the fact that the perturbative approach often overestimates the kinetic damping, as compared to the non-perturbative approach (see e.g. Ref. [2] below), it is of great interest to understand how the FOW affects the mode stability following a non-perturbative formulation. Such formulations have recently been developed, incorporated into the MARS-K code, and will be presented in this talk. Simulation results will be reported for full toroidal plasmas such as those designed for the ITER 9MA steady state scenarios.

[1] I.T. Chapman, et al., Phys. Plasmas 19, 052502 (2012).
[2] Y.Q. Liu, Nucl. Fusion 50, 095008 (2010)

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