Rotation braking and error-field penetration*

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Resonant magnetic perturbations generated by coil misalignment are a serious concern for magnetic fusion experiments including tokamaks and Stellarators. Error fields can drive magnetic reconnection and induce the formation of magnetic islands in otherwise tearing-stable plasmas.[1] The error-field driven magnetic islands exert a braking force on the plasma and thus play an important role in momentum transport, causing qualitative changes to the profile of plasma velocity. The effects of the changed plasma velocity on heat and particle transport generally dominate those resulting from profile flattening inside the islands. As the error field amplitude increases, a mode penetration threshold is encountered above which the plasma rotation is arrested and the island grows to a size comparable to or greater than its size in vacuum. Mode penetration, which should not be confused with mode locking, often leads to loss of confinement and disruption. It has been shown with simple linear MHD models, however, that plasma rotation can effectively suppress the error field penetration. We have investigated how finite Larmor radius effects and diamagnetic rotation affect the error field penetration threshold by comparing the results of a two-fluid code with previously-developed analytic theories.[2,3] We devoted particular attention to the regime where drift-waves are excited and the solution becomes delocalized. We find that the existing linear theories fail to describe this regime properly. In the drift-wave radiating regime, we observe a partial error field penetration even when standard scaling predicts otherwise. It appears thus that the models in literature underestimate the penetration threshold. Future work will focus on the development of a reliable analytic explanation for the observed discrepancy and on the investigation of the effect of turbulence on the critical threshold.

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