Saturation of the Neoclassical Tearing Mode Islands

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The problem of the saturation of the neoclassical tearing mode is of great relevance in magnetic fusion research, since the size of the magnetic island associated with the perturbation, at the end of its evolution, gives a significant measure of the reduction of confinement in the new plasma equilibrium.

New, rigorous analytic results for the classical tearing island saturation are presented. These results are valid for the realistic case where the magnetic island structure is non-symmetric about the reconnection surface and the electron temperature, on which the electrical resistivity depends, is evolved self-consistently with the island growth. The new equilibrium, represented by the saturated island, is constructed using a perturbation expansion which does not need an *ansatz* on the shape of the magnetic field, since it takes into account self-consistently the complete harmonic structure of the mode in the nonlinear layer. The new terms in the Rutherford equation, which are obtained with this procedure, are likely to have an impact on the overall saturation level of NTMs.

In order to attain a more realistic description of the magnetically confined plasma, several additional physical effects must be introduced in the model. The analytic framework of this investigation, has been extended to a MHD four-fields model, which accounts for effects coming from the pressure and the pressure gradient, such as the diamagnetic rotation of the island, as well as the Bootstrap current, which can lead to a nonlinear destabilization of the mode. The complexity of this model is such that the current understanding of physics beneath it relies on analytical investigations based on simple theoretical assumptions or on a numerical approach. The numerical experiments presented here are focused on the investigation of the effect of the Bootstrap current in a drift-tearing regime. They have shown a significant reduction of the final saturated width of the island with respect to the prevision of the generalized Rutherford equation accepted in literature. A theoretical interpretation of this difference may be related to the additional physics present in the four-fields model (i.e. the effect of the ExB convection and of the diamagnetic frequency) and, at present, is under investigation.