Direct prediction of nonlinearly saturated tearing mode islands with SPEC

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Abstract. We demonstrate, for the first time, that it is possible to use an MHD equilibrium code to directly predict the nonlinear saturation of tearing modes without resolving the dynamics and without explicit dependence on the plasma resistivity. This is achieved by exploiting the variational principle of multi-region relaxed MHD, which is numerically implemented in the SPEC code [1, 2]. We predict the saturated island width, w_{sat}, in configurations with strong guide fields and non-trivial current profiles and for a wide range of values for the instability parameter Δ' [3]. Calculations are carried out in slab and cylindrical geometries and the predicted values of w_{sat} are shown to reproduce the theoretical scaling at small values of Δ' and the scaling obtained from resistive MHD simulations at large Δ'. Perspectives on the inclusion of auxiliary and bootstrap currents in toroidal calculations are discussed.

[1] S. R. Hudson et al, Physics of Plasmas 19, 112502 (2012)
[2] S. R. Hudson et al, Plasma Physics and Controlled Fusion, submitted (2020)
[3] J. Loizu et al, Physical Review Letters, submitted (2020)