Magnetic Island Saturation in Different MHD Equilibria

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A recently submitted paper by R.B. White et. al. showed that the asymmetry of magnetic island created by tearing mode is crucial to understand its evolution. The asymmetry, coupled with temperature flattening, provides current perturbation terms which are very important. Their inclusion substantially enhances island growth and saturation of islands of sufficient size, and leads to a potential mechanism to explain the Greenwald density limit. In this work, we investigate the island saturation in different island equilibria in cylindrical geometry with the asymmetric current perturbation term included in a semi-analytic reduced model in comparison with full MHD simulations.The equilibrium profiles are given by Furth, Rutherford and Selberg [Phys. Fluids 16, 1054 (1973)] current and a simple low beta temperature profile. The impact of axis safety factor $q(0)$, width of current channel $r(0)$ and current profile peaking factor ν on saturated island width is analyzed. The scan of $q(0)$, $r(0)$ and ν is chosen to be from below density limit to above, aiming to understand the different equilibria relevant to density limit experiments. Saturated island width and asymmetry of island are analyzed. Results from a semi-analytical calculation and a 3D resistive nonlinear MHD code DEBS are compared. The scan of equilibria around density limit provides clues of island evolution for future work where more accurate physics models to represent the detailed effects of radiation and Ohmic heating would be added.