Evaluation of core beta effects on pedestal MHD stability in ITER and consequences for energy confinement

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High confinement mode (H-mode) in fusion plasmas is characterized by a steep pressure gradient, or pedestal, that is limited by Peeling-Ballooning instabilities driven by pressure gradients and edge currents. Ideal MHD studies of the pedestal stability have shown that the maximum stable pedestal pressure increases with more peaked core pressure profiles through the effect of the Shafranov shift. Because of stiffness of the core pressure profile this can lead to a positive feedback between core and edge pressure but this is found to saturate beyond given values of core beta [1]. Such positive feedback has been found to lead to a more favourable scaling of the plasma energy with input power in tokamak experiments of that expected from the ITER-H(98,y2) scaling (e.g. [2]) but the extrapolation of this experimental results remains uncertain.

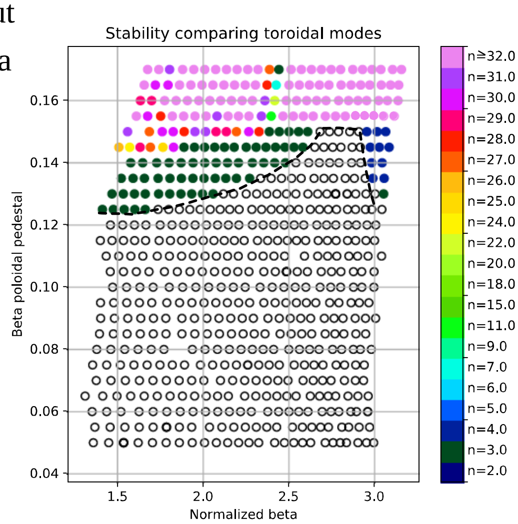

Figure 1. Stable (empty circles) and unstable (mode number given by colour) equilibria for different core (normalized beta) and pedestal (pedestal beta) ITER 7.5MA/2.65T plasmas pressure.

This paper deals with the ideal MHD pedestal stability aspects of this positive feedback for ITER, which may differ from present experiments given the larger levels of bootstrap current expected in ITER (due to low plasma collisionality). Ideal MHD stability studies have been performed for a range of ITER plasmas in which the stability boundary for the pedestal pressure has been identified for a range of plasma betas. This is done by self-consistently changing the pressure profile and scaling the corresponding bootstrap current and modelling the corresponding equilibrium with HELENA and calculating the ideal MHD stability with the MISHKA code (an example with the results of such analysis is shown in Fig. 1 for a 7.5 MA/2.65T H-mode plasma). The modelled pedestal marginal stability relation obtained ($\beta_{ped} = f(\beta_N)$) will be used to determine the α parameter global energy confinement scaling $\beta_N \sim P_{input}^{\alpha}$, for a range of assumptions on core pressure profile changes with additional heating power $\frac{\beta_{core}}{\beta_{ped}} \sim P_{input}^{\gamma}$, where γ characterizes the stiffness of the core pressure profiles.

[1] Wolfrum, E., et al., Nuclear Materials and Energy **12** (2017) 18.

[2] Challis, C. D., et al., Nuclear Fusion **55** (2015) 053031.