Performance and stability of ITER steady state plasmas with ITBs

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Steady state scenarios envisaged for ITER aim to optimize the bootstrap current drive, while maintaining sufficient confinement and stability to provide the necessary fusion yield. Target plasmas have H_{98}~1.6, which is found to be necessary to access 100% non-inductive current in the range of 7-10 MA and fusion yield of Q~3-6 [1]. The prediction of advanced tokamak scenarios uses the pedestal temperature as a boundary condition. From EPED1 peeling-ballooning analysis, this is prescribed to be in the range of 3.3-3.7 keV, at pedestal densities of $0.5\text{-}0.65\times10^{20}$ m^{-3} [2]. The thermal diffusivity profile is prescribed to produce an internal transport barrier (ITB) and scaled to provide the target value of H_{98}.

We have analyzed the stability properties of steady state scenarios that use 8-33 MW of Neutral Beam with addition of different mixtures of external heating, namely 20-40 MW of EC, 20-40 MW of LH and 5-20 MW of IC [1]. Plasma discharge simulations have been run with the free boundary Tokamak Simulation Code (TSC) [3]. The current deposition profiles and the total current for EC and NB are prescribed by PTRANSP [4]. The base scenarios span densities of n/n_G~0.8-1.0 and produce plasmas with normalized pressures of β_N~2.2-2.6 and bootstrap fraction of 0.5 [1].

Stability against ideal kink and ballooning modes has been studied by recomputing the TSC equilibrium at selected times with the JSOLVER [5] fixed boundary equilibrium code, and examining the stability with the PEST [6] and BALLOON [7] linear MHD codes. Results indicate that the base scenarios are stable to ideal, low-*n* kink modes, for variations of the pressure profile and pressure derivatives within 20%, corresponding to maximum normalized pressure up to β_N~3.0, depending on the scenario. For values of β_N~2.6-2.7 they are instead unstable to ballooning modes with *n*=10-20. It is found that broader pressure profiles and ITBs located at larger radial positions are favourable to stability, although this may degrade the plasma confinement and reduce the total non inductive fraction.

The stability and performance of steady state scenarios and the sensitivity to the variation of plasma parameters will be discussed.

[1] C.E. Kessel *et al*, IAEA 2010
[2] P. Snyder *et al*, Nucl. Fusion **49** 085035 (2009)
[3] S.C. Jardin *et al*, J. Comput. Phys. **66** 481 (1986)
[4] A. Kritz *et al,* IAEA 2010
[5] J. DeLucia, *et al* J. Comput. Phys. **37** 183 (1980).
[6] R. C. Grimm *et al* J. Comput. Phys. **49** 94 (1983).
[7] J. M Greene and M. S. Chance Nucl. Fusion **21** 453 (1981).

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