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ITR/P1-21: Stability and Performance of ITER Steady State Scenarios with ITBs

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Steady state scenarios envisaged for ITER aim at optimizing the bootstrap current drive, while maintaining sufficient confinement and stability to provide the necessary fusion yield. Non-inductive steady state scenarios on ITER will need to operate with Internal Transport Barriers (ITBs) in order to reach adequate fusion gain at typical currents of 9 MA. We have analyzed the ideal MHD stability 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. Target plasmas have H98˜1.6, which is necessary to access 100% non-inductive current in the range of 7-10 MA and fusion yield of Q˜3-6 [1]. These configurations are established as relaxed flattop states with time-dependent transport simulations, which have been run with TSC [2]. The sensitivity of n=1,2 kink (with and without a wall) and n=∞ ballooning instabilities has been analyzed against variations of the pressure profile peaking between 2.3 and 2.9, and of the Greenwald fraction up to 1.2.
It is found that LH heating is desirable to maintain the safety factor profile above 1.5. By operating with broad pressure profiles and ITBs at 2/3 of the minor radius, plasmas with 33MW of NB and 40 MW of LH have q_min>2, are ideal MHD stable and can achieve beta_N >4l_i with an ideal wall. The EC provides localized heating and current drive profiles, but 40MW of EC raise the self-inductance and drive q_min down below 1.5, driving n=1 and n=2 kinks instabilities. The stability of these configuration can be improved for deposition outside ρ(q_min)=0.35. The trade-off of current drive efficiency vs ideal MHD stability with rho(q_min) will be discussed, with focus on the effectiveness of the upper launcher in controlling the current profile.

[1] Kessel CE et al, Development of ITER Advanced Steady State and Hybrid Scenarios, IAEA Fusion Energy Conference 2010.

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