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Evaluation of Fuelling Requirements and Transient Density Behavior in ITER Scenarios

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ITER operation requires effective fuelling of the core-plasma for conditions in which neutral dynamics through the scrape-off layer is expected to affect significantly the efficiency of gas penetration. In order to assess fuelling requirements in transients as well as in stationary phases, integrated core-edge plasma modelling has been carried out for plasma conditions expected in the reference 15 MA Q = 10 scenario with emphasis on H-mode operation. The simulations follow the build-up of the H-mode scenario all the way through the L-mode phase, L-H transition, initial ELM free H-mode and the stationary ELMy H-mode phase with controlled ELMs. The JINTRAC suite of codes has been used for this analysis. As a first step the edge plasma has been modelled separately for a range of conditions with the EDGE2D/EIRENE code (included in the JINTRAC suite) and previous results obtained with SOLPS have been confirmed. Full plasma simulations have been carried out with JINTRAC in integrated mode with both the Bohm gyro Bohm core-transport model and GLF23 including two impurities species (Be and Ne). Simulations show that following the H-L transition for the 15 MA DT plasma fuelled by gas-fuelling only the plasma density increases initially on a very fast timescale. However, after this initial phase the pedestal density starts to evolve at a much slower rate due to the low value of particle transport diffusion in the pedestal (~ neoclassical) and decreasing edge transparency to neutrals and finally saturates at values of <ne>~(5-6)x1019 m-3, even for the largest gas-fuelling rates achievable in ITER. Following the L-H transition the pedestal temperature raise rapidly until the edge stability limit is reached and ELMs are triggered. In correspondence of each ELM the density rise drops down significantly. This evolution is similar for DT H-mode plasmas in ITER over a large range of conditions suggesting that, within the uncertainties of the particle transport model, <ne>~(5-6)x1019 m-3 is the highest plasma density achievable in H-mode with gas fuelling alone in ITER; thus allowing high <ne>/nGW operation by gas-fuelling only for the lowest plasma currents (5–7.5 MA). The achievement of high density H-modes for plasma currents above those requires pellet injection.

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