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ITER Fuelling Requirements and Scenario Development for H, He and DT through JINTRAC Integrated Modelling

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The evolution from X-point formation of ITER H, He and DT plasmas with gas and/or pellet fuelling has been studied for the first time self-consistently with the integrated core and edge suite of codes JINTRAC developed at JET. Our results show that understanding how to optimise fuelling performance is vital to operate ITER and to achieve high fusion yield without exceeding operational limits for neutral beam (NB) shine-through and divertor power fluxes (10MW/m^2).In present devices gas can fuel the core as the edge plasma is fairly transparent to neutrals. In contrast the ITER edge plasma will be hotter and denser so more gas will be ionised in the far scrape-off-layer (SOL) and not penetrate to the separatrix.We show that routine use of pellets in ITER is likely to reach the minimum density for safe NB operation in L-mode or for H-modes with Q equals 10. In L-mode with only gas fuelling, we reach a Greenwald density fraction less than 30% before the density build-up in the SOL leads to a MARFE. These can also be triggered by pellets and to avoid them in our simulations we had to fine tune the discrete pellet mass to the core density.To access ELMy H-mode in 15MA/5.3T ITER DT plasmas, we show that alpha heating is crucial. Thus, during the L-H transition fuelling will have to be kept low to allow the ion temperature to rise on-axis to boost the build-up of fusion power. Here, we prove the viability of heating (33MW NB, 20MW ICRH) and fuelling schemes to reach Q of 10, with no need for Ne seeding to ease the divertor power loads while Q is less than 5.For a 15MA/5.3T ITER DT Q equals10 baseline scenario we show that if particle fuelling is too high during the H-L transition, the target power loads in our simulations may stay below the design limit, but a MARFE may occur.
In summary our results show that pellets may be crucial to obtain an L-mode density above the NB shine-through limit. We also prove that density control during the L-H and H-L transition is critical. Pellet fuelling should rather be turned off during the L-H transition to aid the access to ELMy H-mode by minimising the density rise to boost the fusion power. Gas fuelling and Ne seeding can be used during the H-L transition to keep the power loads to the divertor tolerable, but precise feedback control over radiation is needed to keep the plasma within the permitted operational range.

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