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The effect of the isotope on the H-mode density limit

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Identification of the mechanisms for the H-mode density limit in machines with fully metallic walls, and their scaling to future devices is essential to find for these machines the optimal operational boundaries with the highest attainable density and confinement. Systematic investigations of H-mode density limit plasmas in experiments with deuterium and hydrogen external gas fuelling have been performed on JET machine with fully metallic walls, and results have been compared with one another.

The observed H-mode density limit on JET in D- as well as in H-plasmas demonstrates similar operation phases: the stable H-mode phase, degrading H-mode, breakdown of the H-mode with energy confinement deterioration accompanied by a dithering cycling phase, followed by the L-mode phase. Independent of the isotopic effect, total radiated power as well as the radiation power in the main chamber (Prad, bulk) stays almost constant during the H-mode phase until the H-L transition. The density limit is not related to an inward collapse of the hot discharge core induced by overcooling of the plasma periphery by radiation. It was observed in D- and H-plasmas that detachment, as well as the X-point MARFE itself, does not trigger the H-L transition and thus does not present a limit on the plasma density and that it is the plasma confinement, most likely determined by edge parameters, which is ultimately responsible for the H-mode DL. Independent of the isotopic mas of the main plasma, it has been observed that the transition from H-mode to L-mode is not always an abrupt event but may exhibit a series of H-L-H transitions (‘dithering H-mode”), or a gradual transition (which is orders of magnitude longer than energy confinement time τE). Although the operation phases are identical for D- and H-plasmas, the DL shows strong dependency on the isotopic mass effect, the DL is up to 40% lower in the H-plasma than in the deuterium plasma. Basically, the density limit in H mode on JET-ILW is nearly independent of the power in the range of observed heating powers and the corresponding densities only approach in this configuration a Greenwald fraction of about fGW=0.9 and fGW=0.84 in D-plasma and in H-plasma correspondingly.

The measured Greenwald fractions are found to be consistent with the predictions from theoretical model based on MHD instability theory in the near-SOL.

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