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Isotope Dependence of Confinement in JET Deuterium and Hydrogen Plasmas

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Heat, particle and momentum confinement in L- and H-mode in deuterium (D), hydrogen (H) and in D/H mixtures have been investigated in JET. In L-mode (3T/2.5MA) at fixed density (2.5x10^19m^-3) a weak positive scaling of stored energy with ion mass, tau_Eth~A^0.15, is found [1], consistently with multi-machine scaling tau_Eth~A^0.2 [2]. Core temperature profiles are stiff with Ti~Te, and R/LTe~8 at mid-radius [1]. Flux-driven core transport modelling with TGLF show ITG's to be dominant and predict no isotope scaling as a result of the Ti profile stiffness. A fuelling rate ~30%, higher in H than in D, was necessary to achieve the same density as in D, indicating a difference in particle confinement which was confirmed by EDGE2D/EIRENE simulations near the LCFS [1]. In type I ELMy H-mode (1T/1MA, 1.7T/1.4MA and 1.7T/1.7MA, Paux in the range 3 to 17MW) it was not possible, except in a couple of cases, to establish the same densities in H as in D, despite gas fuelling rates several times higher in H, showing a strong reduction of particle confinement. The best regression for the thermal stored energy for ELMy H-mode is obtained as W_Eth ∝ A^0.38 P^0.64 Ip^0.89 n^0.5 G^0.21 where A is the ion mass and G the fuelling rate. The mass scaling is twice that of IPB98(y,2). GENE gyrokinetic calculations in H-modes show ITG's to be dominant in both species. The observed negative dependence of momentum confinement on the gas fuelling rate suggests that edge fuelling leads to a direct deterioration of ion heat transport. Dimensionless identity experiments for H and D pairs provided good matches for the kinetic profiles in L-mode, but not in H-mode. In H-mode the scaled confinement time in D was 30% higher than in hydrogen for the best approximate match. The evidence from these experiments suggests that the isotope scaling in these experiments, as well as the absence of good dimensionless matches in H-mode, have their origin in the pedestal and boundary region, which are sensitive to atomic physics, fuelling and recycling.

[1] C.F. Maggi et al, Plasma Physics and Controlled Fusion 60 (2018) 014045
[2] ITER Physics Basis, Nuclear Fusion 39 (1999) 2175

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