Isotope Dependence of Confinement in JET Deuterium and Hydrogen Plasmas

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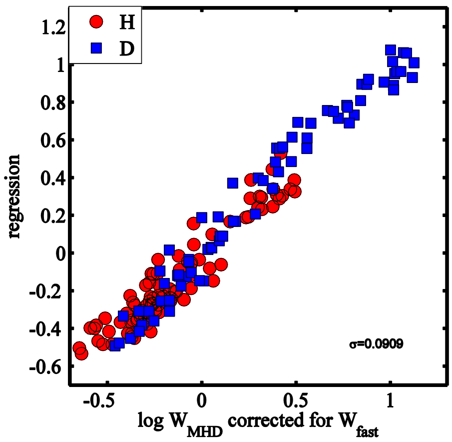
Heat, particle and momentum confinement in L- and H-mode in deuterium (D), hydrogen (H) and in D/H mixtures have been investigated in JET. In L-mode (3T/2.5MA) at fixed density ($2.5\times10^{19}m^{-3}$) a weak positive scaling of stored energy with ion mass, $\tau_{Eth}\propto A^{0.15}$, is found [1], consistently with multi-machine scaling $\tau_{Eth}\propto A^{0.2}$ [2]. Core temperature profiles are stiff with $T_i\cong T_e$, and $R/L_{Te}\cong 8$ 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 and confirmed by EDGE2D/EIRENE simulations for $0.9<\rho<1.05$ [1]. In type I ELMy H-mode (1T/1MA, 1.7T/1.4MA and 1.7T/1.7MA, $3MW<P_{aux}<17MW$) 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 are obtained as $W_{Eth} \propto A^{0.38} P^{0.64} I_p^{0.89} n^{0.5} \Gamma^{-0.21}$ where A is the ion mass and Γ the fuelling rate (figure). The mass scaling is twice that of IPB98(y,2)[2]. H-modes in H/D mixtures have confinement times intermediate between those in H and in D. GENE gyrokinetic calculations in H-modes show ITG's to be dominant. The profile stiffness suggests that the origin of the isotopic differences in these experiments lies in the pedestal transport [1]. The isotope effect in the pedestal, however, is not understood. As momentum transport is not subject to equipartition with electrons, a clue to the underlying ion heat transport may come from the ratio of the momentum-to-energy confinement times, which varies from 0.4 to 1, depending on electron density and gas fuelling, with no clear dependence on ion mass. The observed negative dependence of momentum confinement on the gas fuelling rate suggests that edge fuelling may lead to a direct deterioration also of ion heat transport, rather than only as an indirect result of electron cooling by edge fuelling. Dimensionless identity pairs in H and D were successfully obtained in L-mode, not however in H-mode suggesting that other parameters beyond ρ^*, ν^* and β play a role in in H-mode confinement.



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