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Isotope identity experiments in JET with ITER-like wall

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Dimensionless experiments test the invariance of plasma physics to changes in the dimensional plasma parameters, when the canonical dimensionless parameters are conserved [1], [2]. Isotope identity experiments exploit the change in isotope ion mass $A = m_i/m_p$ to obtain plasmas with identical dimensionless profiles in the same tokamak. However, conditions at the plasma boundary may introduce additional physics, potentially invalidating this approach. Although the isotope mass appears explicitly only in the parameter ρ_i*, changing A in experiment will affect all plasma kinetic profiles, therefore achieving an isotope identity is not trivially expected a priori. The isotope identity technique [3] was revisited in JET-ILW with H and D plasmas, both in L-mode and type I ELMy H-modes.

An L-mode isotope identity pair was obtained in H (1.44MA/1.74T) and D (2.5MA/3.0T) NBI-heated plasmas [4]: the ρ^*, ν^*, β, q , T_i/T_e (= 1) profiles and Z_{eff} (=1.4) were all matched in the core confinement region, where the dominant instabilities are ITG modes for both isotopes. The dimensionless thermal energy confinement time, $\Omega i\ \tau_{E,th}$, is identical in H and D, indicating lack of isotope mass dependence. Predictive flux driven simulations of the identity pair with JETTO-TGLF are in very good agreement with experiment for both isotopes: the stiff core heat transport, typical of JET-ILW NBI heated L-modes, overcomes the local gyro-Bohm scaling of gradient-driven TGLF, explaining the lack of isotope mass dependence in the core confinement region of these plasmas [6]. Although the *M*-profiles are not well matched in H and D, the effect of $E\times B$ shearing on the predicted heat and particle transport channels is negligible for these low beta and low momentum input plasmas [6].

In type I ELMy H-modes, an isotope identity pair was obtained in H (H-NBI, 1.0MA/1.0T) and D (D-NBI, 1.7MA/1.7T). The scaled n_e and T_e profiles were matched in H and D both in the core and pedestal regions, as well as the q, T_i/T_e (=1) profiles and line averaged Z_{eff} (= 1.4). Matching the scaled ELM frequency ($A\ f_{ELM}/B_T$ = 54 Hz/T) - using f_{ELM} control via feedback on gas injection in the D discharge - was key to achieve similarity of the scaled pedestal density profiles. $\Omega_i\ \tau_{E,th}$ increases strongly with A, in line with the strong isotope mass scaling derived from the regression of the dimensional energy confinement time of H and D type I ELMy H-modes [5]). The Mach-number profiles are not identical in H and D, but the *ExB* shear is similar for both isotopes, suggesting the latter to be the relevant parameter (and not *M*) for achieving the identity in ITG dominated H-modes.

References: [1] Connor J W and Taylor J B 1977 Nucl. Fusion **17** 1047; [2] Luce TC et al., 2008 Plasma Phys. Control. Fusion **50** 043001; [3] Cordey J G et al. 2000 Plasma Phys. Control. Fusion **42** A127; [4] Maggi C F et al. 2019 Nucl. Fusion **59** 076028; [5] Maggi CF et al., 2018 Plasma Phys Control Fusion **60** 014045.