Isotope identity experiments in JET-ILW

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Dimensionless identity experiments test the invariance of plasma physics to changes in the dimensional plasma parameters, e.g. n_e and T_e, when the dimensionless parameters are conserved [1] [2]. However, conditions at the plasma boundary, such as influx of neutral particles, may introduce additional physics. An isotope identity experiment was carried out in the JET tokamak with C wall (JET-C), in which ELMy H-modes were obtained with different hydrogenic isotopes, H and D, but with the same profiles of ρ^*, ν^*, β and q [3]. The thermal energy confinement times, ELM and sawtooth frequencies scaled as expected, suggesting that the invariance principle was satisfied in JET throughout the plasma radius, despite the different physical processes in the plasma centre, core confinement and edge regions [3].

The isotope identity technique was revisited in recent experiments with H and D plasmas in JET with the ITER-like Be/W wall materials (JET-ILW) and with improved edge profile diagnostics. In L-mode, an isotope identity pair was achieved at I_P/B_T of 2.5MA/3.0T (D) and 1.48MA/1.78T (H), q_{95} = 3.4, with D-NBI and H-NBI, respectively, delivering very similar scaled power density profiles (TRANSP/NUBEAM). The line averaged Z_{eff}, the scaled thermal energy confinement times, $B\ \tau_{E,th}\ /A$, and core plasma effective heat diffusivities, $A\ \chi_{eff}/\ B$, were matched within experimental uncertainties, suggesting that the invariance principle is satisfied in the L-mode core confinement region. In type I ELMy H-modes the experiments were conducted at 1.7MA/1.7T (D) and 1.0MA/1.0T (H), q_{95} = 3, with D-NBI and H-NBI, varying input power ($P_{abs} \sim B^{5/3}$) and injected gas rate to achieve the match in density and temperature profiles ($n \sim A$ and $T \sim A^{1/2}$). The scaled ELM frequencies, $A\ f_{ELM}/B$, and the scaled $\tau_{E,th}$ were not matched simultaneously in H and D discharge pairs, unlike the JET-C case. Scaled $\tau_{E,th}$ and core χ_{eff} were also not matched simultaneously, unlike the L-mode case. When the pre-ELM profiles of ρ^*, ν^*, β and q are matched in H and D, the ELM averaged profiles are not matched and the scaled thermal energy confinement times and ELM frequencies are larger in D than in H, suggesting that in JET-ILW H-modes the invariance principle is not satisfied simultaneously in the core and edge regions. Atomic physics of the edge recycling neutrals, thought to play an important role on pedestal confinement and stability in JET-ILW [4], may invalidate the isotope identity technique in the pedestal region.

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