Effect of isotope mass on transport and confinement: overview of past observations and recent experiments

Costanza Maggi

EUROfusion Consortium, JET, Culham Science Centre, Abingdon, OX14 3DB, UK
CCFE, Culham Science Centre, Abingdon OX14 3DB, UK

The dependence of plasma transport on the hydrogenic ion isotope mass is of fundamental importance for understanding turbulent transport and thus for accurate extrapolations of confinement from present tokamak experiments to burning plasmas, which will operate with D-T mixtures. Furthermore, knowledge of the dependence of plasma properties and edge transport barrier formation on main ion species is critical in view of the initial, low-activation phase of ITER operations (H or He).

The favourable scaling of global energy confinement time with isotope mass, which has been observed in many tokamak experiments, does not follow the gyro-Bohm scaling as expected for the local ion heat conductivity and remains largely unexplained theoretically. Moreover, the mass scaling observed in experiments varies in magnitude depending on the plasma edge conditions, in particular L-mode or H-mode.

The talk reviews recent and past experimental results of isotope effects on heat, particle and momentum transport and confinement in H, D, T and isotopic mixtures, highlighting common elements as well as contrasting observations that have been reported. In H-mode, some – but not all - experiments find a strong isotope effect at the pedestal, specifically in the pedestal transport, however the underlying physics mechanism is not yet understood. Different results and interpretations of the isotope effects on confinement obtained across experiments are likely related to a variety of factors, such as different plasma heating methods utilized, the role of T_i/T_e and/or high beta stabilization on ion-scale core turbulence, the impact of E x B flow shear stabilization in the plasma core, T_i profile stiffness. The experimental findings are discussed in the context of fundamental aspects of core and edge plasma transport models.