Isotope effect in energy confinement in high density FT-2 tokamak regimes.

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The isotope effect in a tokamak confinement resulting, in contradiction to the theory expectations, in the anomalous transport decrease in numerous experiments with growth of the hydrogen isotope number remains a long-standing puzzle for the period of 40 years [1]. The novel approach to explanation of this effect, which is favorable for fusion applications, is based on accounting for the multi-scale turbulence nonlinear interactions. Within this approach the isotope effect in particle confinement, but not energy, was demonstrated recently in FT-2 tokamak in hydrogen (H) and deuterium (D) ohmic discharges with modest electron density $\langle n_e \rangle \sim (1.5\text{-}2.5)\times10^{19}\ m^{-3}$. The higher particle confinement in D-discharges was correlated in these experiments to a higher excitation level of the GAM in agreement with results of specially performed global full-f gyrokinetic modeling by ELMFIRE code [2, 3].

In this paper we present the results of further development of energy confinement studies [4] in FT-2 tokamak at high densities. Special series of Ohmic discharges are performed in H and D plasmas within the chord averaged density range $\langle n_e \rangle \sim (5\text{–}9)\times10^{19} m^{-3}$. The energy confinement time calculations based on measured kinetic profiles demonstrate essential difference in τ_E behavior for different gases. Hydrogen plasma follows the LOC to SOC transition that happens at the densities above $\langle n_e \rangle \sim 6\times10^{19}\ m^{-3}$. At the same time deuterium plasma behavior at the highest densities shows further increase of τ_E with growing density typical of LOC scenario. In vicinity of tokamak operational density limits $\langle n_e \rangle_{lim} \sim 9\times10^{19}\ m^{-3}$ the energy confinement time in D is twice as high as in H. Confinement improvement in D-discharge is accompanied by the flattening of the electron density profile in the central region and its steepening at the edge, followed by essential decrease of radiation losses. The turbulence evolution with growing plasma density in these regimes is studied both with reflectometry diagnostics and by the gyrokinetic modeling.

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