Energy confinement time study at the FT-2 tokamak. Scaling and gyrokinetic modeling.

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The energy confinement time dependence on the tokamak ohmic discharge plasma parameters is usually described by empirical scaling formulas benchmarked against the data base obtained at numerous machines. The two most popular dependencies are given by neo-Alcator $\tau_{nA}(\text{ms}) = 0.007 a R^2 n_{eq}$ and Goldstone $\tau_{Gs}(\text{ms}) = 0.01 a^{1.04} R^{2.04} n_{eq}^{0.5} A^{0.5}$ scalings. They roughly agree predicting the linear dependence of the energy confinement time on the plasma density, however the Goldstone scaling in addition includes the proportionality of the energy confinement time to the square root of the hydrogen isotope atomic number, the so-called confinement isotope effect. The linear dependence on the plasma density corresponding to the linear Ohmic confinement (LOC) in many experiments saturates at high plasma density leading to the saturated ohmic confinement (SOC) regime. The saturation is attributed to the ITG mode turbulence contribution to the anomalous transport, whereas the LOC is explained by the dominance of the TE mode in the drift-wave turbulence [1].

In the present paper we determine the electron energy confinement time scaling at the small research FT-2 tokamak ($a=0.08\text{m}$, $R=0.55\text{m}$, $19\text{kA}<I_{pl}<35\text{kA}$, $1.2\text{T}<B_t<2.5\text{T}$, $q\sim5$) using the ASTRA code transport modeling of the experimental data base parameter profiles obtained using laser Thomson scattering, microwave interferometry, NPA and bolometric diagnostics. In parallel we investigate the anomalous transport in several typical discharges from the data base using local gyrokinetic code Gene and global full-f code ELMFIRE.

It is shown that the Goldstone scaling better fits to the set of data obtained in different gases (hydrogen, deuterium and helium), however the experimental points do not show a clear isotope effect for the electron energy confinement time, unlike the scaling predictions. It should be mentioned that the isotope effect consistent with the Goldstone scaling (proportionality to the square root of atomic mass) is demonstrated for the energy transport in the ion channel. No transition to SOC with growing plasma density is observed in experiment, which is explained by the gyrokinetic modeling by the dominance of the TE mode.