DOI: 10.34854/ICPAF.51.2024.1.1.051

UNIVERSALITY OF NORMALIZED TEMPERATURE AND DENSITY PROFILES IN TOKAMAKS: A REVIEW OF EXPERIMENTS AND THEORETICAL MODELS *)

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The universality of the profiles of temperature and density of the toroidal electric current as functions of the normalized minor radius of the plasma column in the tokamak at the stage of quasi-stationary state of the total toroidal electric current was proposed by B. Coppi [1]. Testing this hypothesis (starting from [2]) and creating heuristic theoretical models (substantiation of the phenomenon of the so-called "profile consistency", starting from [3, 4] and similar approaches) showed its productivity. The current state of the approach, based on the development of ideas [1], [3], [4], taking into account experimental data from various installations, is presented in the monograph [5].

The hypothesis [1] is confirmed by a recent statistical analysis [6] of the spatiotemporal dynamics of electron temperature Te and density n_e profiles in approximately nine thousand discharges in the JET tokamak during the last 10 years of its operation. Additionally, it was discovered that strong, up to ~100% in amplitude, jumps in electron temperature at the stage of quasi-stationary state (flat-top) of the total toroidal electric current in the plasma column, caused by the switch-on of strong auxiliary heating of the plasma (total power up to 20 MW) , can be described by jumps of the temperature averaged over a spatial variable if the found universal normalized profiles are used to describe the stationary form (but not the absolute values) of the spatial temperature profile.

The report provides an overview of experiments and theoretical models that point to the universality of normalized temperature and density profiles in tokamaks and the difficulties of modeling the fast transient events. This includes, in particular, analysis of the time of significant rise in the Te profile while maintaining the universal normalized Te profile when powerful auxiliary heating is turned on in the JET and comparison with the characteristic times predicted by modern models of anomalous heat diffusion; modeling the formation of "self-consistent" pressure profiles in the turbulent plasma of the T-10 tokamak in modes with ohmic heating and in transient modes with the switch-on of electron cyclotron (EC) heating [7]; demonstration of the need for an abrupt change in transfer coefficients when EC heating is turned on to explain experiments in the T-10 [8] and ASDEX [9] tokamaks.

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*) abstracts of this report in Russian