Principles of statistical analysis of the similarity of spatial profiles of tokamak plasma [[1]](#footnote-1)\*)

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The phenomenon of self-organization of plasma in tokamaks, manifested in the tendency of plasma to maintain the shape of spatial profiles of density and temperature under external influences (turning on and off a strong auxiliary heating of the plasma during the discharge) traces its history back to the work of B. Coppi [1], in which the idea was proposed of universal, “canonical” distributions of plasma parameters as functions of the normalized minor radius of the plasma column (“profile consistency”). This idea was confirmed in the subsequent analysis of experimental data from various installations. For example, a detailed comparison of experimental profiles from different tokamaks with the circular poloidal cross-section of plasma, which confirmed the ideas [1], was carried out in [2] (see also subsequent works [3, 4]).

A number of solutions to the problem of the MHD equilibrium for a finite pressure gradient have been given in literature for the case of a smooth profile of plasma pressure and electric current, i.e. plasmas without internal transport barriers. In tokamak case, the substantiation of the “profile consistency” phenomenon [1] has been independently given in [5–7]. The current state of the approach based on the development of ideas [1], [5] and [6] with account of experimental data from various installations is presented in the monograph [8]. However, the problem of mass statistical analysis of experimental data is by no means exhausted, and its addition and expansion is, in our opinion, of interest for the further development of theoretical approaches that use the concept of plasma self-organization in their axioms.

Here, we formulate basic principles of the statistical analysis of spatial profiles of plasma parameters *f* (temperature, density, pressure, etc.) at the stage of quasi-stationary plasma current (the so called flat-top stage). For all these parameters, the existence of universal profiles $\overbar{G}\_{f}\left(ρ,ρ\_{max},k\right)$ should be investigated ($ρ$ is the normalized minor radius of the plasma column, which is a label of the magnetic flux surface and is determined with respect to the poloidal or toroidal magnetic flux, *k* is the discharge number). The universal profiles are obtained by dividing the space-time-dependent profile by its value at the center of the plasma column ($ρ\_{max}=0)$ or by the space-averaged value of this parameter in the region $ρ\leq ρ\_{max}=0.5—1$, and subsequent averaging over time *t* at the flat-top stage of each discharge. Averaging over the time of the quasi-stationary stage of all discharges gives the profiles $̿\_{f}\left(ρ,ρ\_{max}\right)$. For each discharge, the relative root-mean-square (average over $ρ\leq ρ\_{max}$ or *t*) deviation σ of the normalized profile from $\overbar{G}\_{f}\left(ρ,ρ\_{max},k\right)$ may be found, and for the entire set of discharges, the root-mean-square deviation (average over time) from $̿\_{f}\left(ρ,ρ\_{max}\right)$ may be obtained. The effect of the switch-on of auxiliary heating on the profile self-similarity may be investigated. The applicability of such a program to the existing databases is discussed.

References

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