Statistical Description of Turbulent Particle Fluxes in the Edge Plasma of the L-2M Stellarator

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Plasma turbulence studies carried out in the last few decades have shown that the measured distributions of amplitudes of plasma density fluctuations in both the central and peripheral regions have non-Gaussian probability density functions. These distributions are leptocurtic and have slowly decreasing exponential tails. Besides, these distributions possess self-similarity. These characteristic features were observed in studies of fluctuations in both tokamaks and stellarators.

The paper presents results of studies of turbulent particle fluxes measured in the L-2M stellarator in essentially different regimes: with and without chamber wall boronization intended for improving discharge conditions.

Fluctuating particle fluxes were analyzed in terms of fractional stable (FS) densities. These densities appear as limit densities (at $t \to \infty$) in the compound process

$$S(t) = \sum_{j=1}^{N(t)} X_j, \quad \text{where} \quad \sum_{j=1}^{N(t)} T_j < t \leqslant \sum_{j=1}^{N(t)+1} T_j, \quad t > 0.$$

Here, $X_1, X_2, \ldots$, are independent, identically distributed random variables with a distribution function $\mathsf{P}\{X_j < x\} \propto x^{-\alpha}$, $0 < \alpha \leqslant 2$, whereas $T_1, T_2, \ldots$ are independent, identically distributed random variables on the positive semiaxis with a distribution function $\mathsf{P}\{T_j < t\} \propto t^{-\beta}$, $0 < \beta \leqslant 1$. The physical interpretation of $S(t)$ is the particle coordinate in the CTRW model (Continuous Time Random Walk).

The parameters of fractional stable distributions were statistically estimated from measured signals. It is shown that fractional stable distributions give a good fit to the probability density functions of amplitudes of fluctuating particle fluxes. It appears that, with boronization, the scale parameter of FS density becomes reduced and, in its turn, reduces the diffusion coefficient in the corresponding generalized equation of diffusion. The Hurst parameter was calculated for all the discharges under study. Its values lie in the range 0.64 to 0.75, which agrees with results obtained in other devices. Algorithms for data processing and the algorithm for estimation of parameters of FS densities, along with results of calculations, will be presented in the report.