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Statistical Instability of Physical Processes

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Abstract—New parameters describing disturbance of statistical stability on a finite observation interval are proposed. Measuring units that allow to quantitatively characterize disturbance of statistical stability for the known and new statistical instability parameters. It is shown that fluctuations of expected value, which lead to changes of mean expected value, and dispersion fluctuations under certain parameters play an essential role in disturbance of statistical stability. Change ranges of sampling statistical instability parameter values weakly depend on the distribution law.

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INTRODUCTION

Statistical stability of events frequency initially revealed by fabric merchant J. Graunt [1] is one of the exciting physical phenomena. There exists fragmented information about research on statistical stability, which were conducted starting from the end of XVIII century until the end of XIX century by D. Venn, S. D. Poisson, I. J. Bieneme, O. Cournaut, A. Ketle, Y. Bernoulli and others [2, 3].

Systematic research of statistical stability began at the end of XIX century. German statistic V. Lexis in 1879 was first to attempt connecting the notion of statistical stability with dispersion of a random quantity. In the beginning of XX century studies on statistical stability were carried out by K. Pierson, A. A. Chuprov, V. I. Bortkevich, A. A. Markov, R. von Mizes and others [2, 3].

For example, it is known that frequency of coin's side appearance was studied by Laplace, Buffon, K. Peirson and many other scientists. Descriptions of these and other similar studies are provides in literature, for example in [4].

Many experimental results imply likelihood of hypothesis on statistical stability of real events, which allows assuming, as was noted by B. V. Gnedenko in [4] (page 42), "presence of phenomenon regularity independent on the observer, which show up in the mentioned quasi-stability of the frequency".

The phenomenon of statistical frequency stability was laid as a physical basis for developing the probabilities theory, which is widely used in various spheres of science and technology, specifically in radio electronics and radio engineering.

Modern probabilities theory may be considered as a physics-mathematical theory [5], the mathematical part of which is grounded on abstract axiomatic base suggested by A. N. Kolmogorov [6] and treated today as an international standard [7], while its physical component is based on statistical stability hypothesis and the possibility of adequately describing them by stochastic models [5, 8, 9].

On relatively small time and time-space observation intervals the statistical stability hypothesis almost perfectly agrees with experimental research, however on larger intervals some significant deviations [5, 8–12] are observed for all studied physical processes.

Disturbance of stability may be explained by the fact that environment is an open system with constantly changing characteristics and parameters including the statistical ones.

Research of statistical stability disturbance for physical phenomena and development of effective means of their adequate representation changed the vision of the real world, which lead to formulation of hyper-random phenomena physical-mathematical theory [5, 8] targeted at consideration of statistical stability disturbance.

Interestingly, until recently the notion of statistical stability has not been formalized mathematically. In [5, 11, 12] the notion of statistical stability is introduced for a sequence of random quantities and random processes and parameters for describing disturbance of statistical stability on a finite observation interval are