

# The concept of “chaos measure” in the aspect of social synergetics

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**Abstract.** We understand chaos as a bifurcation process, the quantitative characteristic of which is reduced to the number of possibilities for the further evolution of the system, which in real time is directly expressed by self-oscillations of chaos and order (bifurcation cascade). The questions are being investigated: the scientific correctness of such formulations as “chaos measure”, “evolution of chaos”, correlation of the concepts “measure of chaos” and “magnitude of entropy”; does the concept of “measure of chaos” correlate with the concept of entropy; how the concepts of “measure of chaos” and “measure of order” relate, and is it possible to “control” chaos? Models that study the evolution of open systems provide a bifurcation picture of development opportunities in at least two directions: complication and simplification, progress and regression, hierarchization of systems and their de-hierarchization, where a quantitative measure of chaos corresponds to the number of possible outcomes. The conclusion drawn from this is that human influence on the vector of the evolutionary process is reduced to a deliberate impact on the structure, which is commonly called the norm: an individual is able to comprehend the “measure of chaos” of the system of which he is an element, correlate it with the “measure of order” of the system and, setting the norm, thereby determine the direction to the superattractor.

## 1 Introduction

The analysis of specific social problems requires the improvement of the scientific and methodological apparatus of social synergetics. Among the problems of natural science synergetics and social synergetics, the problem of *general trends and regularities* of chaotic processes, and their *measure* should be highlighted. A measure, as a philosophical category, is determined by the boundaries or by the limit of quantitative changes that determine the preservation of this quality. Questions about the scientific correctness of such formulations as *the measure of chaos*, *the evolution of chaos*, as well as the question of the correlation of the concepts “measure of chaos” and “magnitude of entropy” are pertinent.

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Much becomes clear when chaos will be understood by us as a bifurcation process, the quantitative characteristic of which is reduced to the *number of options (possibilities)* for the further evolution of the system, which is directly expressed in real time by self-oscillations of chaos and order (the so-called bifurcation cascade). But first, let us determine the question: does the concept of a measure of chaos correlate with the concept of entropy? And also - how in relation to social synergetics the concepts of "measure of chaos" and "measure of order" are related and is it possible to "control" chaos?

According to S. Khaitun, "The fact that the entropy of real systems is a measure of disorder ... was postulated by the classics of physics, only without articulating the very fact of postulating. It was postulated blindly". And further, "... For implicit knowledge, this is normal. Its difference from the scientific one is that no one is engaged in the substantiation of its provisions. But it's impossible to dispute. Implicit knowledge is built on faith, which makes it so tenacious "[1]. S. Khaitun justifies the fallacy, or rather, the approximation and inaccuracy of interpreting entropy as a "measure of chaos" by proving the extreme difficulty and complexity of attempts to scientifically express the complete agreement between the magnitude of entropy and the measure of chaos.

Let's agree with that. Indeed, starting from the 19th century, there's a trail of ideas about entropy that connect this term with the concept of chaos, while scientific understanding of the nature of chaos in those days was just being created. On the one hand, there are many scientific facts that indicate that the second law of thermodynamics does not prevent the complexity of systems from growing and their progress, but, on the other hand, the law of entropy growth in physics "is formulated as the evolutionary law of continuous disorganization or destruction of an initially given structure" [2].

It would seem that there is clearly a contradiction in which it is argued that the measure of system disorganization directly depends on the magnitude of entropy, and at the same time there is no direct dependence of the chaos measure and the magnitude of entropy, since another (synergetic) interpretation of the chaos measure correlates with a relative decrease in entropy. Actually, this will be discussed in our article.

Therefore, in the context of such statements, a need arises to determine the nature of the dependence of the "measure of chaos" on the "magnitude of entropy." This is important, because often representatives of social synergetics, as well as those who write on social and humanitarian topics in general, use the calculations of natural science to illustrate the conclusions of their research or directly transfer natural science concepts into their texts, using analogies that prove to be untenable in scientific analysis. In this case, the causes of this insolvency are associated with the physical meaning of the evolutionary function of an isolated system - with entropy and with the interpretation of its physical meaning.

Unlike energy (its magnitude), which is not "produced" (does not arise), but is only "transferred" from system to system by converting one type of energy into another, which expresses the essence of the concept of "energy conservation", entropy is "produced", that is, it "arises" in the form of an increase in the magnitude of structural (spatio-temporal) differences in the process of evolution of the system.

However, it should be noted that the physical understanding of entropy, as a rule, is expressed in the reduction of any type of energy to thermal energy; therefore, the magnitude of the increase in thermal energy inside the system (the production of entropy) is described. Hence the expression "entropy is a measure of chaos." Obviously, this definition in form is much more abstract than the concrete physical content embedded in it, concerning the phase transition from high-order energy to thermal energy.

It is also obvious that entropy is produced both in the case of simplification of the structure and in the case of its complication - in both cases there is a process of growth of thermal energy, but in this case, in one case there is a phase transition from order to chaos, and in the other - from chaos to order, but only in conditions of export of a part of entropy

into the environment (entropy flow), which already directly indicates the appropriateness of the concept of “chaos measure”. “This can only mean that, as applied to real systems, entropy is not a measure of disorder,” S. Khaitun writes [1]. It remains to ask the question, what is actually a measure of chaos (disorder) in an open system?

It is known that the subject of research of the Nobel Laureate I. Prigogine was the spontaneous occurrence of complex structures, far from thermodynamic equilibrium, through the processes of irreversible dissipation of energy. According to the correspondence principle, each new and more general (i.e. universal) theory must subordinate to itself theories that do not go beyond its subject area, as its special cases. It turns out that classical dynamics and classical thermodynamics are special cases of the theory of dissipative structures or, in a broader context, the theory of self-organization.

In classical thermodynamics, energy and entropy are functions of the state of a system that *uniquely* determine a given state, which is associated with a linear type of thinking. So, the law of conservation of energy recorded the reproduction (or conservation) of the magnitude of this function during transitions from one form to another. There was a “postulate of fundamental invariance that lies behind all the transformations occurring in nature” [3].

Statistical physics considers entropy as a measure of the probability of a system staying in a given state (Boltzmann principle), namely, an irreversible thermodynamic change is a change towards more probable states and that an attractor state is a macroscopic state corresponding to a maximum of probability, in other words, an increase in entropy is equivalent to probability growth of thermal equilibrium of the system - its conditionally final state.

In fact, the growth of entropy is directly related to the irreversibility of evolutionary processes. But in open systems there are different probable prospects for self-organization: transitions from order to chaos and from chaos to order. Moreover, it is obvious that even the transition from order to chaos cannot be fully described in terms of entropy, not to mention the transition from chaos to order (we are talking about the level of measurement of the entropy of real, that is, open systems, achieved by science).

There is chaos-simplification — this process can be described by the term entropy as an increase in the degree of probability of a final state, and there is chaos-complication as a decrease in the probability of a possible final state. On the nature of the determinism of complex macroscopic processes academician N. Moiseev says the following: “For example, the intensity of mutagenesis depends on temperature, and temperature is, ultimately, the level of chaos generated by the energy of random walks of many molecules. And any averaging (our knowledge. - Auth.) does not save. We cannot, in principle, imagine this movement as deterministic either. Perhaps this explains the probabilistic nature of heredity?” [4]. The concept of “determined chaos” introduced by G. Schuster, includes dynamic laws that uniquely determine the time evolution of the state of a system with a known background [5].

However, we note that it is necessary to take into account such an important factor as the evolution of the initial conditions, which implies different scenarios of transition to chaos, i.e., different entropies. Based on this, different interpretations (generalizations) of entropy are possible, which does not mean that we are talking only about different points of view on the same subject. It is just a matter of expanding the subject area — the study of the nature of chaos — and methods of measuring, fixing, and describing chaotic processes, that is essential for science.

Thus, in science there exist “Clausius entropy”, “Boltzmann entropy”, “Shannon entropy”, etc. According to O. Chumak, Kolmogorov entropy (or K-entropy) gives us an estimate of the rate of information loss and can be considered as a measure of the “memory” of the system, or a measure of the speed of “forgetting” the initial conditions. It

can also be considered as a measure of the randomness of the system [6]. In our opinion, the dependence of the present on the past (the well-known principle of causality) needs to be repeatedly rethought.

What makes this idea relevant is that any phase transitions in the evolution of systems include bifurcation zones, where randomness prevails, which does not contradict the necessity and causal dependence, but serves as their manifestation. Here we refer to the opinion of G. Haken, the founder of synergetics: "In synergetics we study systems consisting of a very large number of separate parts, so we are entitled to expect the appearance of microscopic rather than deterministic chaos.

But here the most significant facts discovered by synergetics come into play: as a result of the cooperation of individual parts, microscopic states may arise that obey order parameters. As for the number of order parameters, it can be very small, for example, equal to three or a little more. Thus, the complex dynamics of the entire system, it turns out, can be described using a small number of order parameters that exactly satisfy the equations of deterministic chaos.

Synergetics explains why deterministic chaos arises in the behavior of complex systems" [7]. Here, G. Haken, in fact, comes very close to the content of the concept of "chaos measure" regarding the magnitude (number) of "order parameters" or modes (waves) arising in chaos of the coordinated behavior of individual elements, that is, gives a detailed picture of the bifurcation process.

## 2 Research method

It is obvious that the concept of chaos is not reduced only to the condition, although necessary, for the transition to a new order, but is a self-sufficient state of systems, an important, so to speak, aspect of their existence. Chaos and order are aspects of the existence of an object, they are opposites that are interconnected as mutually penetrating and as complementary sides of a single process of existence of an object. It becomes possible to designate their categorical status at the level of such concepts as randomness, regularity, necessity. If in relation to an object, statements about its "possibility of existence" or "necessity of existence" are true, then statements about the "order of existence of the object" or "chaos of the existence of the object" are also true.

The point, however, is not so much in the name as in the philosophical, namely, categorical, understanding of the nature of complex processes. Chaos is characterized by the presence of fluctuations that violate the stability of the cycles of the existence of systems when randomness "prevails" and the "uncertainty of the future" intensifies, that is, the probability is reduced when even small fluctuations cause desynchronization of processes in the system. According to E. Laszlo, chaos has its own structure and therefore is a "complex and unpredictable form of order" [8].

According to M. Cheshkov, there are three models of chaos. In the first model, chaos is a combination of multidirectional turbulent movements, which nevertheless preserves coherence. According to the second model, chaos is a "destructor", generating an alternative path of evolution, replacing the branch of self-organization in vibrational, cyclic or dynamic modes. Accordingly, in the third model, chaos appears as the probability of various evolutionary paths, which cannot be reduced either to waves, or to trajectories, or to ensembles of trajectories [9]. In the first, second and third models, the measure of chaos is obviously expressed by the presence of "order parameters," that is, it manifests itself as a bifurcation process that generates a certain number (size) of options for the further evolution of the system.

It should be noted that we are considering the terminology of natural science synergetics (chaos, order, bifurcation, fluctuation, etc.), which can work in the framework

of social and humanitarian problems only with a certain conversion of natural science terms. The methods of such conversion can be different and, in particular, one of such methods is the gestalt method. So, for example, in the empirical concept of an object, that is, in gestalt (for example, in physical experience, where there is a synergistic effect), we replace its elements with idealized objects (say, elements of the organizational structure of society), and we end up with a speculative model of society, a social process where an ideal object functions in the logic of gestalt.

The principles of selection, which determine the nature and direction of evolution of living nature and society, do not contradict the laws of physics and chemistry, although they are not directly derived from them. In the framework of the scientific apparatus of the St. Petersburg scientific school ("V. Bransky's school"), to which the authors of the article consider themselves to belong, of the above models of chaos, the ones most often used are those where chaos appears as a destroyer or, on the contrary, as a creator - these are models allowing to reveal the bifurcation moment in the history of the evolution of open systems.

In such models, the bifurcation process manifests itself in two directions as complication and simplification, which is associated both with the progressive branch of evolution and the regressive one, both with the hierarchization of systems and with their de-hierarchization. In the analysis of chaotization, it is necessary to determine what "law of increase of what entropy - full or thermal - to consider operating» [1]. It is obvious that the increase in "total entropy" contains, in addition to the possibility of simplification (dehierarchization), also the possibility of complication (hierarchization) of dissipative structures.

The formulation of entropy as a "quantitative measure of disorder" in this context is rather erroneous, since it does not allow us to consider the process of chaotization within the framework of regularity, that opens up various possibilities for evolutionary development. A number of "different entropies", that is, different scientific "measures of chaos", are also obviously necessary, to analyze the measure of chaos, especially in such environments as wildlife and society.

### 3 Findings

Human activity can be described in the form of bifurcation chains. Conventionally, at each bifurcation point, a person is forced to make a choice from an objective set of scenarios formed against his will – possible ways of his future life. The moment of choice at the previous point explicitly affects the subsequent moments of choice, increasing or, conversely, reducing the number of options.

The measure of chaos that vibrates in this way corresponds to the fluctuating measure of human freedom in a changing social world. The cycles are being detected in such self-oscillations directly tell us about the presence of certain laws and trends in the life of the individual and society. The unity of freedom and necessity is manifested, which is described by the synergetic theory of social selection [10]. Herewith, the possibility of choice is a necessary but insufficient sign of freedom, which requires two more important conditions - autonomy and awareness of the act of choice. Awareness of choice just assumes that the individual is able to comprehend the "measure of the chaotic existence of the system", of which he is an element, correlate it with the "measure of the ordered existence of the system" and thereby determine under what conditions the transition to the desired for him in the future qualitative state of the system is possible.

As J. Deleuze and F. Guattari write, the challenge is to defeat chaos by cutting through it with the secant plan [11]. By "secant plan" is meant creativity expressed in art, science, and philosophy. It seems that the well-known long-standing dream of the "Western" mentality is manifested here - to control chaos, to "defeat" it. However, this is hardly

possible even in the distant future. The challenge is to be able to guide social self-organization. And the vector of this direction is defined by the St. Petersburg scientific school of social synergetics as a “superattractor” [12].

Before talking about the superattractor of social self-organization, one should decide on the relationship between the chaos measure and the measure of order. The complexity of an open system consists primarily in its *multilevelness*. Chaos at the micro level manifests itself at the macro level in the form of a process of successive change (alternation) of chaos and order. This process can be represented by a growing thesaurus of opportunities - options for the further evolution of the social system.

Following our earlier thesis, which reduces chaos to a bifurcation process, the quantitative characteristic or measure of which corresponds to the number of possible outcomes, we can conclude that human influence on the vector of the evolutionary process reduces to a conscious effect on the structure, which is commonly called the norm. The concept of a norm, in particular, a social norm, is an expression of a measure of order in the form of regularity of reproduction of the characteristics of system stability.

Thus, in a complex ethnic environment, a situation arises when the formation of new ideals is required to overcome the contradictions that have arisen. The concept of the ideal is connected with the idea of an object devoid of any contradictions, where the essence coincides with existence, and this becomes the image of the desired future. The ideal through the activity of the subject initiates the emergence of a hierarchy of values in society. However, its implementation, eliminating some social contradictions, gives rise to others, for example, conflicts between fathers and children, the state and civil society, between ethnic groups, etc.

Society is experiencing a crisis when people, who are guided by different value priorities, are not able to agree, because the ideals that have arisen “at the call of time” become independent, and their carriers are ready to make sacrifices for their triumph. The non-stop process of differentiation and integration of ideals, closely associated with the dynamics of ethnic stereotypes of behavior through the regulatory impact of the law of relevance, ultimately leads to the formation of a kind of norm of social adaptation.

According to the law of relevance, “in the process of ethnogenesis, the correspondence of the ethnic stereotype of behavior and the social ideal is cyclically manifested” [13]. The stereotype of behavior is associated with conformism - adaptation to the natural and social environment; the ideal is connected with transformism, i.e., with the transformation of both environments [13]. Both of these components are an expression of the needs of the ethnic group. A series of such repeated correspondences of ideals and stereotypes leads to the emergence of a stable dominant ideal, attracting more and more supporters, which can certainly affect the formation of a stable social norm and, ultimately, the direction of development of society.

## 4 Conclusion

We conclude the article by criticizing the term “chaos management” or “management of social self-organization». In the book «Chaos Theory and Strategic Thought» [14], Stephen Mann is also quite critical of proponents of controlled chaos theories, calling them adherents of the “mechanistic paradigm”, although, according to Valentina Fedotova, the methodology described in his article was used when “color revolutions” were organized [15].

As it is known, the goal is a management tool, and not an attribute of self-organization. The final goal is often associated with the concept of an attractor, but they are different: the goal is of an informational nature, the attractor is material. In the process of self-organization, prerequisites arise so that a local goal can be “transformed” into a global goal.

But the problem is that the global goal and the final goal are not identical, since the final goal presupposes the completion of the process, the finished image of history, and the global goal presupposes, rather, the image of self-organization of society, because it coincides only with the concept of the *meaning* of history. Often supporters of the so-called theory of “controlled chaos” confuse the global goal and the final goal, and sometimes connect these concepts with social attractors, that is wrong.

As already mentioned, local goals (ideals) are capable, according to the law of relevance, affect the formation of social norm, which, in turn, can affect the volume of the thesaurus of the evolutionary possibilities of society. With the beginning of the functioning of ideals in the history of society, a stage begins that has not yet been fixed post factum, it is, as it were, “carried away into the future,” but speculatively defined by us as a superattractor — the “ceiling of complexity” of the social form of existence of cosmic matter.

Its peculiarity is that if all the “global attractors” that preceded it (the emergence of life, the emergence of a rational person) became “local” thanks to the evolution of the Universum, then it remains “global”, because in accordance with the ideology of the “V. Bransky’s school” there is nothing higher (and further) than it. Therefore, a superattractor is in principle unattainable for a finite period of time.

Mathematically speaking, it can be approached arbitrarily long, never reaching it in a finite time. The infinity of the movement to the superattractor is due to its dependence on the transformative activity of the subject (see transformism), guided by the global intersubjective ideal (global goal), filling his life with meaning and giving meaning to the whole world history.

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