INFORMATION EXCHANGE AND ENERGY FLUCTUATIONS ARE THE BASIS OF EVOLUTION

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Abstract. *Within the standard cosmological model, there are several approaches that explain the evolutionary development of the Universe quite convincingly. However, in general, this model is contradictory and not all of its provisions are confirmed by observations. In this article, the author managed, as he believes, to comprehend some incomprehensible processes of evolution, including those related to the origin of life.*

Keywords**:** *Big Bang, vacuum, information exchange, fluctuation, phase transition, material and intelligent origin of the world, chemical and biological evolution, replication, life.*

The Universe is not a frozen, unchanging entity, but an evolving, purposefully developing, functioning material entity according to its life cycle. Information occupies an important place in the evolution of the Universe, along with matter and consciousness. Meanwhile, in the modern standard cosmological model, information is considered something private and secondary in relation to matter and its energy characteristics. Matter and its energy, in other words, are considered the primary basis of the real world, and information is a kind of "shadow" of reality, serving only to describe it. In this regard, I have attempted a more fundamental definition of information, according to which it is considered a universal fundamental logical category, a collection of all possible information about the world and each of its individual parts [1–3]. This is not just a means of describing their "data" on composition and functionality, but an objective logical basis that shapes the perception of the world, a kind of source of knowledge about it. Being in an inseparable unity with its material and intelligent components, information stimulates the development of the functional capabilities of the systems of the surrounding world, the creation of developing ordered stable structures, patterns and functional relations.

Information, being not a material but a logical category, is inactive in itself. The exchange of information and its influence on the processes occurring in the Universe become possible only under the condition of its transfer by material carriers from each given object to the objects surrounding it. As a result of the imposition of information on the carrier, an information signal arises. The information modulating the signal becomes a source of knowledge, and the exchange of information contributes to the dissemination of this knowledge, its possible consolidation and mutual learning of the objects participating in the exchange.

Information signals have a dual nature and include energy and information components. The energy component, inextricably linked with the information signal, exerts a force effect on the receiver. The information component, modulating the signal using one or another code system, in turn determines the form, meaning and nature of the interaction.

For example, to set any machine in motion, it must be supplied with a certain amount of energy from the outside, but not any energy, but energy modulated by information imposed on it, which reflects pre-thought-out kinematics, circuit solutions, technological methods and manipulations, i.e. energy directed and appropriately dosed in the elements of its design and changing according to the rules specified by the information.

Despite the fact that a machine, like any material object, has a huge amount of its own internal energy, equal to:

$$E = mc^2, \quad (1)$$

where E – internal energy of the object; m – mass of the object; c – speed of light in vacuum its operation and performance of the intended useful function can be ensured only by the energy modulated component of appropriately selected information signals introduced from the outside.

The energy component of the information signal thus determines the action, and the information component directs, modifies and differentiates this action and its influence, forming its semantic character [1, 2].

The presented approach changes our perception of the Universe and evolution. It boils down to the fact that information is not just a reflection of reality, but its fundamental component. Evolution should be understood not as purely random changes in the material world, but as a directed process in which information acts as a kind of guiding "catalyst" for ordering and purposeful increase in the functionality of systems. This does not mean the presence of a predetermined goal, but indicates the rationality of the Universe and its natural development.

An in-depth study of this concept can bring clarity to the mechanisms of development and formation of systems of any complexity.

The final understanding of the role of information in the ordered evolution of the Universe has yet to be formed with the involvement of additional observations and mathematical apparatus, but the approach we have laid down opens up broad horizons for further theoretical and practical research.

Before its birth, or the so-called Big Bang, the world, from my point of view, was represented by a physical vacuum in which material entities, by definition, were absent. Therefore, due to the absence of carriers, there was no exchange of information signals in it, there were, therefore, no interactions, i.e. nothing happened in it except for the microscopic fluctuations inherent in it by nature.

Vacuum, by virtue of this circumstance, is a quantum object and is subject to uncertainty relations:

$$\Delta E \cdot \Delta t \geq \hbar/2; \; \Delta P \cdot \Delta x \geq \hbar/2, \qquad (2)$$

where ΔE, ΔP, Δx, Δt – intervals of possible changes in energy, momentum, coordinates and time; $\hbar$ – Planck's constant.

Its fluctuations, although uncertain, are on average ordered and unchangeable, occur practically on the Planck scale and are inaccessible to observation. And this, from the point of view of the standard model, means that it is populated by virtual particles and is described by almost zero entropy. According to quantum field theory and the standard model, all material objects, with the exception of fundamental particles, are composite, systemic formations. Their structural elements are material particles with half-integer spin (fermions), which are connected with each other by exchanging particles of the corresponding fields with integer spin (bosons). The measure of the connection of particles is the physical quantity of the so-called binding energy. The greater the connection of particles, the smaller the changes in the systems they form, and the greater the binding energy, the smaller their changes and the magnitude of their energy of motion (change). Since the energy of motion is always measured by a positive value, the binding energy (a measure of the absence of change) is negative. Bound systems are quite well ordered, their entropy is comparatively low.

According to the definition, the energy of motion of the vacuum is ideally absent, therefore, the binding energy in it is the maximum possible. This means that it, as a negative value, and, consequently, the total energy, are also equal to zero. In reality, due to its uncertainty, the energy of motion, on average not changing and remaining the minimum possible, fluctuates near zero (on the Planck scale). These fluctuations are irremovable, on average unchangeable and ordered. They form a set of unobservable, i.e. constantly annihilating virtual particles and antiparticles.

Irremovable scaled fluctuations of energy are usually attributed only to the vacuum. However, from my point of view, they are universal, inherent in the Universe as a whole and each of its parts, which function due to the exchange of information signals with the external environment. The chaotic energy component of the signals of the environment, the carrier of information, is directed by the modulated information component into the necessary channel, as indicated above, i.e. it is ordered. After it has performed the necessary work, it returns to the environment in a smaller amount, dissipating that part of the chaotic energy that cannot be ordered. In this connection, the connections of systems weaken over time, entropy increases, and the systems age and collapse. As is known, this is where the second law of thermodynamics manifests itself. As a result, their energy of connection decreases over time and turns into the energy of motion.

At the same time, the accumulation and increase in the concentration of structural elements of collapsing systems, under the influence of gravity and electromagnetic fields, leads to a wide spread of the reverse process in the Universe, compression and binding of these structural elements, the birth of new systems, i.e. the transformation of the energy of motion into binding energy.

The fundamental particles of matter that emerged in the first moments after the Big Bang – quarks, leptons and field quanta – united with information and created information signals. Interacting and combining in various combinations according to the rules of combinatorics, they and their later atomic formations led to the emergence of a huge variety of complex systems. Thus, the initial Universe gave birth to a multitude of elements of the material aggregate, which, exchanging information, emergently ordering and becoming more complex, increased its organization.

Thus, already at the level of fundamental particles, interactions became a consequence of the exchange of information signals, bringing "knowledge" about the states and capabilities of the systems of the material aggregate. As atoms, molecules, protostars, stars and galaxies were formed, this process scaled up, forming a semblance of an information network. In such networks, objects, interacting, "learned", created new combinations that were tested for strength and adaptation, of course, not in the cognitive, human sense, but in the systemic sense: stable structures were fixed, unstable ones were destroyed and disappeared.

At higher levels of organization, for example in biological systems, this process enhances the obvious features of self-learning and adaptation. Living organisms "test" new combinations of features and behavioral strategies, and humans analyze and evaluate purposefully attracted information and ideas constructed by their consciousness and use the knowledge

obtained to change the surrounding reality. Evolution, like everything in Nature, does not proceed continuously. We have shown [2–4] that creative processes develop according to the logarithmic law (2), namely:

$$\Delta f_i = \text{kln}\frac{t_i}{t_i + 1}, \tag{3}$$

where Δf_i is a change in some function over time, which describes the state of the innovation level (quality), realized in the process of evolution in practice at a given moment in time of its countable set;

$t_i//t_i+1$ (i = 0, 1, 2, 3…) is the ratio of the time of the nearest i-th jump to the time of the next jump, counted from the present time t_0 of the system's development, while the present time is separated from the big bang by the value t_0 = 13,8·109 years.

It follows from this law that periods of quantitative accumulation of system changes are replaced by qualitative leaps, as a result of which new properties and an increased level of organization are created, alternating with stagnation periodically replacing them, which decrease over time according to the logarithmic law.

Evolutionary leaps can be considered as peculiar phase transitions. Until the quantitative accumulation of small changes reaches a critical level, the system remains relatively stable, i.e. does not undergo qualitative changes. This is a consequence of the fact that any external influence is opposed by internal resistance. When the information reserve crosses a certain threshold (bifurcation point), a "leap" occurs – the birth of a new quality. This mechanism is accompanied, as a rule, by energy fluctuations.

Let us consider the mechanism of the origin and evolution of the Universe from these positions. The Big Bang arose, most likely, by chance, when, under the intense compressive effect of an almost improbable, but in principle possible, according to the uncertainty principle, fluctuation burst of energy, the virtual particles of the vacuum did not have time to annihilate in a tiny time interval in this case (see 3), therefore they materialized and began to be carried away from the vacuum at the speed of light. In accordance with the law of conservation, the binding energy concentrated in the vacuum was transformed into the energy of motion. As a result, the vacuum seemed to disappear, or rather passed through a singularity, and the resulting avalanche-like increasing energy flow transformed its orderly fluctuating virtual particles into an avalanche of realized material particles and antiparticles (quarks, leptons, quanta of the primary field), chaotically moving at a speed almost equal to the speed of light. The information superimposed on them created information signals, facilitating information

exchange, and the almost zero entropy of the vacuum increased sharply and abruptly. According to the uncertainty relation, particles and antiparticles should have emerged with a small time shift, so after their annihilation, excess material particles remained (according to calculations, one particle per billion annihilated antiparticles), and the energy of the quanta that arose during the annihilation led to an inflationary, almost instantaneous, expansion of space-time created by the set of excess particles and the restoration of the vanished vacuum.

In the first moments, practically point-like material particles, moving with an enormous speed, close to the speed of light, could not bind together during collisions. But, filling with fluctuations of the vacuum dispersed throughout space and its binding energy, under the action of the Higgs field and a number of other factors, material particles acquired mass, which led to the curvature of space-time, the appearance of gravity, braking, a decrease in the speed of particles, and an increase in the tendency to bind them. As a result, a single quark-gluon plasma arose, quarks united, created massive hadrons in accordance with their characteristics, including protons and neutrons, as well as mesons, nucleosynthesis, which acted for a short time, a source of energy for the functioning of the initial Universe, arose.

The exchange of information signals and the ergentially growing information after 380 thousand years led to such a redistribution of energy that contributed to the recombination of electrons and protons and the start of chemical evolution, the formation of the first hydrogen atoms, their self-copying and unification into gas clouds, which were compressed under the action of gravity and, accordingly, heated up to an enormous temperature. This led to the birth of the first protostars, the resumption of nucleosynthesis and the ignition of stars, which united into galaxies. This process initially resisted further gravitational compression of stars, but as the hydrogen fuel inside them burned out, many of them began to explode (supernova explosions), contributing to the intensification of the reverse processes of star formation.

Thus, already in the first second after the Big Bang, the process of reverse transformation of the energy of motion into binding energy was activated, but over time it was again replaced by the process of transformation of binding energy into the energy of motion, then continued in the opposite direction, etc. Thus began the development of the life cycle of the Universe and its systems, in the process of which the systems were born from their singularities, developed, aged, transforming binding energy into the energy of motion, part of which was dissipated, and ultimately were destroyed. The atomic-molecular products of their destruction, connecting with each other, became the material for the formation of new systems.

These processes are continuously periodically repeated. In other words, energy fluctuation is a scaled form of the existence of all material systems, without exception, and the functioning of the Universe as a whole. The constant fluctuation of energy, as well as the phase transitions associated with it, the exchange of information and the accumulation of knowledge are natural, periodically repeating processes that are integral to the material world and determine its evolution. Important characteristics of this process are its scaling (periodic fluctuation of scales with each phase transition), its inevitable attenuation over time and the resulting finiteness or cyclicality of the world.

Since part of the energy is dissipated during fluctuations, the fluctuation, oscillating and scaling, gradually fades. With the emergence and development of life, which is a natural and, in my opinion, necessary stage of evolution, and, in this regard, inevitably distributed throughout the Universe, the dissipation of energy increases sharply, and the scale of fluctuations decreases significantly, and the Universe rushes to its finish line. It is also inevitably preceded by chemical evolution. The essence of chemical evolution, at the beginning of which is hydrogen, i.e. the simplest element of the material aggregate, is that, using the nucleosynthesis of its nuclei and the information exchange regulating them, it creates systems of increasingly complex compounds and functionality. It occurs naturally in a variety of conditions under the influence of information exchange, gravity, electromagnetic fields and intranuclear interactions. In exactly the same way, i.e. with the help of ordinary chemical reactions, organic compounds arose. They differ from inorganic compounds only by the higher chemical activity of the elements included in their composition - carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur, etc., and, consequently, the ability to create high-molecular compounds by combining identical functional groups (monomers), forming long polymer chains and forming their ordered spatial arrangement.

An analysis of the chemical composition of meteorites arriving on Earth indicates that some of the first to appear in space, approximately 9 billion years ago, in full accordance with the laws of chemical evolution, were relatively simple organic compounds – formaldehydes and amino acids.

As for the origin of life, among the many versions, two dominate: the natural-scientific and the mystical.

A successful discovery of the first of them is the idea of DNA and cell replication. However, the theory of replication does not explain the origin of the first replicator or the first living cell, since it is unable to comprehend the clearly expressed rational nature of the processes that have developed in them, requiring the presence of a preliminary plan,

programming, analysis and imagination. In this regard, the authors of the replication model ultimately resort to ideas about a random coincidence or to a far-fetched semi-mystical anthropic principle. With the help of this principle, you can explain anything. But what does science have to do with it?

The mystical version is based on the presence in one form or another of an external (God) or internal (Nature) Creator in relation to the Universe. This version can also be presented in the variant proposed by B. Spinoza, i.e. in the form of the omnipresent God of Nature, which, although without mentioning God, is widely used by modern biological synthetic theory, or by the recognition of the bipolarity of the world and the action in it of the indissoluble unity of the material and conscious principles. The disadvantage of the latter is that the conscious spiritual factor is inaccessible to observation. In this article, the author examines the third, more realistic, from his point of view, and more scientifically substantiated version of the origin of life.

According to this version, amino acids, with the help of sufficiently intense peptide bonds under certain conditions that took place on the young Earth, could first, in my opinion, be linked by self-assembly into comparatively short (up to 300 links) chains of simple organic polymers (polypeptides). It should also be noted that, due to their composition (they contain both an amine, i.e. basic (NH_2), and a carboxyl, i.e. acidic (COOH) group), amino acids interact with both acids and alkalis and therefore exhibit high activity, occupying among functional groups the same privileged position as carbon among other elements. When combined with each other, they exhibit high and most diverse functionality. Polypeptides (proteins) are, in addition, excellent catalysts. The enormous amount of information accumulated in the links of polypeptides and the urgent need for carriers of this information revealed the need to use a simple but effective two-stage code in the processes of exchanging information signals [3]. It was apparently possible to realize this need already under terrestrial conditions, where high-energy photons of ultraviolet light from the Sun, intermediate products of catalysis modulated by protein information, could serve as carriers of information. The first stage of the code was 64 codons obtained by combinations of 4 nucleotides (adenine, guanine, cytosine, thiamine or uracil [2]) by 3. The second stage is a huge number of combinations of 64 codons. This code was apparently created gradually, by trial and error.

As a result of the information exchange, polypeptides began to copy combinations of their compounds that determined their functionality into corresponding relatively short combinations of nucleotides (genes). In other words, each functionality of polypeptides, encoded by a certain combination of amino acids, unambiguously corresponded to a corresponding

combination of polynucleotides. It is quite clear that in the complex initial conditions of the newly formed Planet, even relatively short formations of polypeptides and their genes could not exist for long; they required protection. There was nothing unnatural here. Protection and adaptation are necessary conditions for the stability of any ordered state of the system. Therefore, in the process of evolution, the appearance of each new order and, accordingly, new functionality is inevitably accompanied by the creation of a mechanism for its protection. It can be considered with great certainty that these are causally determined natural processes inherent in the initially material Universe, without which it could not have arisen and functioned. In this case, this protection turned out to be multi-level and contained the following elements and processes:

– protective shells (diaphragms) that unite all interconnected proteins (polypeptides) and genes into one common cell, providing them with mechanical protection, as well as protection from the penetration of foreign elements into the cell;

– the connection of genes with each other and the creation of one common source of information for all polypeptides (proteins) in the form of a high-molecular compound (nucleic acid, DNA or RNA); here we observe the sudden emergence of a new, improved mechanism of information exchange, in which the source of information is DNA, and its carrier is RNA, the catalyst and transmitter of information is the ribosome, composed of variously specialized RNA (transport, ribosomal, etc.); this made it possible to significantly accelerate the coding process, increase its accuracy and reliability, and also provided the ability to exclude and correct many errors that arose during the coding process;

– reverse coding (i.e. protein coding) in order to reduce labor intensity, improve its quality and reliability; this freed amino acids from the need for self-assembly and made it possible to sharply increase the length of the polymer chain of proteins (from 300 to 40 thousand links) and, accordingly, significantly increase the number of proteins with different specializations (there are about 200 thousand of them in a human cell);

– division (copying) of cells, which ensured the reproduction, specialization, stable functioning of the system due to its continuous reproduction and renewal;

– metabolism (metabolism), which arose in the process of exchanging information signals and was also used as a source of energy, amino acids and lipids, other building materials necessary for coding and the structure of membranes, as well as for the removal of waste materials from the cell [2];

– immunity, i.e. recognition and destruction of foreign proteins.

All these processes are causally determined, interconnected, therefore, without disturbing the natural course of events, they could occur both sequentially and in parallel, at the same or different times, abruptly or gradually, creating a living cell and life. After that, another 2 billion years were needed for the cell, gradually improving, to approach the modern one. There is no consensus in the standard model on the question of when life originated on Earth. Quite accurate data on dating the stages of life development were obtained within the framework of paleontology based on the results of the analysis of remains in the layers of cross-sections of the crust of the globe. However, the unicellular organisms of the first living creatures did not leave any traces behind. Therefore, dating the origin of life is done approximately by various indirect methods. According to these data, short-term processes resembling life and extracellular functioning of viruses emerged 4.1–4.2 billion (according to some data even 4.4 billion years ago), and cellular life with a chromosome set of DNA and protein coding – much later, namely 3.8 billion years ago. If this is really so, then this confirms the model of the origin of life proposed by us. In addition, this model is also confirmed to a certain extent by modern technology of synthesis of oligonucleotides or artificial genes [5].

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