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ENTROPY SEISMOLOGY AND THE VIEW OF COSMOLOGY: DARK ENERGY, DARK MATTER, AND GRAVITATION

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ABSTRACT

In the context of the seismic formalism and alphabet of evolution, the analogy with cosmology is drawn: the theory of entropy seismology with the elements of classical and quantum mechanics is modified for creating a simplified model of the emergence of space, time, gravitational field, and primary substance of gravitational matter. At the lowest energy level, the definitions are given for the dark energy (composed of a mixture of three pairs of gravitons and anti-gravitons), the quantum of action and the first fundamental constant of the Universe - the gravitational constant *G*. It is shown that out of the three fundamental constants of physics, at the beginning there has only been *G*; the speed of light constant *c* and the Planck's constant h_p have not yet been formed in the dark matter. The entropy theory of the origin of the primary dissipative and material structures from dark energy in the non-relativistic early Planck epoch is developed. The concept of dark energy in our approach differs from the notion of dark energy in physical cosmology and astronomy. Following our formalism, we present the definitions of dissipative energy and dark matter in cosmology; and construct the model of formation of the primary gravitational cells consisting of gravitons (the material nuclei) and anti-gravitons (the entropy shells around the nuclei). The cells contain the encoded energy information necessary for the origin and evolution of the observed Universe. The model of an elementary gravitational cell and its inflation provides the physical explanation of the origin of the law of gravitation and anti-gravitation. The dissipative force (antigravity) is, in fact, a new type of interaction in the Nature, which permeates the entire space. It is revealed near the masses in the form of attraction and in deep space, on the border with dark energy, in the form of repulsion (cosmic centrifugal forces). The relic dark matter and dissipative energy in the suggested theory are the structural elements which could have formed the observed dark matter and hypothetic dark energy (the unknown form of energy) in astronomy. The results are discussed in the light of the modern theories and problems in cosmology. Hence, a certain realistic picture of the origin of the Universe at the early stage, before the Big Bang and the advent of light, is constructed for the so-called `dark' Universe.

Key words: *Theoretical seismology, Statistical seismology, Geopotential theory, Instability analysis, Self-organization, Spatial analysis*

INTRODUCTION

The paper is a logical continuation of the [3] where it was develops the seismic formalism and alphabet of evolution. The seismic formalism is understood here as the theory of entropy seismology expanded to other forms of energy. Description of the Earth's evolution and dynamical processes in relation to seismicity and the appropriate transfer of this knowledge to cosmology can provide a novel insight into the theory of evolution of the Universe and the modern problems related to the dark matter, dark energy, and black holes [15, 21, 27-29]. By analogy with the nucleation of energy flows in the (seismically invisible) Earth's mantle and formation of the cold density structures, lithosphere plates, which inevitably produce complicated structures radiating seismic waves in their contact zones, it is possible to also construct the similar scenario for the emergence of gravitation field and matter as the foundation of the Universe, leading to the formation of stars, galaxies, and black holes. The models of Universe evolution mainly develop at the junction of physics and astronomy. The solution of the problems arising in the construction of standard models of the Universe evolution hinges on the progress in these fields of science: the breakthroughs into the microcosm in physics and far beyond the Earth, deep into the macrocosm, in astronomy. Of course, cosmology has a solid basis in the physics whose development together with the astronomical observations gives a strong impetus to the development of cosmology. Nevertheless, advances in physics are constrained by the technological progress which requires consistently increasing investments and material resources from the mankind. On the other hand, when developing the theoretical models of the immense Universe, the physicists are fundamentally limited by the rate of the information arrival from the space, which is equal to the speed of light *c*. In this situation, the entropy seismology could help much in expanding the spatiotemporal limits for testing the models of the Universe evolution and philosophical reasoning of the significance of the obtained results. The paper develops the seismic formalism and applies the methods of entropy seismology as an instrument for theoretical modeling the incipient (embryo) stage in the formation of spatiotemporal structure of the Universe, the origin of the gravitational field and matter. This stage in the evolution of Universe can be referred to as

'dark' because at that time, the particles known to us, electromagnetic waves and sources of light did not exist. The present-day data of the astrophysical observations unambiguously testify to the presence of the so called dark energy and dark matter in the Universe [8, 30, 31, 38]. The subject area of dark matter has formed and incorporated the most important current problems of physics and natural science. It borders with the fundamental problems of cosmology, quantum theory of gravity, and elementary particle physics. However, let us look at this problem from the standpoint of seismic formalism and try, as properly as possible, to transfer this knowledge into physics and cosmology. The obtained results are surprising even for me (author of article), because they concern the fundamental problems of the present-day cosmology such as the formation of the space-time continuum and matter, the nature of gravitation and anti-gravitation, dissipative forces and the initial structural elements. The author understands all the complexity of the issues and problems of seismology and giant field of physics and cosmology considered in the present work. These problems have been a focus of the research by many outstanding scientists. This paper is only an endeavor to maximally (as far as possible) simplify some difficulties and try to find common origins of the macrocosm at the initial stage of the evolution of the Universe within the scope of the theory of entropy seismology developed by the author.

TRANSITION FROM ENERGY TO GRAVITATIONAL FIELD AND MATTER

Dark energy. In terms of seismic formalism, dark energy is the virtual homogeneous medium where there are no such notions as time, space and matter. In the virtual medium the notions volume and distance have purely mathematical meaning. In the language of statistics, all the parts of such a medium are identical to each other. A tiny observer placed into this medium (*Fig. 1*) will not have reference points for determining his location. Any volumes allocated in such a medium will be indistinguishable from each other. Hence, in order to know the state of all these volumes, it is sufficient to know the state of one of them, regardless of their shapes and sizes. In other words, from the standpoint of a tiny observer, his position makes no difference to him, or, to put it another way, there are no internal possibilities that would allow him to perceive the space. In this homogeneous medium, there is no notion of mass, radiation, temperature, no concept of time and space. If there is no concept of space for a tiny observer, then the notion of movement also does not exist, which makes all the moments of time identical. Therefore, our observer is also unable to gain his own perception of time. Meanwhile, we need to introduce some scale characteristics for describing such a medium.

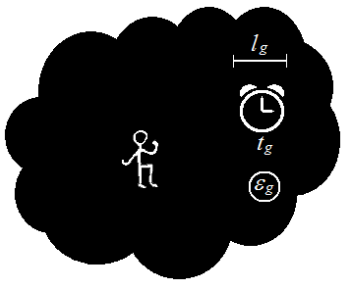

Fig. 1. Dark energy, tiny observer and the initial scale units.

Proceeding from the seismic formalism (or, as we have defined it in [3], the *Simplified theory of quantum entropy*, STQE), we introduce the minimum quanta of energy ε_g and time t_g. Since a notion of movement is absent in this medium, we can formally assume the modulus of velocity to be $v_g = 1$ and determine the quantum length l_g through the time quantum, $l_g = v_g t_g = t_g$. We refer to this medium, which only consists of energy, a 'dark energy'. The physical nature of dark energy is yet to be elucidated. We assume that this medium consists of the smallest portions (quanta) of energy and define this smallest quantum as the energy of a graviton ε_g. Here we suppose that dark energy is the initial form of quantum gravitational energy, a progenitor of all the other types of energy and radiation that have been formed later. We suppose that the first elementary material particles (gravitons) originated from dark energy with the equivalent energy ε_g; and that the evolution of the Universe began from the formation of gravity (relic gravitational field).

What is the physical nature of dark energy? This concept of energy (pure energy without mass and radiation) cannot exist in the modern physics because the laws of physics do not work there. From the physical standpoint it is a virtual energy because it cannot be measured directly. However, it shall contain the encoded properties of Nature, familiar to us, and the laws of physics. Our purpose is, based on the STQE, to reveal, or, more precise, to endow this dark energy with the properties (to encode them) which would enable the observed Universe to originate from this energy. The concept of energy in physics was introduced based on the thermal form of energy. Energy was considered as the mechanical equivalent of heat recalculated into the ability of doing work. Thus, in order for energy to be felt and estimated, motion is necessary, i.e. the work should be done. The first law of thermodynamics (the law of energy conservation and transformation) was disclosed by Mayer, Joule and Helmholtz in 1841-1847. Later it has become clear that Sadi Carnot should be added to them in the first place. It was written in the new edition of *Reflections on the Motive Power of Fire* [7] by Carnot: 'Heat is simply motive power, or rather motion which has changed form. It is a movement among the particles of bodies. Wherever there is destruction of motive power there is, at the same time, production of heat in quantity exactly proportional to the quantity of motive power destroyed. Reciprocally, wherever there is destruction of heat, there is production of motive power. We can then establish the general proposition that motive power is, in quantity, invariable in nature; that it is, correctly speaking, never either produced or destroyed. It is true that it changes form, that is, it produces sometimes one sort of motion, sometimes another, but it is never annihilated'.

In *Reflections*, Carnot based on the notions of the material particles and motion existing in nature. At the initial stage from which we started our description, the concept of nature (as the category of being) was absent therefore we can state that dark energy is definitely not a heat form of energy in the formulation of Carnot. The notion of dark energy essentially abstracts this definition of energy and makes it absolute. Dark energy is a conserved energy with huge reserves. Its reserves cannot be evaluated because there is no space and time, and the measurements are impossible

there. We hypothesize that the dark energy was the source of all the known forms of energy: gravitational, electromagnetic, thermal, mechanical, nuclear, chemical, etc. The first transformations of energy occurred as a result of the emergence of space and time. Generally, we assume that DE_U fills an extremely large and absolutely closed system whose boundaries are practically inaccessible. Formally, by analogy with the Earth, the dark energy can also be considered as an open system which is continuously replenished with energy from beyond. In the inversion image in *Fig. 13b* in the [3], we assumed that the Earth's mantle is dark energy despite the fact that it is supplied with energy from the outer core. However, it is almost impossible to prove the existence of such a mechanism beyond the dark matter of the Universe.

According to seismic formalism [3], the dark energy will consist of a mixture (family) of three types of gravitons g_1, g_2 and g_3 with energies ε_g, $2\varepsilon_g$ and $3\varepsilon_g$. In this medium we can introduce the notion of action h_g for the unit time interval $\Delta t = t_g$; then

$$h_g = \Delta E\, \Delta t = \varepsilon_g\, t_g. \qquad (1).$$

(Strictly speaking, following the logic of [3], we should introduce the matrix of action containing 9 independent elements; however, we will not complicate the task at this step.) This means that in each time interval, a graviton can equally probably be in any of the three energy states (*Fig. 2*). The dimensionless density of the states of dark energy is $S' = S/h_g = 1, 2, 3$, and the entropy is $W = \log S' = 0, 0.3, 0.48$. For the dark energy of the Universe DE_U, we can take t_g equal to the Planck time $t_g = t_p \approx 1.7\times10^{-43}$ s. In DE_U, we have determined the minimum quantum length of $l_g = 1.7 \times 10^{-43}$ cm, which is equivalent to introducing the notion of a unit velocity $v_{0g} = 1$ cm/s, as a scale conversion unit ($l_g = v_{0g}t_g$). This means that there are no zero values of the parameters in the dark energy and the initial (minimum indivisible) values of time and space are merged together. If we introduce the concept of a system in the dark energy, its characteristic size L should then be less than the Planck length, $L \le l_p$ ($l_p \approx 5.1 \times 10^{-33}$ cm). In the ground states, these 'miniature' systems consisting of the three portions of energy are stable and not degenerate. As seen in the track diagrams (*Fig. 2*, right), at each time step Δt, the system immediately passes into equilibrium and the trajectory interrupts at the equilibrium diagonal. This means that the own time in the system is symmetric and it does not increase; every time it 'ticks' by one unit t_g. Within a unit time step, the notions of a discrete energy and number of states are identical: $\Delta E \equiv \Delta S = k\varepsilon_g$, ($k = 1, 2, 3$).

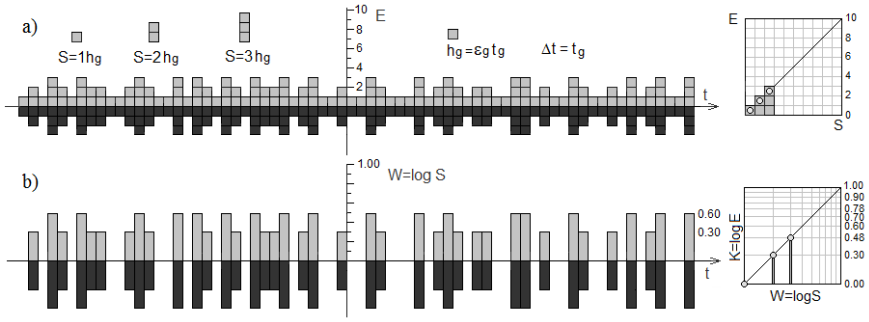

Fig. 2. Dark energy: (a) ground energy states and (b) entropy states. The trajectory diagrams of the ground states are shown in the right. The light-coloured and black squares denote gravitons and anti-gravitons, respectively.

If we apply the analogues of the laws of thermodynamics [3] to this system, the inflow of energy into the system at each unit time step is then completely compensated by the outflow. If we introduce the concept of negative potential energy of a graviton $-u_g$ (which we refer to as the energy of anti-graviton) for the inflow ([3], *Fig. 14*), the dark energy can then be modeled as a symmetric chaotic mixture of three pairs of gravitons with positive energy $k\varepsilon_g$ and three anti-gravitons with negative potential energy $-ku_g$. Let the energies of graviton and anti-graviton be ε_g^+, and ε_g^-, respectively. At each unit time step in dark energy, the graviton and anti-graviton in pairs compensate each other

$$k\varepsilon_g^+ + k\varepsilon_g^- = k\varepsilon_g - ku_g = 0, \qquad k = 1,2,3 \qquad (2)$$

and the system in dark energy immediately passes into ground state equilibrium. The pair action leads to the fact that the trajectory of the state of ultramicroscopic system forcibly returns to the origin of coordinates from the equilibrium points of the diagonal (*Fig. 2*, right). Therefore, the internal time, according to [2] does not grow but, instead, it ticks (the arrow on the virtual clock vibrates). That is how the STQE manifests itself on the lowest energy level, in dark energy, where the effects of quantum fluctuations governed by the uncertainty relation (1) are present. It is analogous to the uncertainty relation of the minimal measurement errors in seismology (Eq. (15) in the [3]); however, in the case of dark energy it gains a fundamental value due to the limitations of measurement capabilities. As will be shown below, this structure of dark energy at the lowest energy level is the necessary condition for creating space and time, particles and antiparticles. In *Fig. 2* the black squares at the bottom denote the energy of anti-gravitons that compensate the energy of gravitons. Thus, dark energy is a symmetric mixture of three pairs of energies of gravitons and anti-gravitons where the (positive) energy of graviton is minimal whereas the (negative) energy of anti-graviton is maximal. We note, that in the relativistic quantum mechanics the concept of particle and antiparticle, matter and antimatter, is introduced

on the basis of negative energy and charge for the standard model of particles, which already exist in space and time [9, 10, 17, 37]. Each charged particle in the standard model corresponds to the antiparticle having the same mass and opposite charge. However, in our case the notions of a charged particle and space-time are still absent. We have only the positive and negative bunches of energy. Our purpose is to construct the mechanism that describes the formation of dark matter from dark energy based on the minimal characteristics of dark energy introduced by us at this early (zero) stage of the analysis. We recall that, formally, the antimatter filled with substance is considered as a dark matter in cosmology; however, cosmology does not provide a definition of dark matter. In our statement of the problem, dark matter originates from dark energy. For such a transition it is necessary first of all to separate the energy of gravitons from the energy of anti-gravitons, i.e. to create the graviton and anti-graviton particles with the certain properties and to determine the conditions of their stable existence. We will then be able to give the physical definition of these particles. Formally, the anti-graviton is 'an inverse' of the graviton: instead of a portion of energy, it has an equivalent negative portion of energy.

In [3] we described the simplest case of an SS leading to the formation of the structure and radiation in DM_e in seismic formalism. *Fig. 3* shows a cell of dark energy V_g and two open systems, V and V_{st}. The enclosed volume V that is arbitrarily selected within the dark energy will be an open system. By subdividing the system, we can represent it in terms of multiple miniature systems with volumes V_g in the ground state, which exchange energies of gravitons and anti-gravitons with the environment (*Fig. 3*). Within the dark energy, all the miniature systems V_g and, therefore the system V composed of them will be in equilibrium. The violation of this balance in the system can lead to the 'structure-formation' (system V_s in *Fig. 3*). In [3], formula (4) of structure formation was presented for the simplified model of an earthquake source. If we assume that radiation energy in this formula is $E_s = 0$, all the work in the local area is then converted without losses into energy E_{st} of the structure of dark matter.

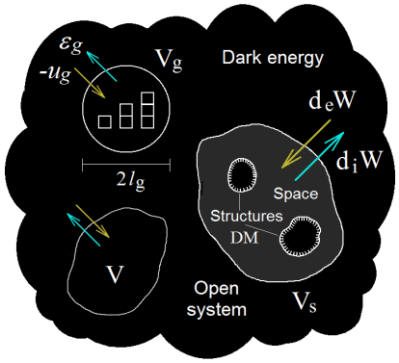

Fig. 3. Open systems in dark energy. A tiny open system in the ground state V_g and an open system of structure-formation V_s are shown.

As was noted in [3], in the case of the Earth it can be the heat dissipation and residual deformations of compaction, plastic flows, creep, etc., whose description is beyond the scope of this article. Nevertheless, if we try to describe the Earth's evolution at the earliest stages, the deviation from the equilibrium in the mantle can then be modeled by the self-organization through the formation of the Benard convective cells [33, 39]. This description would have been exhaustive if the Earth existed forever. However, the Earth is a material object (a planet) and the theory should explain the origin of the Earth as a part of the Universe. That is, the problem of DM_e formation from DE_e reduces to the problem of formation of DM_U and DE_U. The process of formation of 'matter' can be described as the action of the internal energy source in the system. The violation of symmetry between gravitons and anti-gravitons in the open system V_s within dark energy should lead to the formation of the dark matter structure. As shown in [3], the necessary condition of the matter formation consists in the violation of time symmetry (the emergence of the arrow of time). This results in the separation of the information entropy from the physical entropy (at $S = 4$) and emergence of the degenerate energy states. It is the information entropy that is responsible for the formation of structures. This requires an additional energy flow into the system. This inflow will lead to the formation of dark matter in the open system within dark energy.

Scales and principle of uncertainty. Thus, we should develop the theory for the formation of primary structures in dark energy on the pre-Planck scales. This theory should be stitched with the Planck scales and it should provide the conditions and appropriate mechanisms for the emergence of high velocities and, eventually, the light. At this 'embryonic' stage there is no interaction and radiation, no known particles and fields, there is only darkness. The Planck constant h_p has not yet formed and the quantum mechanics does not work there. In physics, different definitions have been introduced for the vacuum including the cosmic vacuum whose physical nature is still unclear [6, 9, 13, 15, 26, 41]. In almost all the definitions of vacuum, the physicists consider space and time (the so called Minkowski space) as absolute quantities. For example, the solution of the Einstein equation in vacuum (in the absence of matter and at zero Λ-term) is the flat Minkowski space, that is, the metric considered in the *Special theory of relativity* (STR). The quantum field theory states that in accord with the uncertainty principle, virtual particles are permanently born and die in the physical vacuum: the so called zero-point energy field oscillations take place. In other words, the theory is again based on the concept of physical vacuum. In physics (in the theory of relativity) space and time are combined in the concept of space-time interval (also called invariant interval) between the two events. However, since the notion of an event is connected with a material object, the interval cannot be defined for the empty space (i.e. for vacuum). The definition of vacuum in physics allows the existence of space without matter (without the known particles); however, it is then unclear, what is the space physically? What does it consist of? In other words, the vacuum without matter is a mathematical abstraction that is intended to replace the lacunae in our knowledge.

In our definition, there is no vacuum in dark energy and no a familiar concept of space-time; however, dark energy has the properties based on which the theory will yield the mechanism of formation of the dark matter and space composed of gravitons and anti-gravitons. Anti-graviton in the dark energy is a certain physical analogue of a hole in the Dirac vacuum [9]. In [3] we have formulated the STQE relying on the generalisation of seismic entropy method with elements of quantum mechanics. We now subside to the lowest energy level (the level of dark energy) and, based on the general

considerations, provide some estimates of the characteristic scales in dark energy and dark matter. Since time in dark energy stands still, the 'absolute' origin of time and the unit time step in the formula of action (1) were specified by the Planck time, $t_g = \delta t = t_p$. In dark energy, the virtual particle of graviton is at 'rest'. We defined the minimum velocity at rest by $(v_g)_{min} = v_{0g} = 1$ cm/s, and the corresponding size (radius) l_g of virtual graviton, which reflects the absolute 'graininess' of space, was determined by $l_g = 1.7 \times 10^{-43}$ cm. By using the formula of escape (parabolic) velocity

$$v_g = \sqrt{2} v_{0g} \qquad v_{0g} = \sqrt{\frac{G m_g}{l_g}} \tag{3}$$

as the upper limit for the condition of rest of a virtual graviton, at $G \approx 6.7 \times 10^{-8}$ cm^3/(g s^2), we estimate the rest mass of the graviton $m_{0g} \approx 2.5 \times 10^{-36}$ g. By using the formula for relativistic mass, $m = m_0/(1 - {v^2}/{c^2})^{1/2}$, we can calculate the difference between the rest mass of graviton at $v_{0g} = 1$ cm/s and the absolute rest mass at $v_0 = 0$: $(m_{0g} - m_0) \approx 10^{-57}$ g. Formally, it is the accuracy of determining the rest mass of a virtual graviton in our formalism (in the STQE). The physical meaning of formula (3) will be discussed below. Then the energy at rest for the family's lowest graviton will be $\varepsilon_g \approx 2.5 \times 10^{-36}$ erg $= 2.5 \times 10^{-43}$ J. The notions of a mass and radius for a virtual graviton are finite. The energy and mass in dark energy are indistinguishable. For separating them, it is necessary that the velocity differs from unity. Recall that the Planck scales of mass ($m_p \approx 10^{-6}$ g) and the energy ($\varepsilon_p = 10^9$ J) are by 30 and 52 orders of magnitude larger than the mass and energy of virtual graviton, respectively. Such a significant difference is, in particular, due to the relativistic effects of the Planck units. The Planck mass is the upper limit for the mass of elementary particles and the lower limit for the mass of black holes. In dark energy black holes cannot exist by definition (3), because the gravitational (or Schwarzschild) radius of the black hole in dark energy should be $\sim 10^{-64}$ cm and the escape velocity on the surface would be equal to the speed of light. Dark energy has an incredibly high density equal to

$$\rho_{de} = \frac{m_{0g}}{\frac{4}{3}\pi l_g^3} \approx 6.0 \times 10^{92} \frac{\text{g}}{\text{cm}^3} \tag{4}.$$

Only under the condition of $v_g \geq \sqrt{2} v_{0g}$, the formation of 3-D space is possible. The pre-Planck era which is considered here is non-relativistic; its duration should be $\delta\tau < 3 \times 10^{10} t_p$. Depending on the flow velocity in a non-relativistic domain, for example, at $v_{g3} = 3$ cm/s, the graviton will grow up to the Planck scale length l_p during the time interval $\delta\tau \approx 1.7 \times 10^{-33}$ s $= 10^{10}\ t_p$. During this time, the constant c is formed (which is equal to the speed of light)

$$c = \frac{l_p}{l_g} v_{0g} \approx 3\ 10^{10} \text{ cm/s} \tag{5}$$

defined by the ratio of the Planck length to the radius of graviton. Note that condition (5) is necessary but not sufficient for the emergence of light. It has rather mathematical than physical meaning. At this stage of evolution, the mass of graviton is still much less than the Planck mass, and $h_g \ll h_p$. The emergence of the velocity other than unity leads to the separation of the notions of space from time and the energy from mass. The Planck reference scale is based on the three constants: the gravitational constant G, the speed of light c, and the Planck's constant h_p [16, 40]. In other words, besides gravitation, this reference scale also relies on the speed and electromagnetic nature of light. The idea of decisive importance of the Planck parameters for describing the matter on the ultra-microscopic level is inapplicable for dark energy and dark matter. The Planck scale of length in our approach is formed at the next (intermediate) stage of evolution, when the conditions (spatial-temporal heterogeneity and integration of the action parameter, $h_g \rightarrow h_p$) will be created in the dark matter for the emergence of the white matter. The intermediate stage and the next stage, when white matter is conceived from dark matter (relativistic stage of evolution), will be discussed in my future papers. In our statement of the problem, out of the three fundamental constants of physics G, c, and h_p, the last two constants have not yet been formed. For describing the dark energy, we should preserve the gravitational constant G and the Planck time t_p ($t_g = t_p$) in the reference scale. In addition, it is necessary to include the energy of gravitons ε_g and the unit velocity v_{0g}, with

$$G = \frac{t_g}{\varepsilon_g} v_{0g}^5 \approx 6.7 \times 10^{-8} \frac{\text{cm}^3}{\text{g s}^2} \tag{6}.$$

This is the definition of the first fundamental constant of the Universe in our formalism. All the gravitons have a strictly constant ratio between lifetime and energy, or, in the case of a virtual graviton, the ratio between the mass and size (m_g/l_g). A graviton is incompressible and indivisible. Based on the parameters of time and energy, also the fundamental scale of action (1) in dark energy is defined: $h_g = \varepsilon_g t_g \sim 10^{-86}$ J s. This scale is by 52 orders of magnitude smaller than the Planck's constant. There is no gravity in dark energy; however, parameter (6) of a virtual graviton contains all the necessary components for the creation of matter (mass m_g) within radius l_g. Thus, energy, time and unit velocity are the absolute scale values of dark energy through which the gravity constant G, metrics h_g and virtual parameters m_g and l_g are expressed.

The Heisenberg's uncertainty principle in quantum mechanics and the related problems arise an attempt is made to develop the modern theory deep into the microcosm and apply it for the pre-Planck quantities. In the modern cosmology, when moving backwards in time when constructing the BB theory, one involuntarily transfers there to the

notions and knowledge about the present; however, present notions did not exist before the BB. This approach may lead to the insurmountable contradictions and mathematical peculiarities such as singularity. For example, the solution can be hampered by the uncertainty relation [17, 40]. Here we have touched upon the fundamental problem that arises on the ultramicroscopic scales and is concerned with the inconsistency of the *General theory of relativity* (GTR) and quantum mechanics. This problem is considered among the key challenges for developing the theory of quantum gravity. The uncertainty relation of quantum mechanics directly contradicts the central principle of GTR, i.e. a smooth geometric model of space and time. An attempt to overcome these contradictions in the contemporary string theory by following the principle of passing from large-scale to micro-scale description of the phenomena and retaining the traditional physical notions of physics (quantum mechanics and GTR) enormously complicates the primary structure of the Universe in its part that is unknown to us (the quantum constraints lead to the notions of twisted and not-twisted strings). At the same time, the theory of the Universe based on strings introduces some revolutionary elements into the physics, which are missing in the theory of particles. In the string theory and the related approaches such as the supergravity theories, a brane is a physical object that generalizes the notion of a point particle to the higher dimensions [4, 5, 14]. For example, a point particle can be considered as a brane of zero dimension, whereas a string can be treated as a brane of dimension one. It is also possible to consider branes of higher dimensions.

In Section 2.4, when enlarging the SS, it was shown that when the threshold energy values increase, parameter *h* which specifies the accuracy of energy and time measurements should be enlarged. Applying the same approach to the cosmology, we have reached the very bottom and started to construct the theory from below upwards by introducing the analogue of the uncertainty relation (1) for energy ε_g and time t_g of gravitons. However, in contrast to the uncertainty principle in quantum mechanics, the uncertainty of energy and time of gravitons in dark energy cannot be less than these quantities. In this unimaginable world, the problem of simultaneous measurement of the position and velocity of the virtual particles within the system does not arise. The notions of uncertainties in the dark energy and dark matter have a purely mathematical meaning because there is no 'measuring instrument' in the dark matter. Speaking about the 'measuring instrument' we mean the presence of a physical interaction between the particles, which could be measured by the virtual observer, whereas the absence of a 'measuring instrument' is results from the absence of the known particles.

Gravitational field. The definition of Newtonian gravity in classical mechanics and field theory [24, 25] is based on the notions of the material particles that already exist in space-time. That is, it is implied that the Newtonian matter already exists. Based on these assumptions, in mechanics, the Lagrange function is introduced and the least action principle is formulated, from which the equation of motion (Lagrange's equation) is derived. In the case of the inertial systems (which means the uniformity of space and time), the Lagrange function depends only on the absolute value of velocity (i.e. on squared velocity $\mathbf{v}^2 = v^2$) of a freely-moving material point, $\mathcal{L} = \mathcal{L}(v^2)$. In mechanics, it is thought that there is no such an 'absolute' reference system that is preferable to the other systems. In the dark energy which we have defined above there are no notions of a material point, course of time, motion, and space. Hence, if we enter a purely formal inertial reference system in the dark energy, it will be the only, an 'absolute' rest inertial system. In this system, the energy, action (1), and entropy will have an absolute minimum.

The concept of mass in mechanics appears together with the consideration of a freely moving material point relative to the inertial reference system. The Lagrange function of a material point in mechanics is directly proportional to the square velocity, $\mathcal{L} = mv^2/2$, where *m* is referred to as the mass of a material point. For one material point, the unit mass is uncertain and can be multiplied to any number, therefore we refer to such a particle as virtual. Introducing the notion of a constant speed *v* of the flow is equivalent to the emergence of the notion of a length increment Δl for time interval Δt, i.e., $v = \Delta l/\Delta t$. Initially, the speed is a measure of distance, a measure of space; it shows how much space is contained in the time unit. As was shown above, time and space in dark energy are fused together (inseparable) and $l_g = t_g$. If we introduce the notion of interval for dark energy, it can be written in the form $ds^2 = v_{0g}^2 t_g^2 - l_g^2 = 0$ which excludes the notion of a point ($l_g \neq 0$). The minimum quantum of velocity (v_{0g} = 1 cm/s) is the definition of the state of rest in DE_U. In the quantum description of dark energy, the zero velocity has no physical meaning. (We note that, according to the uncertainty relation, the state of absolute rest with zero velocity cannot exist.) Therefore, the cited definition of the absolute inertial system at rest associated with dark energy does not contradict the Heisenberg's principle. The very fact of existence of the absolute minimum in the speed of gravitons can be equally fundamental than the maximum value of the information transmission rates in STR, which is limited by the absolute value of the speed of light.

The appearance of a flow in dark energy with the velocity $v_g \geq v_{g3}$ is related to the emergence of a virtual graviton particle with mass m_g. Due to the additivity of mass of the virtual non-interacting particles moving with constant velocity, it is sufficient to only consider one virtual particle with mass *mg*. As the virtual particle appears, we can introduce the reference point for time and space in the dark energy. The spherical space around this point will be homogeneous and isotropic, and time will be uniform. Any moving object with energy should have a mass, therefore the flow of virtual graviton particles with mass m_{0g} in the dark energy will be modeled by the kinetic energy ε_{gk} (letter *k* in the index denotes kinetic energy, not to be confused with coefficient *k*)

$$\varepsilon_{gk} = v_g^2 \varepsilon_{0g}, \quad \varepsilon_{0g} = \frac{k m_{0g}}{2} \quad (k = 1, 2, 3) \qquad (7),$$

where ε_{0g} is the energy of virtual graviton at rest, which is expressed through the mass at rest. From (3) and (7) it follows that the mass at rest of the real graviton is equal to the minimum of kinetic energy: $km_{0g} = 2\varepsilon_{0g} = (\varepsilon_{gk})_{min}$. The three gravitons ($g_1$, g_2 and g_3) of the family must have different masses of rest (m_{0g}, $2m_{0g}$ and $3m_{0g}$, respectively). The

emergence of the velocity different from unity leads to the separation of space from time and makes these notions relative. In the next section we will show how it is possible to determine the amount of the materialised mass knowing the portion of energy (7).

The interaction between material particles in mechanics is described through the potential energy which is the function of the coordinates of the interacting particles. Potential energy is a structure of the field; it exists everywhere where there is space. This way of describing the interactions includes the assumption of the instantaneous propagation of the interaction. Among all the interactions existing in the nature (strong, weak, electromagnetic, and gravitational), the gravitational interaction is most universal. Nothing in the Universe can avoid this force. All the bodies and particles, not only those having the mass but also the fields are involved in the gravitational interaction. We assume that the relic dark matter has no radiation and no known particles of the standard model (quarks, leptons, photons, electrons, neutrinos, etc.), and many laws of physics are inapplicable. Therefore, our modeling will be based on the generalised method of seismic entropy. In the modeling of the dark matter, we take into account two basic properties of the gravitational field. Firstly, the gravitational field is central; its potential energy is negative and it only depends on distance r to the central mass. Secondly, all the bodies that have been 'trapped' by this potential field regardless of their masses will move in this field in the same manner (under the given initial conditions). This modeling identifies the notion of space with gravitation, which makes the concept of space physical.

In the classical science, the potential energy of gravitational interaction of two material points with masses m_1 and m_2 is negative and described by the law $U = Gm_1m_2/r$, where G is the gravitational constant and r is distance between the masses. This definition already contains the cited properties of gravity. However, it is associated with the mechanical mass of two equivalent known particles and does not completely explain the physical meaning of the origin and the structure of the gravitational field. On the quantum scales, this can lead to the errors and is therefore unsuitable for modeling. How has mass with the property of gravitation originated in the Universe? What determined the mass-to-radius ratio of a tiny sphere of space that contained the primary matter? What is the structure of gravitation? These questions are still unsolved. In the Standard Model [19] the 'responsibility' for gravitational interaction was attributed to the graviton (gauge boson is defined as gravitational force carrier). In theoretical physics, graviton is understood as a hypothetical massless particle that mediates the gravitational interaction. By analogy with a photon, a graviton is thought to have dual properties of a particle and a wave. It is supposed that gravitational waves for a mass are the same as electromagnetic waves for electrical charges [26]. In our model a graviton is not a carrier of the interaction but rather the basic smallest mass particle (quantum of matter). The gravitational interaction is rendered by anti-gravitons which are the constructors of space. Gravitons and anti-gravitons form the primary stable structure (an elementary cell of dark matter), which consists of the gravitational form of matter and a space surrounded by the dark energy. The scheme of formation of dark matter from the family of gravitons and anti-gravitons of dark energy is shown in *Fig. 4*.

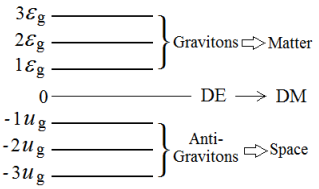

Fig. 4. The energy levels of the families consisting of three pairs of gravitons and anti-gravitons in dark energy produce dark matter (gravitational matter and space).

In the ground state, the potential (by the absolute value) and kinetic forms of energy have three minimal levels. However, as seen in *Fig. 4*, the potential energy is negative therefore this energy in the ground state is maximal. The kinetic energy of a virtual graviton (7) is accompanied by the formation of the negative potential around it by the anti-graviton with mass $m_g^- = -m_g$. This potential on the surface is modeled by the formula

$$\varphi_g = \frac{Gkm_g^-}{r_{gr}} = -\frac{Gkm_g}{r_{gr}} \quad (k = 1, 2, 3) \qquad (8),$$

where m_g and r_{gr} are the mass and radius of a spherical graviton that has not yet been created. We denote the radius of the graviton by r_{gr} in order to avoid confusing it with the conventional designation of the gravitational (Schwarzschild) radius r_g, which is associated with mass m of the body, $r_g = 2Gm/c^2$ [22, 26]. The notion of negative mass of a graviton $-m_g$ appears when a graviton and anti-graviton merge. We then assume that the free anti-graviton occupies the equivalent empty volume of the virtual graviton and is the structural unit (metrics) of space. At formation of space, the anti-graviton can be deformed (to deviate from the spherical shape), keeping the volume. The anti-graviton is simultaneously both the creator of space and the carrier of gravitational interaction. This means that in our model, the anti-graviton also performs the function that is attributed to the hypothetical (massless) graviton particle in the modern physics. In the modeling by formula (8), we will proceed from the fact that in the extremely (ultra) small confined domain it is possible to create an artificial force field which exactly reproduces the natural gravitational field. Below we will show how the dark matter originates from the dark energy and how this process is connected with the separation of the kinetic energy from the potential energy and with the appearance of the dissipative form of energy.

Formation of space-time and gravitational matter. With the emergence of a flow in the dark energy, the entropy production process is initiated. In the case of dark energy, the entropy is not thermodynamic; it is determined by energy and time of gravitons by formulas (16) and (8) in the [3]. Let us consider an open system V_s in dark energy (*Fig. 3*). The entropy change for an open gravitational system can be written by analogy with seismic system (SS) in the following form:

$$d^g W = d_e^g W + d_i^g W. \qquad (9).$$

The negative inflow of entropy $(d_e^g W < 0)$ from dark energy into the open system consisting of anti-gravitons leads to the decrease in the total entropy $d^g W$, which eventually reaches its minimum $\frac{d^g W}{dt} \cong 0$. The second term in (9) corresponds to the internal production of entropy. The initial stage of the evolution occurs under the general decrease in the entropy. In [3] we considered the development of the trajectory with time for the fluctuating portion of energy $4\varepsilon_g$. In *Fig. 9c* in the [3] it was shown how the trajectory blurs and how the most probable areas are formed depending on the chaotic portions of energy of gravitons. The family of three gravitons leads to the degeneration of certain states of the system and turns them into the most probable states at the earliest stage of the evolution of virtual gravitons. To put it another way, the family of three gravitons leads to the formation of an attractor as the most probable state of structure formation. Let us qualitatively illustrate these results and consider a simple model with the time-constant energy increment $\Delta\varepsilon$ (k = 1) equal to the kinetic energy of a virtual graviton $\varepsilon = \varepsilon_{gk}$ (7). Due to the violation of time symmetry, this portion of energy starts the time $t = t_g N$ ($N \geq 1$) (*Fig. 5a*).

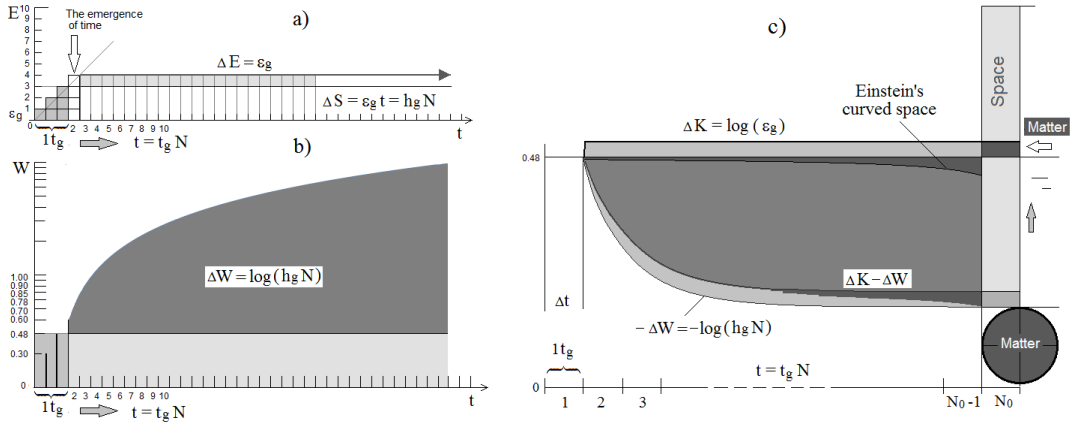

Fig. 5. The onset of the evolution in *DE*: (a) the graph of energy; (b) the graph of entropy; (c) the schematic graph of the formation of matter. The designations are described in text.

In the dark energy N = 1, and the emergence of the flow is primordially related to the fluctuation in the dark energy. For understanding the subsequent discussion, we should note that at the velocity $v_g > 1$, simultaneously with time also the notion of length is run: $l = v_g t = l_g N$ ($l_g = v_g t_g$). With a constant speed of flow, the change in the scale of time and length is described by the same dimensionless parameter $N = t/t_g = l/l_g$. This means that the dynamic problem of duality of time and space is considered. Since we introduced the notions of energy and time for dark energy, we can apply formulas (7), (8) and (12) of the paper [3]. The increments of energy and entropy at zero initial conditions will have the following simple form:

$$E_c(N) = \varepsilon_{gk}, \qquad K(N) = \log \varepsilon_{gk} \qquad (10),$$

$$S(N) = N t_g \varepsilon_{gk} = N \bar{h}_g \qquad W(N) = \log N \bar{h}_g \qquad (11).$$

Here, t_g is the time step equal to the Planck time (lifetime of a graviton, equals 1.7×10^{-43} s); N is the dimensionless time (N = 1, 2, 3, ..., N_0); and $\bar{h}_g$ is the enlarged parameter of action equal to

$$\bar{h}_g = v_g^2 \, h_g \qquad (v_g > 1) \qquad (12).$$

All the changes are controlled by the dimensionless parameter N. In the general case, entropy (11) is defined within the accuracy of the arbitrary additive constant that depends on the initial conditions in dark energy. *Fig. 5b* illustrates how entropy W grows with time. From the origin of time $t = t_g$ up to the time $t = t_g (N_0 - 1)$, the negative inflow of entropy into the system, $d_e^g W$, in formula (9) is equal to the change in entropy (relative to the entropy of dark energy):

$$d_e^g W \equiv \Delta W_e^g = -\log N \qquad (13).$$

During this interval there are no true internal changes and only the initial state specified by the kinetic energy of a virtual graviton (7) evolves in a fairly deterministic way. We assume here that the system creates the primary structure (matter) during a finite time interval $t_0 = t_g N_0$ (*Fig. 5c*). In *Fig. 5c*, the potential (8) corresponding to the primary mass is shown by the dark colour. In fact, this is just the Einstein space warp that will be discussed in Section 4.6. In our modeling we create an artificial force field that precisely emulates the natural gravitational field of the future matter. The physical factor responsible for the formation of the gravitational field is the emergence of the attractor domain which attracts the trajectory (the entropy law of gravity described in Section 2.3 works here). In our simplified consideration, this may occur because of the system transition to the state of least dissipation Q (for example, at $N_0 \approx 100$, $dW/dt = Q = 1/(N_0 \ln 10) \approx 4 \times 10^{-2}$) [2]. Just as in the seismic cycle, the analogue of the second thermodynamic law for open systems works on the long time interval and the energy conservation law transferring the system into the equilibrium state acts on the short time interval [3]. By analogy with the elastic and inelastic energies of an earthquake, we can record the energy conservation law at the last time step at $N = N_0$ in the following form:

$$\varepsilon_g = \varepsilon_{mg} + \varepsilon_f \qquad (14).$$

The left-hand side of this formula contains the total dimensionless energy supplied to the system $\varepsilon_g = \varepsilon_{gk} N_0$ the abbreviated action producing space and matter. The virtual graviton particle materializes and becomes a real particle at rest with mass m_g and energy $\varepsilon_{mg} = 2\varepsilon_{gk}$

$$\varepsilon_{mg} = m_g v_g^2 \qquad (15).$$

The doubling is due to the equal fractions (on ½ $m_g v_g^2$) of the kinetic and potential energy of coupling $\varepsilon_{mg} = \varepsilon_{gk} + u_{gp}$. By using formula (3), we can easily show that the fraction of potential energy is

$$u_{gp} = \frac{m_g v_g^2}{2} = \frac{G m_g^2}{r_{gr}} \quad \text{as} \quad v_g = \sqrt{\frac{2G m_g}{r_{gr}}} \qquad (16).$$

These formulas mean that a graviton as a real primary particle and primary matter can only be formed under the condition of escape velocity [3]. That is, the escape velocity is the necessary condition for the formation of mass from dark energy. The bulk of energy in (14) is converted into the 'dissipative energy' of space ε_f (*Fig. 5c*)

$$\varepsilon_f = \frac{(N_0 - 2)\varepsilon_{mg}}{2} \qquad (17).$$

Routinely, we have got accustomed to the irreversible processes such as energy dissipation due to friction or heat conductivity inherent in the large-scale macroscopic phenomena. However, at the dawn of evolution beyond the cosmos, in the pre-Planck epoch, we will understand the dissipation as a scatter of energy over the expanding space. The transition to the ordered equilibrium state as a result of phase transition leads to the formation of a primary cell consisting of matter (2% of energy) and dissipative structure of space (98% of energy).

The physical meaning of phase transition and formation of the new type of dissipative structure is the following. Prior to the formation of this structure, a virtual graviton behaves chaotically in the space of anti-gravitons. The energy of a virtual graviton as sort of scattered' smeared over the surfaces of the spheres. However, since the energy of a virtual graviton is indivisible, the graviton simultaneously behaves as a particle and as a spherical wave converging to the centre. The position of the particle on the spheres having a large radius is uncertain; however, the location of the particle on a sphere does not matter; what is important is its distance from the centre. With the approach of the centre, the position of the particle becomes more certain. This 'scattered' energy is with time used by the dissipative structures for self-organizing. Under the phase transition, the virtual particle materializes within the quantum spherical volume with radius r_{gr} and forms the material core of the cell. Anti-gravitons cannot penetrate into the core by the definition because the formed mass m_g of the graviton fills this space. In the spherical envelope surrounding the material core, anti-gravitons create the ordered spatial twisted entropy fields promoting the self-organization of the graviton and the development of the stable structure of cell.

The formation of two forms of energy (14) is connected with the nature of the emerging fields of force: the conservative fields generated by gravitons and the dissipative fields created by anti-gravitons. The force field of gravitational matter pertains to the potential fields whereas the forces operating in them are conservative (i.e. the work done by these forces does not depend on the path of the motion but only on the initial and final states). On the contrary, as opposed to the force field produced by graviton, the work of the dissipative forces depends on the geometry of the displacement trajectory. We use here the notion of a force; however, this notion is not yet defined in the dark matter. The second Newton's law $F = ma$ does not yet work there and the accelerations are absent ($a = 0$). The primary cell is characterised by constant speed. In classical physics it is known that two types of forces exist in the case of constant velocity modulus. The first type is observed when the direction of the forces acting on the body coincides with the direction of motion. In this case, the accelerated motion affected by the deceleration forces becomes uniform. These drag forces acting on the body are referred to as dissipative. The frictional motion of a load along a rough surface under the action of a force is the example. If in this situation the load moves uniformly (without acceleration), the entire force goes to overcoming the friction. The second type is when the force and the displacement are mutually perpendicular (centripetal and centrifugal forces). In this case, motions with a constant speed (but not in the constant direction) are also possible.

These motions are referred to as the curvilinear uniform ones. The both types of forces have been fairly well studied in physics; however, the primary physical nature of the origin of such forces in the Universe, just as the nature of the gravitational forces, is unknown. It is just these forces that emerge in the primary structural cell. Modeling these forces will be discussed in the next section. The formation of a primary 'matter' and space in the dark energy is similar to the emergence of the source of internal energy in the form of an elementary microearthquake in the SS. We have studied these processes in detail in the Section 2. The mass of a graviton and its surface act as the energy of seismic radiation and the slip plane, respectively, whereas the space created by anti-gravitons plays the role of the dissipative energy. For constructing the phase diagrams and entropy funnels, transformations (28) and (29) in the [3] are used. The formation of primary matter and space is schematically illustrated by the track and phase diagrams constructed by analogy with the earthquakes and shown in *Fig. 6ab*, respectively. The linear zone of instability $K = a\,W + b$ in *Fig. 6a* is formed in the general case when we consider the fluctuation with three portions of energy of virtual gravitons. The evolution of entropy trajectory of a virtual graviton becomes spiral in phase plane (R, φ) under the transformation $R(t) = W_{N0} - W(t)$ and $\varphi = \varphi_0 t$. The spiral trajectory forms the entropy envelope between the dimensionless radii

$$R_{max} = \log N_0, \quad R_{min} = \log N_0 - \log(N_0 - 1) \approx \frac{1}{N_0 \ln 10} \tag{18}.$$

In the equilibrium state (14) these radii correspond to the external and internal radii of the cell envelope that is formed between the dark energy and the materialised graviton (*Fig. 6b*). The radial velocity of entropy tending to the centre is

$$\dot{R} = \frac{dR}{dt} = -\frac{1}{N \ln 10} \tag{19}.$$

This formula means that the radial velocity is equal to the dissipative function with negative sign, $\dot{R} = -Q$. The minus sign means that when moving toward the centre (by phase transformation), we observe the process that has been already implemented in time, and from there we sort of look backwards in time and see how the spiral trajectory approaches from the past to the present. As the trajectory moves away from the dark energy and approaches the centre, its velocity (just as the dissipative function) decreases to a finite non-zero value. The principle of constructing the phase diagrams and the numerous examples for the strong earthquakes are presented in [1, 2]. The twist and the radial entropy rate *dR/dt* depend on the kinetic energy (velocity v_g) of a virtual graviton. *Fig. 6c* shows the dependence of the twist of spiral trajectories on velocity (19). The higher is the trajectory located on the diagram (see *Fig. 7b* in the [3]), the less twisted is it (the faster it reaches the centre).

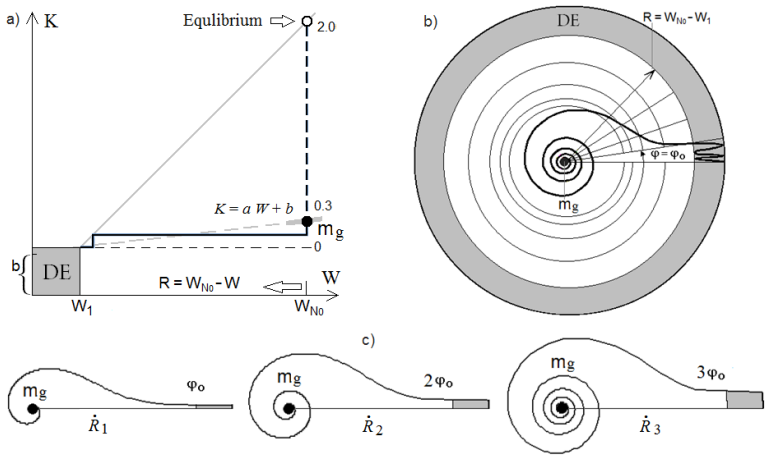

Fig. 6. (a) Track diagram, (b) phase diagram, (c) dependence of the phase diagram on the speed ($\dot{R}_1 > \dot{R}_2 > \dot{R}_3$).

In [2] it was shown that the probability of an earthquake has a normally distribution with respect to entropy and is described by the Gaussian probability density function. In the time domain, the probability density function is governed by the derivative of entropy, i.e. by the dissipation function $Q = dW/dt$, whereas the probability of an earthquake is described by the lognormal distribution. We will also use the lognormal distribution when modeling the formation of dark matter at the transition from the trajectory diagram to the spiral trajectory. By definition it is assumed that random quantity N has a lognormal distribution when its logarithm (i.e. the entropy of $W = \log N$) has a normal distribution. By analogy, the probability formula for the formation of matter in the phase space $R(t) = W_{N0} - W(t)$ for the family of three gravitons can be written out in the following form

$$\mathrm{R_W}(t) = \int_{R_{min}}^{R_{max}} \Phi(\mathrm{R})\,\mathrm{dt}, \qquad \Phi(R) = \frac{\dot{R}}{\sigma_W \sqrt{2\pi}} \exp\left[-\frac{\mathrm{R}^2}{2\sigma_W^2}\right] \tag{20},$$

where σ_W is the mean square deviation in the case of the normal distribution

$$\sigma_W = \left\{\sum_{j=1}^{3} (W_k - W_0)/3\right\}^{1/2} \qquad W_0 = \frac{1}{3}\sum_{j=1}^{3} W_k \tag{21}.$$

At large N, the mean square deviation $\sigma_W << W_0$. *Fig. 7ab* shows the lognormal density and probability functions at $W_0 = 16$, $\sigma_W = 0.14$ and $W_{N0} = 17$. In contrast to the normal distribution, the curve of lognormal distribution in *Fig. 7a*, is right-lateral asymmetric as a result of expansion (inflation). This indicates the high probability of entropy to deviate upwards (to increase). Unlike entropy, the cumulative energy in the track diagram only obeys the normal distribution. Equilibrium (14) is a special case of the equilibrium state, namely, the case of a non-equilibrium steady state because the external conditions permanently change and shift the system from equilibrium. The phase space enables us to fairly well describe the cumulative properties of the volume of the system. The spiral trajectory has a direction in time and describes the evolution. However, on a fixed time interval when the system passes to and remains in the equilibrium state, we can describe the twisted but already the real spatial structure of the cell. In the virtual space that appears in the

dark energy, we use two measures of the distance for describing the irreversible self-organization processes: distance l from the dark energy and distance r from the centre of the formation of matter. It is just these measures that are key issues of the Earth's inversion conducted in Section 3. With this inversion it is clearly seen that the self-organization and evolution of the Universe, just as the SS, begins within the dark energy.

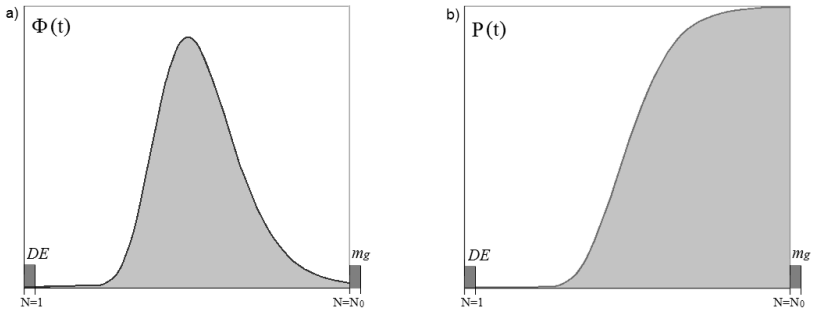

Fig. 7. The probability of graviton formation from the dark energy.
(a) Lognormal density. (b) Probability function (at $W_0 = 16$, $\sigma_W = 0.14$).

We recall that our cosmological model addresses the emergence of primary inhomogeneities in the unknown Universe (the origin of the system V_s in *Fig. 3*), even before the BB when our known Universe had been formed. This corresponds to the scales in the units of $l = v_g t_g$ in the pre-Planck space. When we describe the inflating sphere of radius L, the internal virtual spheres with the discrete radii r_N are formed, and, eventually, a graviton emerges within the spherical space of radius r_{gr} (*Fig. 8a*). The distance from the dark energy to the inscribed spheres measured in the units $l_N = L - r_N$ will correspond to the chronology of the events viewed from the dark energy, whereas the measurement of r_N will correspond to the chronology of the events viewed from the centre of the matter formation. Philosophically this means that we, as an observer, leave the virtual space for the real, material space where we have been subsequently created by Nature. Thus, the formation of space in our model always precedes the formation of matter.

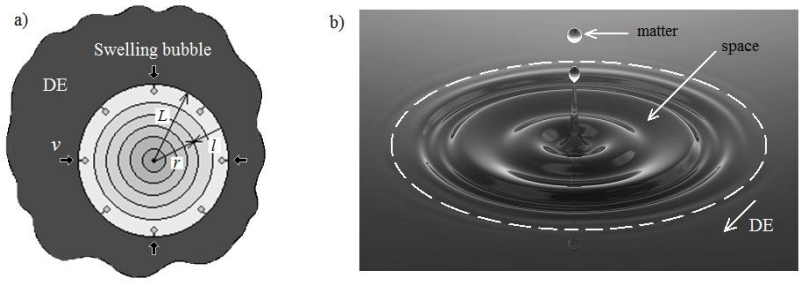

Fig. 8. (a) The scheme of inflation of the sphere in DE_U; (b) the fall of a drop into water (an illustration of the formation of space and matter by the example of a drop.

The process of self-organization and formation of the dissipative structure (envelope) and mass (core) in the primary cell can be liken to the pattern observed when a drop falls into a large volume of water (*Fig. 8b*). If we record this process on video and then play it backwards, we will see that the converging circular waves with the increasing amplitude will close at the centre, forming a drop. However, in our case the role of the circular waves is played by a virtual particle and the role of the increasing amplitudes is played by the entropy probability (*Fig. 9*). The amplitude of the spherically symmetric wave pattern of detecting a virtual graviton which is shown in (see *Fig. 9*) coincides with the probability distribution on the inflating spheres. One can easily see this by rotating the picture of radial distribution of probability in *Fig. 7b* around the axis of the maximal probability. The drop in *Fig. 8b* emulates the materialized particle in the area of highest probability (20). This results in the formation of the unimaginably fine structure of the primary cell consisting of the central core (the matter from the graviton) and the dissipative envelope (space) which is in the steady equilibrium state with the ambient dark energy. This typically takes place at $N_0 \sim 10^2$ which corresponds to the time point $t = t_g N_0 \approx 1.7 \times 10^{-41}$ s.

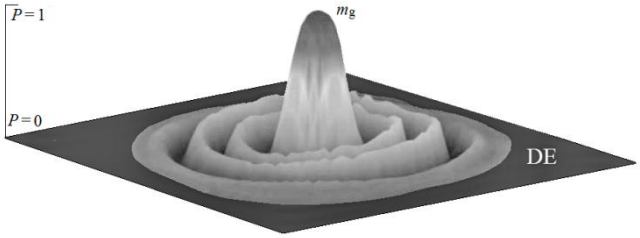

Fig. 9. The amplitude of the spherically symmetric wave pattern of a virtual graviton coincides with the probability distribution of graviton formation in dark energy. The virtual graviton materializes and is localized at the maximal probability.

The non-equilibrium steady state is maintained by the continuous supply of negative entropy inflow. The subsequent evolution of the non-equilibrium steady state can be described by the analogy with the SS where the role of the indicator earthquakes is played by a graviton mass and the role of the cumulative energy is played by the total growing mass. Unlike the SS where the indicator earthquakes are scattered within the volume of the system, all the mass in the case of dark energy is concentrated in the centre due to the central symmetry. The scheme in *Fig. 10* illustrates the evolution (inflation) of the primary cell by analogy with the track diagram of SS (*Fig. 7a* in the [3]). The designations have the same meanings (as in *Fig. 7a*); however, the cumulative energy (the vertical axis) is understood as the energy of the total mass of gravitons. After a certain threshold S_{th} the trajectory is inevitably drawn up to the attractor. In contrast to the SSs which have three dimensions (x, y, z), the primary cell in the dark energy is spherically symmetric and has one dimension (radius r). The process of expansion of the SS from a small size to the large systems was illustrated in *Fig. 10*. At the same time, the volumes of the hierarchically low SSs are not nested one into another; they sum up and gradually fill the volume of the large systems. Unlike the SS, during the evolution of the primary cell of a graviton, the cells are nested into each other like the matryoshka (Russian nesting doll, i.e. a set of wooden dolls of decreasing size placed one inside other), the cell is inflated and the central mass builds up. This means that the inflation preserving the proportion of the external and internal radii (18) of the shell takes place.

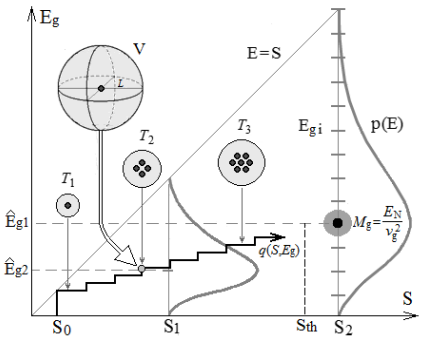

Fig. 10. The schematic representation of the trajectory evolution in the dark matter during the pre-Planck epoch.

Mathematically, the growth of the primary cell can be represented in the following way. With the lapse of time, after the completion of n cycles, the core is formed in the cell. This core is composed of gravitons with the total mass of rest

$$M_{0g} = \sum_{i=1}^{n} m_g = n m_g \qquad (22).$$

If after n cycles the system reaches an equilibrium state, the law of energy conservation (15) at constant speed is summed and has the following form:

$$E_g = E_M + E_f \quad E_M = M_{0g} v_g^2 \quad E_f = n\varepsilon_f \qquad (23),$$

where

$$\frac{E_f}{E_M} = N_0 - 2 \approx 0.98 \times 10^2 \qquad (24).$$

In fact, E_f is the dissipative energy of the space filled with anti-gravitons. The time passing after the completion of $n = 10^8$ cycles, with $N_0 = 10^2$, will be ~ 1.7×10^{-33} s. During a split second the cell will reach the Planck size $L = l_p = 5.1 \times 10^{-33}$ cm. By analogy with an egg cell consisting of a nucleus and a fluid shell, we refer to this gravitational cell as an elementary structure of the relic dark matter. The rest mass of the nucleus will be $M_{0g} = m_g 10^8 = 10^{-28}$ g and the density of the dark matter cell, $\rho_{dm} \sim 10^{71}$ g/cm^3, i.e. by 21 orders of magnitude lower than the density of dark energy (4). The mass M_{0g} of the cell's nucleus will contain the total kinetic and potential graviton-binding energies $E_M = M_{0g} v_g^2 \approx 10^{-26}$ erg. The structure of the relic dark matter is forms (after the onset of the fluctuation in dark energy) to the time $t_{dm} \approx 10^{-33}$ s. During pre-Planck time the parameter of action (1) increases up to value

$$h_{dm} = \Delta E \, \Delta t = E_M \, t_{dm} = 10^{-67} \text{J s} \qquad (25).$$

This is by 18 orders of magnitude higher than the parameter of action in the dark energy. It is this minimal action from which the new stage of the evolution of the dark matter begins. Prior to the beginning of the stage of electromagnetic radiation, the action should additionally grow by 33 orders of magnitude in order to reach the Planck constant $h_p = 10^{-34}$ J s. The cell of the dark matter with the nucleus having the mass $M_{0g} = 10^8 m_{0g}$ and radius (equal to the Planck length) $l_p = 10^{-33}$ cm is the largest stable structural energy unit unable to emit the light. Starting from the Planck length, the virtual particle can be accelerated to the speed of light during the time 10^{-43} s. If we assume that the present-day mass of the Universe is $M_U \approx 10^{56}$ g and that the entire Universe consists of gravitons, the number of the gravitational nuclei with mass M_{0g} will then be 10^{84}. This entire mass will occupy the volume of the hypothetical core with a radius of 10^{-7} cm and can be localized within the spherical cell with a radius of 10^{-5} cm. Formally, this cell can be accepted as the minimal primary singularity in the BB model if we assume the mass of the Universe to be constant since the beginning of the BB.

Summing up the results of this section, we can state that the fluctuation in DE_U leads to the increase in entropy and to the separation of the information entropy from it (*Fig. 8b* in the [3]). Due to the course of time, the entropy increases by ΔW and enlarges the dimensionless radius of the sphere N ($N = l/l_g$), $N = 10^{\Delta W}$. The inflation of the sphere occurs under the unusual conditions, without the conventional energy losses e.g. due to friction, because there is no substance and no concepts of temperature, pressure, thermal energy, and heating. As it will be shown in the next section, the inflation is controlled by the entropy dissipative forces and by the forces of gravitation. The dimensionless parameter N runs the time and creates the space filled with anti-gravitons. The sphere becomes filled with the entropy energy of

dissipation. When the entropy is saturated and reaches its minimum (by the absolute value of the maximum), the flow of virtual gravitons from dark energy creates gravitational matter with the mass of rest $M_{0g} = E_M/v^2\ g$. We consider a virtual graviton as a quantum-mechanical non-relativistic particle with wave properties. The amplitude of the wave increases with the growth in the probability of the formation of mass (with the approach of the centre). It can be said that the self-organization process is described by the elements of quantum mechanics, whereas the formation of a graviton in the equilibrium state is described by the elements of classical mechanics. If accelerated to the speed of light, the mass in the nucleus of the cell contains huge resources of internal energy. However, being located in the cell with a smaller radius than the Planck length, the mass cannot produce other forms of energy and radiate the light waves. Thus, on the pre-Planck scale of the length, the dark matter is formed from the dark energy. The geometric proportions are preserved in the internal dynamics of a bubble. We note that at the initial stage, time is associated with the expanding volume of the bubble (or with the corresponding growth of a mass nucleus). At this stage, there is nothing (except for the dilation) that would allow the past to be distinguished from the future; as a result the internal, dynamic time is stopped. In this model it is clear that the classical laws of thermodynamics, which are based on the thermal form of energy and on temperature, were not operating at that time. In terms of the laws of thermodynamics formulated in the seismic formalism, this initial stage would be described in the following way: the analogue of the second law of thermodynamics leads to the creation of the new forms of energy (kinetic, potential and dissipative) of the dark energy; these newly created energy forms are associated with the formation of the gravitational matter and space. Meanwhile, the analogue of the energy conservation law leads to the formation of a stable spherically symmetric cell (with a core and envelope). As has been already noted, the envelope is filled with two forms of the force fields. Let us now describe these fields and identify the properties of the future Universe that are coded in these fields. We will also look into the physics of the origin of the Newton's law of universal gravitation.

Encoded properties of a structural cell, gravitation and antigravitation. *Fig. 11a* schematically shows a spherical structural cell with radius $L = l_g N_0$, consisting of a core (primary matter) and dissipative shell. The core (graviton without rotation) is formed at the centre and has the radius $r_{gr} = l_g$ ($r_{gr} \ll L$) and mass m_g. The field within the cell's shell is considered as the sum of two fields: gravitational (connected with the formation of matter) and dissipative field of the space. We model the structure of the gravitational field in such a way that the model field produces the same action as the natural gravitational field of a graviton which we simulate by the classical Newtonian potential of gravity field φ_{mg}^{-}

$$\varphi_{mg}^{-}(r) = G\frac{(-m_g)}{r} = \frac{\varphi_g}{(N_0 - N)} \quad \text{where} \quad \varphi_g = G\frac{(-m_g)}{r_{gr}} \qquad (1 \le N \le N_0 - 1) \qquad (26).$$

Here $r = L - l = r_{gr}(N_0 - N)$ and φ_g is the maximum value of the potential at $N = N_0 - 1$ which is attained on the graviton surface with mass m_g. At the boundary with the dark energy, this potential tends to the minimum value $\varphi_{mg}^{-} = \frac{\varphi_g}{N_0}$. Modeling by potential (26) is convenient because the shell of the primary cell does not contain ordinary material particles. The known particles of the standard model are too big (huge) for the scales considered. Hypothetical introducing a material ('trial') particle with mass m_α located at distance r from the centre of this field leads to the potential energy of gravitational interaction $U = m_\alpha \varphi_{mg}^{-}$. This modeling means that when the sphere inflates, the constant G is the 'integral of motion'. It controls the formation of the radial force lines of the gravitational field in the primary cell in accordance with the relation between mass m_g and the sphere with radius r_{gr} of the (structure-forming) graviton. Thus, φ_{mg}^{-} is the energy characteristic of the field of gravitational attraction. In our formalism, the negative mass ($-m_g$) in formula (26) can be considered (by definition) as a result of fusion of graviton and anti-graviton (a certain semblance of annihilation), and difference ($N_0 - N$), as a radial number of anti-gravitons (spatial holes of the matter). The radial number is equal to the dimensionless radius r_N of the hypothetical spherical surface in the shell of the cell (between the graviton and the dark energy). The potential energy of the gravitational field is proportional to the mass of graviton that replaces the 'hole' of the anti-graviton in the core and is inversely proportional to the radial number of anti-gravitons. This is the physical interpretation of the origin of gravitation. The law of universal gravitation in the primary cell between the graviton at the centre and 'a trial particle' m_α on the surface of the sphere with a discrete radius r_N has the following form:

$$F_{mg} = m_\alpha \frac{d\varphi_{mg}^{-}}{dr} = G\frac{m_g m_\alpha}{r_N^2} \qquad r_N = r_{gr}(N_0 - N) \qquad (27).$$

This is the quantum expression of the Newton's law which does not contain singularity ($N \neq N_0$, $(r_N)_{min} = r_{gr}$) and has a small (but nonzero) value at the boundary with the dark energy. The greater amount of anti-gravitons between the graviton and 'a trial particle' corresponds to the smaller force of attraction. In other words, anti-gravitons produce the space of repulsive forces; however, in the vicinity of the graviton we feel the attraction because the repulsion of anti-gravitons beyond the sphere r_N is much stronger than inside the sphere (radial number N of anti-gravitons between the 'trial particle' and the dark energy is above ($N_0 - N$). Thus, the Newton's law of gravitation is not a law of attraction of masses but the law describing the manifestation of the effect of mass attraction against the background of the repulsion forces. This is the result of action of the repulsion forces which inevitably appear during the formation of matter. Since the primary structural cell contains no particles, the Newton's law (27) does not manifest itself there by any signs. We assume that this law is encoded in the cell. The bottom part of *Fig. 11b* illustrates the distribution of gravitation potential (26) and the distribution of the hypothetical conservative force (27) is shown in the upper part of this figure.

Gravitational potential (26) warps the space by the radius and forms the potential well which is balanced by (filled with) the mass of graviton. In the absence of rotation, this warping is spherically symmetric.

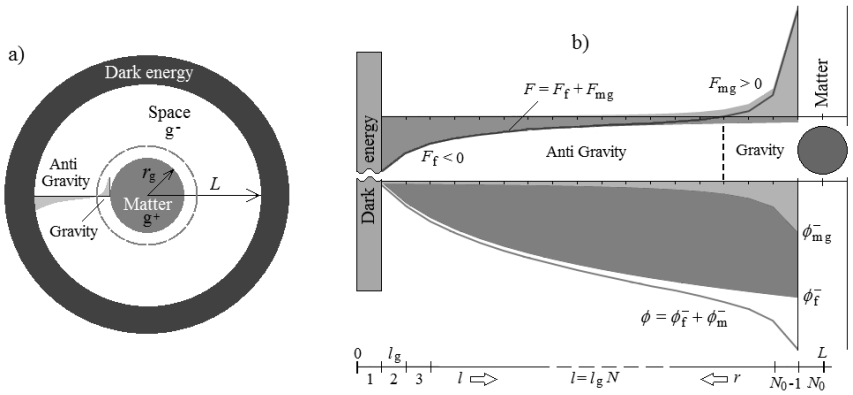

Fig. 11. (a) The primary stable structural cell in the dark energy, which consists of the core (graviton) and envelope (the space filled with anti-gravitons). The image is out of scale.
(b) Scheme of radial distribution of potentials and potential forces in the envelope of the structural cell.

Let us now proceed to modeling the dissipative energy and dissipative forces filling the spherical shell of the cell. In our modeling we take into account the fact that these forces are related to the velocity although not directly related to the formation of the mass m_g of graviton. As was noted above, we model the dissipative energy of space by the spiral trajectories formed by the logarithmic potential

$$\varphi_f^-(l) = v_g^2 R = -v_g^2 \log N - v_g^2 \qquad (28),$$

where v_g^2 is the constant determined by formula (16). We introduce the shift by a free constant in order to allow for the enlargement of the quantum described in [3] in the initial state. *Fig. 11b* shows the radial distribution of this potential in the shell of the structural cell. The potential (28) is determined from the characteristics of the dark energy. This scalar field is maintained by the constant speed (regardless of the direction) therefore it should be proportional to the square of velocity. The role of the analogue of the constant velocity for the SS in seismology is played by the plate motion velocity. The motion of the lithosphere plates is a necessary condition and the initial cause of the formation of seismicity.

The idea of the modeling by the logarithmic potential is the following. During the formation of matter, the random dimensionless quantities N_j obey the lognormal distribution, whereas their logarithms (entropy $W_j = \log N_j$) have normal distribution [2]. If we substitute the entropy in the power of the exponent in the formula $N_j = 10^{W_j}$, we can see that the lognormal quantity N_j appears as a result of the repeated multiplications of the independent quantities, whereas the normal random quantity W_j is produced by the repeated summation. Thus, the scalar potential (28) has the property of summation. We will determine the entropy forces of dissipation by the following formula

$$F_f = m_\alpha \frac{d\varphi_f^-}{dR} = -m_\alpha \frac{v_g^2}{r_g N \ln 10} \qquad (29).$$

As seen in *Fig. 11b*, the entropy forces F_f are forces of the attraction to the dark energy (inflation forces). Formula (29) can be interpreted as the centrifugal forces created by N anti-gravitons between the dark energy and the 'trial particle'. In *Fig. 11b*, bottom, shows the distributions of the potentials (26) and (28) along the radius of the cell and their sum

$$\varphi(N) = \varphi_{mg}^-(N) + \varphi_f^-(N) \qquad (30)$$

and the top part of the figure illustrates their derivatives (27), (29) and the sum

$$F(N) = F_{mg}(N) + F_f(N) \qquad (31)$$

The sum F of the forces is equal to zero at $N_c \approx N_0 - \sqrt{N_0}$, i.e. in the vicinity of the dashed line in *Fig. 11b*, which is always shifted towards the mass. This value divides the shell of the structural cell into the outer area of anti-gravitation and the internal area where gravitation prevails. The outer area of anti-gravitation is dominated by the dissipative forces of the attraction to the dark energy, whereas in the inner area the gravitation forces of the attraction to the matter are predominant. The fewer radial anti-gravitons N in the outer area of the shell, the stronger centrifugal forces. Gravitation and centrifugal forces have the same mechanism. However, centrifugal forces have a specific feature: they increase with the decrease in the absolute value of the potential, whereas the gravitational forces increase with the growth of the absolute value of gravitational potential. This feature qualifies them as the dissipative forces. If we push a ball along the surface of the total potential φ in *Fig. 11b*, the ball will roll down towards the central matter with a decreasing deceleration. The spatial shell in *Fig. 11a* is filled with the repulsion anti-gravitons which, in the absence of trial particles, support the primary cell in the steady equilibrium likewise the twisted spiral springs. If we launch a

'spacecraft' with the escape velocity $v_g = \sqrt{2}v_{0g}$ from the graviton surface, it will reach dark energy by moving along these spiral trajectories.

Fig. 12a schematically shows these spiral trajectories for the fixed diametrical section. From the physical standpoint, fixing (or selecting) the diametrical section is equivalent to specifying the virtual axis of the angular momentum perpendicular to the plane of the selected trajectory (the law of angular momentum conservation). Actually, when we pass from the phase diagrams (*Fig. 6b*) to the spatial coordinates in the primary gravity cell (*Fig. 12a*), the trajectories are entangled (there are no particles, no rotation, and no preferred direction); it is impossible to distinguish between the right-handed and left-handed spirals. These properties of the trajectory's configuration can manifest themselves at the subsequent stages of the evolution and in the macroscopic model (*Fig. 12b*). The entropy spirals 'rest' upon the gravitational matter at the centre and support the 'firmament' of the dark energy (they prevent the cell and the Universe from collapsing). *Fig. 12b* schematically shows how the repulsion field of anti-gravitons forms the central area of the manifestation of gravity for the galactic cluster in the Universe.

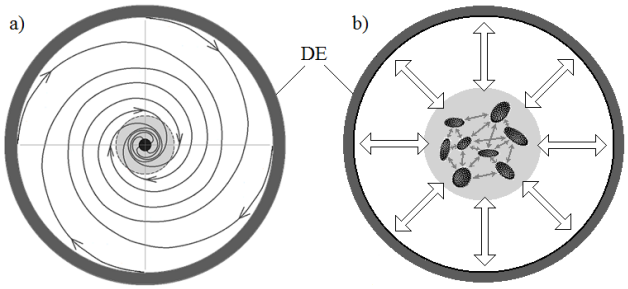

Fig. 12. (a) The scheme of the encoded twisted spiral trajectories of the spatial structure of the graviton's primary cell along the arbitrary fixed diametric cross-section; (b) schematic representation of the repulsion mechanism for the cluster of galaxies in the Universe. The shaded zone indicates the domain of gravity manifestation.

The dark shading in the figures marks the areas of manifestation of gravity and gravitational warping of space. Each two galaxies repel each other; however, the repulsive forces between them are counteracted by the external repulsion forces from the other galaxies and from the dissipative forces of the shell acting on all the galaxies. The complicated system of the repulsion forces between the galaxies and the emerging resultant forces between the pairs of the galaxies lead to their distancing from each other or, conversely, to their attraction and fusion. It all depends on the geometry of their mutual arrangement and on the density distribution of the ordinary matter in the galaxies (with the allowance for their rotation and the presence of an active central nucleus). The same principle of repulsion also acts within the galaxies. The usual Newtonian matter in the galaxy occupies the space, displacing anti-gravitons and reducing the repulsion forces (increasing the attraction). The role of the main 'support' for the entropy spirals is played by the star clusters in the galactic nuclei where the number of the anti-gravitons is minimal and therefore gravity is maximal. The larger mass and density of the ordinary matter in the galaxy correspond to the smaller dissipative forces of repulsion between the material particles and to the stronger dissipative forces of the external pressure. Unlike the nucleus of the graviton cell in *Fig. 12a*, the big stars at the final stages of their evolution and the central nucleus of the galaxy can contract. When they fail to withstand the resultant dissipative forces of external pressure, the Newtonian matter begins to contract and eventually forms non-radiating compact objects (white dwarfs, neutron stars), whereas black holes can be formed within the gravitational (Schwarzschild) radius [22].

The properties of 'elasticity' and twisting are frozen in the 'tissue' of the primary cell of dark matter; they are encoded and only manifest themselves after the introduction of 'a trial particle' into the cell (or formation of the known particles of the standard model). This means that they will show up during the evolution and formation of the contemporary Universe. The physical source of these encoded fields is probabilistic and entropy. The spiral trajectories reflect the virtual behaviour of anti-gravitons during the inflation of the bubble and growth of matter, preserving their geometry and encoding them in the residual field of space at equilibrium in the form of the field lines. While a 'virtual particle' freely moves along the spiral line, it does not feel the impact of the forces. When it is deflected from its natural trajectory or when it encounters an obstacle, it detects the force field. The reliability of these trajectories and their physical meaning will be clear when compared with the observed properties of the gravitational fields in the Universe.

Dissipative forces in the cell are the forces of inflation or the forces of attraction of 'trial particles' to the dark energy. In the modern understanding, these are centrifugal forces which, however, do not appear on the Earth but in the far space, on the huge astronomical distances, far from the cosmic objects (planets, stars, star clusters, galaxies, and metagalaxies). In classical mechanics it is believed that the gravity forces and centrifugal force have the different nature: the former is associated with mass and the latter, with the rotation velocity. According to our results, the modeling of the gravitational field should include both the law of universal gravitation and centrifugal forces. Here are some opinions of the scientists about the discussed questions. The field which is purely produced by gravitational attraction is central symmetric and unstable. If the gravitational interaction were the only interaction in the physical world, the Universe would have then been irreversibly collapsed into the mathematical singularity [32]. The force fields of gravitation and centrifugal forces have been studied quite well in physics; however, the physical source of their

origin on the scales of the Universe is still unclear. Many scientists tried to explain the gravity forces and find a certain model producing the same effect without taking into account the velocities (i.e., centrifugal forces). I cannot describe the problems associated with centrifugal forces better than E. Rogers; therefore, let us refer to his book *Physics for the Inquiring Minds* [36]. In the section entitled 'Centrifugal force and a remedy for headaches for the engineer', he cites four opinions about the centrifugal force and recommends only using the centripetal forces. Centrifugal forces, just as gravitation, permeate the entire space. Concerning this point, Eddington wrote [11]: 'We must consider the field produced by the interaction of both fields, gravitational and centrifugal, because only him can be seen; from this resulting field, none of our observers is not entirely free.' Even after almost a century it is perhaps the best formulation. I admire the ability of great scientists to deeply and truly understand the essence of being. In contrast to Newton, Einstein proposed the mechanism of gravity. Einstein supposed that in the absence of matter and energy the space is flat. In accordance with the Einstein's principle of equivalence [13], the gravitational fields can be considered as the local changes in the geometry of space-time around the mass. By expanding this principle on the case of rotation of 'trial bodies' far from the mass of gravitons, we can state that the centrifugal forces manifest themselves on these bodies as the forces of attraction directed in the opposite direction (towards dark energy). This means that absolute twisted warping of space-time exists in the Universe far from the masses. The dissipative force field in space of the Universe is warped in such a way as if the Universe were rotating as a whole, forming the centrifugal forces (*Fig. 12a*). In terms of the example of a 'spacecraft' discussed above, this means that after escaping the graviton attraction zone it will not move along a straight line as in Einstein's theory (according to which the field is not warped in the absence of matter) but along a curve. Modeling the warped space-time is equivalent to taking into account the centrifugal forces. According to our entropy model, the space formed in the dark energy is warped; otherwise it could not have been formed. Here, rotation of the mass forming the gravitational fields is not necessary.

RESULTS AND DISCUSSION

The discussion also includes the results of the paper [3]. The nature has created a certain stable primary structure like an 'egg cell' from the primary 'material' of dark energy. This structure includes the inner nucleus (the graviton) and the spatial shell filled with anti-gravitons ('holes' without matter). We may draw an analogy between the 'egg cell' and the elementary earthquake in *Fig. 4* of the [3]. The 'egg cell' contains the encoded basic properties of the future Universe, the force of attraction (gravity), and repulsive forces (centrifugal forces of dissipation). Let us also consider several other properties that are encoded in the cell. The graviton nucleus is the minimal quantum of energy equal to 10^{-43} J, and the field of the shell has a quantum action of 10^{-86} J s (the field is quantised by the parameter h_g). Graviton as a particle can only be formed at the centre of the cell where the probability is equal to 1. A materialised graviton can be considered as an ultramicroscopic 'localized object', compared to the virtual (wandering) quantum graviton. Within the cell there is no possibility (no preferential orientation) of determining the direction (left- or right-handed) of twisting of spiral trajectories. This means that the ultramicroscopic cell combines (encodes) the concepts of waves and particles, micro- and macro-notions, the concept of the trajectories and their entanglement, elements of quantum and classical mechanics. In our model, by analogy with the Earth, the dark energy has immense reserves. In accordance with formula (21), dark energy has a average internal energy $< \varepsilon >= 2\varepsilon_g$, i.e. possesses a certain high level of constant 'pressure'. It is quite possible that after the fluctuation it is just this pressure that will supply energy to the bubble, inflate it, and maintain constant inflow of virtual gravitons into the system, just as a gas does the work when moving a piston (increasing the volume of a cylinder) at constant pressure and temperature. The role of a conditional valve for supplying energy to the bubble in *Fig. 8a* is played by the spherical envelope of volume V, because, due to the uncertainty principle, the energy of a virtual graviton is smeared over the entire surface of the sphere. The volume of the inflating bubble can be written out in the following form:

$$V = V_g N^3 \quad (V_g = \tfrac{4}{3}\pi r_{gr}^3) \tag{32},$$

where V_g and r_{gr} are the volume and radius of a virtual graviton. For the equilibrium bubble, $V_{N_0} = V_g N_0^3$.We can draw an analogy with the Mendeleev-Clapeyron equation for the mass m of ideal gas [25]. If at a certain given pressure p_0 and temperature T_0 one mole of gas occupies a volume $V_m = (1/p_0)RT_0$ (R is the gas constant), then mass m of gas under the same conditions will occupy volume $V = (m/M)V_m$, where M (the mass of one mole) is the measure of amount of a substance. In other words, N^3 will have the meaning of m/M (dimensionless amount of a substance), and V_g the meaning of the volume mole of ideal gas V_m. Formally, Eq.(32) can be considered as the equation of state, if we assume that dark energy is an ideal gas in the absolute state, with the lowest (unit) values of temperature and pressure ($T_0 = 1$, $p_0 = 1$).
The cell is a tiniest structural basis of relic dark matter DM_U^r , described in Section 3. The modeling of the formation of a steady cell of a graviton at the lowest level can explain the stability of our Universe as the highest level of the known physical world. The radius of the observable Universe is $R_{M_U} \approx 10^{28}$ cm, the weight is $M_U \approx 10^{56}$ g, and the average density of matter is $\rho U \approx 10^{29}$ g/cm^3 [27]. In *Fig. 12b* these values correspond to the central shaded area of the gravity manifestation (the sphere with radius R_M). In this area, as was noted above, the contraction of matter and the emergence of black holes is possible. These processes can be described by the model of entropy forces of gravitation and entropy funnels presented in Sections 2.3 and 3.2. The gravitational radius of the Universe, calculated by the formula of the escape $R_g = 2GM_U/c^2$ is about $R_g \approx 1.5 \times 10^{28}$ cm. The distance L_U to the dark energy in the Universe will be approximately $L_U \approx 10^{30}$ cm, whereas the distance to the zero-force surface (31) will be $R_{cU} \approx 10^{29}$ cm. Such a huge dark

spherical shell around the observable Universe is a dissipative shell filled with relic anti-gravitons. In our theory, when we speak about dark energy, we describe the 'infinity', blackness in the sky. The primary force lines of spacetime are produced there, where there is no motion and no Newtonian matter yet. We sort of move to the infinitely distant worlds, into the regions where the sources of being are created. It becomes clear now that what is referred to as the observed dark energy DE_U^o with antigravity properties in the modern cosmology is the dissipative energy E_f^r of the spherical shall around the relic dark matter DM_U^r ($DE_U^o \equiv E_f^r$) in our model. That is, the nucleus of the primary cell (graviton) is the structural framework of the observed dark matter DM_U^{ob} whereas the dissipative shall of anti-gravitons is the basis of the observed dark energy DE_U^{ob} in astronomy. Hence, the notion of a dark energy in our approach should be distinguished from the term of the observed dark energy in cosmology.

In fact, dissipative force or force of inflation (29) is a new, poorly studied type of interaction which enabled the emergence and maintains the stability of our Universe during its expansion. The questions concerning the dynamics of the expansion and the future of the Universe are beyond the scope of the present article, but our model excludes the transition of the Universe into the stage of contraction and collapse. The new type of interaction is anti-gravitation. Up to the present, four types of fundamental interactions have been known to exist in the nature. They include gravitational, electromagnetic, weak, and strong interactions; however, the particles responsible for gravitational interaction have not been detected to date. In our model, gravitational interaction is related to the mass of a graviton, or, more precisely, with the mass of the volume of the nucleus. However, since the nucleus of the egg cell is incompressible, the mass of a graviton is the constant density of the nucleus. The anti-gravitational interaction is connected with dark energy and manifests itself in its vicinity in the deep space. The both types of the interactions are carried by anti-gravitons (material 'holes'). The anti-gravitational interaction is not stationary but evolves with time in accordance with the analogue of the second law of thermodynamics. The forces of gravitational attraction are the apparent forces that emerge as the resulting effect of the repulsive forces and manifest themselves in the presence of the Newtonian matter.

When formulating the theory of relativity, Einstein relied on the concepts of space, material point, matter, and light source [12, 13]. Dark energy and dark matter, which can exist in our model in the non-relativistic space-time without light, had not been known at that time. The light in our model is understood as all the types of the electromagnetic radiation (radio, infrared, visible, and ultraviolet waves). The theory of DE_U and DM_U description is non-relativistic, so STR, GTR and quantum electrodynamics do not operate here. Therefore, the well-known formula $E = mc^2$ could not work in such an unimaginable world of 'darkness' at that time. Following our chronology, we can say that in Einstein's formula was initially the energy (E), then time, space and non-relativistic gravitational matter (M_g) appeared; and it was not until this that they created the conditions for the emergence of the ordinary Newtonian matter (m) and light (c). In other words, Einstein, just as Newton, did not provide a physical explanation of the origin of gravity, matter, and space. Einstein combined the Newton's laws of motion with Minkowski's idea about the 'world line' and thus accounted for the effects exerted by gravity on all the material objects. Based on the non-Euclidean geometry, he attributed gravity to the curvature of space-time. According to Einstein's theory, in the absence of matter (or at a large distance from it), the space is flat. Since Einstein replaced the physical cause of the attraction by geometry, he could not predict the warping of space far from the masses due to the new type of interaction. However, Einstein's genius led him to replace the effects described by the dissipative energy in our approach by metric Λ (cosmological constant) which provided the gravitational force of repulsion. This was the way he explained the equilibrium in the stationary static Universe [13]. When it was found that the Universe is not stationary but expanding in space and time [41], Einstein admitted that Λ-term was his biggest mistake. The new data of observational cosmology, which led to the discovery of space vacuum and anti-gravitation [34, 35], have revived the interest to Λ-term. However, the lack of standard theory for the origin of antigravity and space vacuum has resulted in the fact that even now, diverse concepts of the origin of the Universe exist and the debate about the physical impact of the Λ-term on the accelerating expansion of the Universe are ongoing [23]. The fundamental problems arising on the ultramicroscopic distances associated with singularity have been already touched upon in Section 4.2. An attempt to overcome these difficulties in the modern theory of strings by moving from the large-scale consideration to the microscopic scales and simultaneously preserving the traditional physical concepts leads to the enormous complication of the primary structure of the Universe [17, 18, 20]. The theory of evolution of the Universe based on the strings expands the theoretical framework of physics and introduces some revolutionary elements that are absent in the particle theory. The string theory still remains the best theoretical model suitable for solving the appearing problems; at the same time, this theory is difficult to be proven. In this article we have only qualitatively described the structure of a force field of the dissipative shell and provided the physical interpretation of the gravitation law in terms of anti-gravitons which are capable to provide 'curvature' and 'twisting' of these fields. Approaching the boundary with the dark energy, they flatten and, thus, provide the equilibrium on the outer surface of the shell, whereas closer to the centre, to the matter, they become radials stretched and provide the equilibrium on the surface of the inner nucleus so that the surface density of the number of anti-gravitons remains the same. Here we have described the very first stage of the evolution when the action in dark energy increases from $h_g \approx 10^{-86}$ J s to $h_{dm} \approx 10^{-67}$ J s. Simultaneously, the density of the structural cell decreases from 10^{93} g/cm^3 to $10^{71} g/cm^3$. Modeling the electromagnetic radiation will start from $h_p \approx 10^{-34}$ J s, i.e. when the metrics will enlarge up to Planck constant. For comparison, we recall that modeling of the SSs begins from $h_s = 1$ J s. The successive consideration of the stages of evolution of the Universe from small quanta of action to big ones can eliminate the problem of initial integrating the GTR, STR, Newton's gravity, and other three (electromagnetic, strong and weak) fundamental interactions of nature within the quantum-mechanical formalism. The stages of the Universe evolution which are described by these theories could have

been formed from dark energy and dark matter at the subsequent stages of the spatial-temporal and energy scaling, whereas in the modern Universe they are interlaced with each other.

The fundamental conclusions from our model are the following. Gravitation and anti-gravitation is not a field of wave propagation but the property of the space itself. They are formed together with the formation of space-time-matter, and exist wherever there is space in our understanding. Origination space is always proceeds of the formation of matter. Only in dissipative space can be formed and exist matter and radiation. Light originates from matter (of gravitons) at the later stage of the evolution and propagates with finite velocity in the already existing space. It can be destroyed in the structural formations of ordinary matter (for example, in black holes) and can be absorbed in the deep space at the boundary with dark energy. Light cannot exist and propagate in dark energy (in the absence of dissipative shell of anti-gravitons). The absolute nature of gravitation and anti-gravitation makes the existence of space and matter beyond the visible limits (or, to put it another way, beyond our perception of time, beyond our consciousness) quite reliable. This removes the contradiction between gravitation and the finite speed of information propagation in the Universe. The properties of gravitation are encoded in the dissipative space between dark energy and relic dark matter. The action of Newton's law of gravitation manifests itself at the later stage of the evolution of dark matter, when structures of 'coarse-grained' matter are formed in it from the known particles. Nevertheless, the physical nature of gravity as a resultant effect of repulsive forces does not change. The hierarchical multi-scale coarse-grained formations of matter are immersed into the medium of anti-gravitons and are in dynamical equilibrium with dark energy. As multi-scale coarse-grained formations at a certain stage of evolution of the Universe, we can consider, for example, the cloud of electrons of an atom whereas the nucleus consisting of protons and neutrons can be considered as the 'grains'. When the balance of anti-gravitons between 'grains' is violated, gravity instantly manifests itself. The number of anti-gravitons is a measure of the distance between the masses of the objects. The fewer anti-gravitons correspond to the weaker repulsion and stronger attraction. Masses are immersed into the potential well and are in the dynamic equilibrium with the environment. The greater mass corresponds to the deeper potential well. Matter and warped space are fused and cannot 'suddenly' change independently from each other. This means that if the masses and the distances between them 'suddenly' change; the bodies would then instantly feel the change in the mutual gravitational attraction. However, the changes conveyed by the light information (which propagates in the medium of anti-gravitons) will come from one body to another with a delay. This means that the physical meaning of gravitational attraction which is implied in our model can remove the contradictions between Newton's theory (instantaneous nature of gravity forces) and Einstein's GTR (finite speed of light). The metrical properties of dark matter differ from those of dark energy by the fact that space is warped. Dark energy exists in the Euclidean space, whereas dark matter exists in the non-Euclidean homogeneous space. The concept of the velocity of gravity propagation does not exist in the 'empty' dark matter (without the particles of the standard model) due to the absence of interactions. The emergence and propagation of gravitational waves in the dark matter is related to the formation and interaction of the coarse-grained material structures composed of Newtonian matter. However, the carrier of gravitational waves (the propagation medium) is the dissipative field of anti-gravitons which is able to deform in accordance with the matter created in it. The black hole cannot be formed in the non-relativistic cells of dark matter (within the Planck scale), because the radius of the cell nucleus r_{gr} is always larger than the gravitational radius, $r_{gr} > r_g = 2GM_g/c^2$. The nucleus of the cell of dark matter is a 'frozen' substance that does not emit any signals and only interacts with the environment through its static potential (30). In other words, the formation of dark matter from dark energy takes place within the 'event horizon'. This formation is similar to the reverse black hole which enlarges and leads to the radiation and formation of the Newtonian matter. The relic cells of dark matter cannot be destroyed and transformed into dark energy by black holes because it would require a higher density of the nucleus than the density of graviton, which is impossible.

CONCLUSIONS

The result of the paper [3] enabled us to model the geological environment and evolution of SS in terms of dark matter and dark energy and to transfer this unusual scheme to the modeling of the evolution of the Universe starting from the definition of dark energy. According to the suggested model, at the beginning there was only a dark energy where time and space were fused and frozen. The concepts of entropy and energy were equivalent. The mathematical space was without curvature and singularity. The notions of velocity and acceleration did not exist because there were no known particles. Nevertheless, the dark energy contained certain encoded quantum properties that are determined by the scale units of energy, time and velocity. These properties are associated with the family of three paired portions of energy of gravitons and anti-gravitons governed by the constant G. At any time instant, the virtual graviton-anti-graviton pairs were only born to disappear at the next moment of time. The fluctuation in the dark energy has led to the formation of the virtual graviton particles and to the emergence of the flow of negative energy of anti-gravitons into the open system. Space-time and matter are created by the entropy from dark energy. The latter is the initial form of energy (when other forms have not exited) in which the potential and kinetic forms of energy has been encoded but indistinguishable. It is supposed that this is an inexhaustible (immense) energy source which creates other forms of energy in the emerging universes during the inflation process. The emergence of time asymmetry is equivalent to the emergence of entropy and separation of the informational entropy from it as a result of degeneration. The asymmetry produces in advance a virtual potential gravitational field corresponding to the future matter. When the entropy flow reaches the minimum, the system as a result of self-organization and inflation creates matter and dissipative structure (space) compensating the deficiency

of entropy. The ordering caused by to the energy-matter phase transition leads to the formation of an elementary gravitational cell with the dissipative shall and nucleus (graviton). The dissipative shell is the space formed by anti-gravitons; it can be said that this is empty space (without the conventional particles) with the encoded specific properties. In accordance with the energy conservation law, the total dissipative and potential fields of gravitation and anti-gravitation, which fill the space between dark energy and gravitational matter, are in the state of non-stationary dynamic equilibrium. The force field in this cell has an entropy elasticity in the form of twisted spirals 'resting' on the incompressible nucleus of gravitons at the centre. If there were no elastic field and a nucleus, the empty space of a cell would collapse. In contrast to gravitons (indivisible beads of primary matter), anti-gravitons can change their form (elongate, flatten), keeping volume equal to a graviton. The model of an elementary gravitational cell provides the physical explanation of the law of gravitation and anti-gravitation. The dissipative force (that is the anti-gravitation) is, in fact, a new type of interaction in the Nature, which did not exist in physics. Out of the four fundamental interactions known in physics (gravitational, electromagnetic, strong, and weak), only gravitational interaction was initially formed in the dark matter. The new type of the interaction is truly the 'Queen' of all the interactions because the entire Universe rests on it and is obliged to her by origin. As the mass of the incompressible nucleus increases, the gravitational cell (nucleus and shell) proportionally expands from 10^{-43} to 10^{-33} cm forming the primary structure of the relic dark matter during the pre-Planck epoch. Black holes cannot exist in dark energy and in relic dark matter. The Pre-Planck epoch in our approach is the non-relativistic period before the BB, which covers the time interval from 10^{-43} to 10^{-33} s that is necessary for the formation of the primary structures in the dark energy. This epoch is described by the combination of the elements of quantum and classical mechanics. It is shown that under the formation of the primary structure in the form of a gravitational cell it can contain the encoded properties that are necessary for the emergence and evolution of the observed Universe. The physical constants of the speed of light c and Planck constant h_p had not been formed in dark matter yet because of the absence of photons and other known particles of the fundamental interactions. The questions of how they appeared at the subsequent stages of the evolution and whether the relic primary structures were able to lead to the creation of a cloud of inhomogeneous relic dark matter and to the BB will be addressed in the future publications. We note that the concepts of dark energy in our model and in the modern cosmology are not identical. By analogy with SSs, we assume that the dark energy in our model is the absolute environment in which also the other (parallel and independent of ours) universes can be born under certain conditions (just as many SSs existing in parallel in the different seismotectonic situations). In our model, the relic dark matter and dissipative energy space are the prototypes of the observed dark matter and dark energy in cosmology. Thus, the relic dark matter of gravitons and the dissipative energy space are the primary 'scene' where the future actions such as the formation of the Universe from the standard model of particles could take place. In fact, the suggested model developed based on seismic formalism provides the new possibilities for removing the problems the modern theories try to solve in order to eliminate the notion of the initial singularity. In contrast to the modern approaches, for achieving this objective our method does not require complication and abstraction of the origin of the Universe but, instead, it relies on the maximal simplification and on the use of the physically substantiated and experimentally established newly formed entities in the Universe (dark matter and dark energy). Figuratively speaking, when rewinding the 'record' of the space evolution back in time, one should gradually simplify the theory by rejecting the accumulated data that have become scientifically worthless to that time. When drawing an analogy for the schematic modeling of the stages of the evolution, we can, for example, equate the cosmological time interval of 1 Ga and the interval of seismicity of 1 year. In this case, on the scales of the Earth (assuming that the evolution of the seismicity required ~ 4 Ga), we can incredibly expand the spatiotemporal limits of the modeling in cosmology (by a factor of $\sim 10^8$). Since the existing physical theories and methods relying on the data of the observable cosmology are limited by the speed of light, the seismology can provide a modest but uncommon contribution in modeling our and other parallel universes, separated by dark energy.

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