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Deterministic Irreversibility and The Matter Structure

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Abstract

The role of existence of the deterministic irreversibility mechanism in development of evolution physics is studied. The short explanation of physical essence of this mechanism is offered. Based on this mechanism, is proved, that the base element of matter should be an open non-equilibrium dynamic system (ONDS). The principles of the emergence, existence and development of the ONDS hierarchical structure are considered. The questions about hierarchy of the matter and existence of stationary states ONDS are studied. The question, how external constraints determine of the evolution of ONDS, is analyzed. Equations that determine the development of ONDS are submitted.

Keywords

irreversibility, classical mechanics, evolution, entropy, symmetry.

Subject Classification: Mathematics Subject Classification

Type (Method/Approach): Survey

Introduction

The most important problems of physics include the following questions: how to build an evolutionary picture of the world, how complexity arises from simplicity, how matter arises, whether there is a formalism that allows building a "theory of everything" [1-3]. Solutions of these and other issues related to the problem of building an evolutionary picture of the world are based on the ideas of the cognoscibility of the world, its uniqueness, completeness and consistency of physical laws.

For a long time, the main obstacle on the way to building an evolutionary picture of the world was connected with the fact that modern fundamental physics describes the existing world, but does not describe the processes of origin, evolution, and transformation of the world [4-6]. This is connected with that that evolution in nature is irreversible, but until recently, mechanism of irreversibility constructed strictly within fundamental laws of physics was not known. Therefore, it was impossible to construct a physical evolutionary picture of the world.

In the process of solution of the irreversibility problem, its probabilistic mechanism was proposed first [5, 6]. This mechanism was obtained basing on the Lyapunov Exponents for Small Random Perturbations of Hamiltonian Systems [6, 7]. However, since this mechanism of irreversibility was probabilistic, it did not answer the key questions: how order followed from chaos, how to construct an evolutionary picture of the world [8].

The recently found the *deterministic mechanism of irreversibility* (DMI) substantially has eliminated these limitations, having opened possibility to build the evolutionary picture of the world within the limits of fundamental laws of physics [7]. DMI was found based on the mechanics of *a structured particle* (SP). In it, in

the motion equation, instead of a body model in the form of a *material point* (MP), the SP model was used, where SP is equilibrium system consisting from a sufficiently large number of potentially interacting MPs.

The key conclusion that follows from the existence of DMI is the conclusion about the infinite divisibility of matter. It follows from the impossibility of the emergence of a structureless matter element within the framework of the laws of classical mechanics [7, 9]. From this and from the fact of the existence of DMI is follows, that the basic element of matter should be an *open non-equilibrium dynamic system* (ONDS) [7, 11]. In this paper, we will develop this statement. For this purpose the nature of DMI and how it existence helped to expand of the classical mechanics is described briefly. The principles of the emergence, existence and development of ONDS is submitted. How external restrictions define development of ONDS is analyzed. Possible universal laws of behavior of the ONDS are discussed. The conditions under which the ONDS can be in stationary states is determined. The ways of creation of physics of evolution based on ONDS is considered.

THE NATURE OF DMI

On the simplest physical experience, we will explain the key ideas and concepts that were used in substantiating the DMI. It will help us to prove, why ONDS is a basis element of matter.

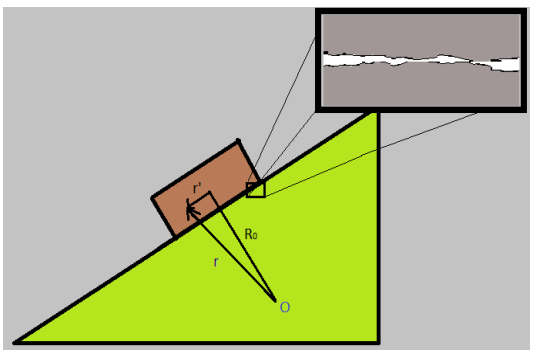
On fig. 1 is shown a body sliding off an inclined hard rough surface under the action of gravity. At the initial moment, the body's energy is equal to its potential energy. In the process of body's sliding, part of its energy is transformed into the kinetic energy of a body. This energy is defined by speed of motion of its *center of mass* (CM). Other part is go on the heating of a body due to the work of the friction's forces because of irreversible transformation of the motion energy into internal energy (hereinafter, the absorption of the energy of a body's motion by the external environment is not taken into account because this does not fundamentally change anything). As a result, the motion energy in each subsequent point of body position is less, than the spent potential energy, on the value of change of internal energy. I.e. the body is similar to "a black hole" which breaks symmetry of time due to absorbing the motion energy. The motion of a body is determined by the empirical equation in which friction force is proportional to the velocity [12, 13]:

$$M\dot{V}_0 = -F_0 - \mu V\,, \tag{1}$$

Here M -is a mass of a body, V_0 - is a velocity of the CM of the body, F_0 - is a force acted on CM (here and after the forces are expressed through the gradient of the potential energy), μ -is empirical friction coefficient.

Eq. (1) is empirically takes into account of the friction without describing the process of irreversible transformation of the energy of body's motion into its heat.

In according with the molecular-kinetic theory of a heat, the equation that will describe such a process should depend on micro-variables, which describe micro-processes inside the body, and macro-variables, which describe the dynamics of the body as a whole. Now let us show how to obtain such an equation.



Let us take the SP consisting from N potentially interacting MP as the model of the body (see fig. 1). The vector r_i determines the position one of MPs in laboratory system of coordinates with the beginning in point O. This vector can be written as a sum of vectors: $r_i = R_0 + \tilde{r}_i$, where vector R_0 directed into the CM of the system, and vector $\tilde{r}_i$ is determine the position of MP relative to CM. Therefore MP's velocity vector can be written as: $v_i = V_0 + \tilde{v}_i$. Let us call the coordinate system of such a representation the dual coordinate system.

Fig. 1. *Dissipative dynamics of the body.*

Each MP participates in two types of motion: in the motion of the CM system and in the motion relative to the CM. Therefore in the dual coordinate system, the energy of SP divide on the motion energy and internal energy. This means that one part of the work of gravity field goes on the motion of a body, and another part goes on the increasing of the motion energy of its elements in relative to CM. I.e., the work of external forces disintegrates on the work moving the SP and the work that goes on its heating. The variables that determine the internal energy are called microvariables, and the variables that determine of the system's motion energy are called macro-variables. Thus, the system's energy can be is written down in the dual coordinate system through micro - and macro-variables. Let us show that micro- and macro-variables are independent [9].

Let us here and below the MPs mass is equal to $m=1$. Then the mass of the system is $M_N = Nm = N$. Take into account, that: $N\sum_{i=1}^{N} v_i^2 = (\sum_{i=1}^{N} v_i)^2 + \sum_{i=1}^{N-1}\sum_{j=i+1}^{N} v_{ij}^2$, where $i, j = 1,2,3...N$, i, j - is a number of MP, $v_i - v_j = v_{ij} = \dot{r}_{ij}$ - is a relative velocity of two MP. Let us carry out the substitution in this equality: $V_o \equiv V_N = (\sum_{i=1}^{N} v_i)/N$ -is velocity of CM. Then we obtain: $T_N = [M_N V_N^2 + m/N\sum_{i=1}^{N-1}\sum_{j=i+1}^{N} v_{ij}^2]/2$ (a).

Now we carry out the substitution: $v_i = V_N + \tilde{v}_i$, where $\tilde{v}_i$ - is a velocity of MP in relative of the CM. Because $\sum_{i=1}^{N} \tilde{v}_i = 0$, then we will have: $T_N = M_N V_N^2/2 + \sum_{i=1}^{N} m\tilde{v}_i^2/2$ (b).

Thus, the sum of the energies of the MP relative motions and the energy determined by the sum of the kinetic energies of the MP motion relative to the CM are coincide. The kinetic energy of the system, represented in the micro - and macro variables divide into the sum of the kinetic energies of the MP relative to the CM and the kinetic energy of the CM motion of the system. Similarly, in the dual coordinate system, we represent the potential energy of the system.

Potential component of the motion energy is equal to total energy of all MP in the field of external forces. The potential component of SP internal energy consists from the energies of interactions MP and the contribution, which arises due to heterogeneity of an external field.

According to (a, b), micro - and macro variables are independent and belong to two different symmetry groups. This indicates on the presence of two invariants corresponding to the two symmetry groups determining the motion of bodies. A body's motion energy is connected with one group of symmetry, and internal energy is connected with the second. That is, the motion of the structured body is determined by its internal symmetry and the symmetry of the space in which it moves. This statement is called the *principle of dual symmetry* (PDS) [7, 8].

Thus, the energy of the system in micro- and macro-variables, has the form:

$$E_N = E_N^{tr} + E_N^{ins} = const \tag{2}$$

where $E_N^{ins} = T_N^{ins} + U_N^{ins}$ is SP internal energy; $T_N^{ins} = \sum_{i=1}^{N} m\tilde{v}_i^2/2$ is a kinetics part of SP internal energy. $E_N^{tr} = T_N^{tr} + U_N^{tr}$ is the SP motion energy, T_N^{tr} is a kinetic part of the motion energy, U_N^{tr} - is a potential part of the motion energy in the external field of forces.

In accordance with eq. (2), the law of the energy is: *the sum of the motion energy and the internal energy of the system are constant along its path.* The SP motion equation, which follow from eq. (2) can be written so:

$$M_N \dot{V}_N = -F_N^0 - \mu V_N, \tag{3}$$

where $F_N^0 = \sum_{i=1}^N F_i^0$; F_i^0 -is external force acted on i -th MP; F_{ij} is interacted force i and j MP; $F_{ij}^0 = F_i^0 - F_j^0$; $\dot{E}_N^{\text{int}} = \sum_{i=1}^{N-1}\sum_{j=i+1}^{N} v_{ij}(m\dot{v}_{ij} + F_{ij}^0 + NF_{ij})$; $\mu = \dot{E}_N^{\text{int}} / (V_N^{max})^2$.

The eq. (3) is fundamentally different from eq. (1). Indeed, the friction coefficient has acquired an analytical form in eq. (3). The first term in the right hand side defines the external force acted on the CM. The second term is bisymmetrical term, as it depends on both micro - and macro-variables that belong to different groups of symmetry of the body and space. This nonlinear term is defines the transformation of the motion energy into internal energy. Thus, the eq.(3) take into account that the work of external forces is divided into the work of moving the system, and the work changing its internal energy.

In according with eq. (3), the time's symmetry violation is associated with the violation of the law of conservation of the SP motion energy due to the non-linear transformation of the motion energy of SP into internal energy. Such a transformation occurs only when the SP moves in a non-homogeneous field of forces. Nonlinearities that cause the processes of evolution and are responsible for breaking the symmetry of time are called *evolutionary nonlinearities*. These nonlinearities are absent within the framework of the canonical formalisms of classical mechanics, since the formalisms are obtained for holonomic systems under the condition of the potentiality of collective forces [7, 12, 13].

The eq. (3) was obtained in DSK by summation of the energy changes for each MP. These changes are due to nonlinear interactions of MPs with the field of external forces. However, the classical motion equation for the system was obtained by summation of the motion equations for each MP [13]. There are no terms in this motion equation, which describe the conversion of the energy of the SP motion into its internal energy, since the sum of the changes in the MP pulses relative to CM is zero. *Thus, the violation of time symmetry is due to the existence of inhomogeneity's of the field of external forces and existence of the internal structure of the body.*

For the SP in equilibrium the total vector of momentum for all MP in arbitrarily selected from SP of the sufficiently large subsystem, is zero. It is can serve as a definition of the equilibrium of the system. If the gradients of the external forces are small, then the disturbance of the SP's equilibrium can be neglected. In this case, the internal energy only increase. It is a nature of irreversibility [7].

The infinite divisibility of matter which follows from the eq. (3), can be explained as follows [7]. The appearance of attractors is possible only for dissipative systems [10]. But according to eq. (3) the dissipation is possible only for systems. That is, all natural objects, if they was appeared in the result of evolution, are systems [10]. The mechanics of a structured body are based on the principle of dualism of symmetry. The essence of this principle is that the external influence on the body changes not only body's motion energy, but also the internal energy of its elements.

It is folowing from the eq. (3), if $\mu = 0$, then the change of the internal energy equal to zero, and we obtain Newton's motion equation: $M_N \dot{V}_N = -F_N^0$. However, if we have due to the friction force: $V_N = -\dot{E}_N^{\text{int}} / F_N^0$, then the acceleration equal to zero. In this case all work of external forces go on increase of the internal energy and we have the Aristotle equation [23]: $V_N F_N^0 + \dot{E}_N^{\text{int}} = 0$.

Thus, the expansion of the classical mechanics to dissipative mechanics arises by replacement of the model body from MP on the model of the body in the form of a SP, i.e. in the results of the transition: MP $\Longrightarrow$ SP (c). As a result we obtain the dissipative the system's motion equation (3), which followes from the non-dissipative motion equation for its elements in the analytical way.

THE MECHANICS OF NON-EQUILIBRIUM SYSTEMS

The accounting of the body's structure led to the taking into account of dissipative processes in the body's dynamics. But we can ask, what the next, third step of the approaching of the body's model to the reality will give. The third step in approach of the matter model to reality is NS: *MP⇒SP⇒NS (d)*. In nature, all bodies are *non-equilibrium systems* (NS). In the approximation of local thermodynamic equilibrium, NS can be submitted as a set of interacting SPs.

At present, the main task of NS research is the description of relaxation processes of NS to the equilibrium. This is the tasks of the kinetics physics [20, 21]. Such a description is based on probabilistic laws [21]. These approaches use the method of statistical ensembles. The basis of these methods is the representation of the system by a set of equilibrium subsystems. This means that the study of NS can be performed using the motion equation for SP.

Let us begin the analysis of the NS from the equation of the energy. Let us NS consist from K SP. Each SP consists from N of MP with masses is equals to 1. So the mass of NS is equal to: $M_{NS} = NKm$. The equation of NS energy in an external field of forces has the form [7]:

$$E_{NS} = \{M_{NS}V_{NS}^2 / 2 + U_{NS}^0\} + \{\sum_{p=1}^{K} M_{SP}V_{SP}^2 / 2 + \sum_{q=1}^{K-1}\sum_{p=1+q}^{K} U_{p,q}\} + \sum_{p=1}^{K}\{\sum_{l=1}^{N} m\, v_{pl}^2 / 2 + U_p\} \quad (4)$$

Here $M_{SP} = mN$ is a mass of each SP; $U_P = \sum_{i_p=1}^{N-1}\sum_{j_p=i_p+1}^{N} U_{i_p,j_p}(r_{i_p,j_p})$ is internal potential energy for p-th SP, due to interaction of each MP from this SP; r_{i_p,j_p} is a distance between i_p-th and j_p-the MP from p-th SP; V_{SP_p} is a velocity of p-th SP; $U_{p,q} = \sum_{l_{q_j}=1}^{N-1}\sum_{l_{P_i}=1+l_{q_j}}^{N} U_{p_i,q_j}(r_{p_i,q_j})$ is a potential energy of MP interaction from different p-th and q-th SP; r_{p_i,q_j} is a distance between p_i-th and p_j - th MP from p-th and q - th SP. That is, the third term in eq. (4) determines the potential energy of the interactions of all SP.

The first term in eq. (4) is the energy of the NS motion. It consists of the kinetic energy of the NS motion and its potential energy in the field of external forces. The second term is the sum of the energies of the relative motions of all the SPs and their interaction energies. The third term in eq. (4) determines the kinetic and potential energy of the MP in SPs. The fourth term, U_{NS}^0, determines the potential energy of the NS in the field of external forces.

The work of external forces go on the motion of the NS in space and on the change of its internal energy. The internal energy is composed of the kinetic energies of the SP motion relative to the CM of the NS, their potential energy of interactions, and from their internal energies. The internal energy of the SP is composed of the kinetic energies of the motion of the MP relative to the CM of the corresponding SP and from the potential energies of MP interactions.

The hierarchy of independent variables that determine the dynamics of the NS corresponds to the PDS at each hierarchical level. If the NS is closed, then NS go to equilibration, because energy of relative motions SP is transformed to their internal energy. It follows that existence of stationary NS can be due to the flows of external energy that compensate the dissipation of the energies of the relative motions of the SP [7].

The PDS takes place both for SP mechanics and for thermodynamics. This makes it possible to introduce the mechanical principle of energy in the SP mechanics [7]: $dU^{sp} = \delta E^{\text{int}} + \delta E^{tr}$. The similarity of the thermodynamic and mechanical principles of energy allowed to introduce into the mechanics of SP a deterministic concept of entropy, defining it as $\delta E^{\text{int}} / E^{\text{int}}$. This entropy was called D-entropy - S^d [7]. For

SPs D-entropy the second law of thermodynamics is valid: $dS^d / dt \geq 0$. For a closed NS with the constant volume, the change in D-entropy is defined by quantity of energy of relative motions SP, which is transferred in their internal energy. The physical meaning of D-entropy for SP lies in the fact that the energy of an orderly motion is transformed to the energy of a chaotic motion of MP. The change in D-entropy for NS is determined by the sum of the increments in D-entropy of each SP. In according with the eq. (3) the D-entropy is determine the dissipative forces. D-entropy is applicable not only for SP, but also for systems with a small number of MPs. The change in D-entropy of a small system may be negative [7].

In general, SP mechanics allows one to substantiate not only the laws of thermodynamics within the limits of the fundamental laws of physics, but also the laws of the nonequilibrium thermodynamics, which describe nonequilibrium processes in continuous media [11].

The NS studies as usually are reduced to the study of the equilibration processes. It is making by using various empirical modifications of the kinetic equations [20]. These equations are based on the canonical formalisms of classical mechanics and statistical laws. In turn, the formalisms are based on Newton's motion equation for MP and constructed under condition that hypothesis of holonomiciy of the restrictions has a place [12, 13]. It has led to a loss of the DMI in formalisms [15-17]. Therefore, the irreversibility of the kinetic equations is introduced by adding empirical terms, which must be obtained from experience each time for a specific task. However, if instead of Newton's motion equation we take of the SP motion equation, then we can obtain extended Lagrange, Hamilton, Liouville equations, as well as Poisson brackets [14].

By making standard procedure for obtaining the Lagrange equation [12, 13], but the using of the motion equations for SP, instead of motion equation for MP, we will obtain [7]:

$$\sum_{i=1}^{N}\left(\frac{d}{dt}\frac{\partial L_p}{\partial v_i^p}-\frac{\partial L_p}{\partial r_i^p}-\Phi_i^p\right)=0. \tag{5}$$

Here Φ_i^p - is a non-potential part of forces, acted on i-th MP from *p*-th SP.

Accounting of the dissipative forces based on SP mechanics also modifies the principle of least action. In the general case for SP in a non-uniform field of forces, it has the form [15]:

$$\int_{t_1}^{t_2}\delta w dt=\delta\int_{t_1}^{t_2}L_p dt=\delta A^d\neq 0 \tag{6}$$

Here A^d is a term, determined by the non-linear transformation of the systems motion energy into the internal energy.

When A^d =0 we have a principle of least action for a structureless body. *The nature of this principle of least action is that the hard bodies move in the direction of the total potential external force*. However, for a system in an inhomogeneous field of forces, when the internal energy changes, $A^d\neq 0$, due to existence of the non-potential forces, and due to dissipation of the motion energy. In the simple case for the system MP A^d is a bilinear function, which in according with the eqs. (3, 5) has a form [15]:

$$A^d=\delta\int\sum_{p=1}^{R}\left(\int\sum_{i=1}^{N}\Phi_i^p dr_i^p\right)dt \tag{7}.$$

The eq. (6) is an extended or *modified principle of least action*, which can be used for studies of the NS evolution taking into account dissipative processes. The canonical equations of the formalism of classical mechanics are a special case of the eq. (6).

Thus, the mechanics of SP is arise from the mechanics of MP. But from the mechanics of SP arises the mechanics of NS. If the mechanics of the SP allowed explaining DMI, then the NS mechanics allows explaining the laws of thermodynamics in the framework of the fundamental laws of physics [11]. In this case, the next question arises: what the transition from the body model in the form of NS to the model of body in the form of ONDS can give.

ONDS IS A BASIC ELEMENT OF THE MATTER

The emergence and existence of all objects in the nature is possible only due to dissipative processes in the result of bodies' interaction and exchange of energy, momentum and by the matter. From it follows, that for describing evolutionary processes, an account of the openness of bodies is necessary [18]. In addition, it is necessary to take into account that the dissipative processes arise only if the bodies, as well as their structural elements, are NS [10]. From the mechanics of the SP also follows of the infinite divisibility of matter and the impossibility of the existence of bodies with zero internal energy. That is, if all bodies have all these properties and they were arisen in a resultant of evolution, then they are ONDS. Thus, the ONDS is a basic element from which all the bodies are built. Therefore, in order to cover all the qualitative properties of the dynamics of matter, the chain (d) should be extended by at least one more step to cover all the qualitative properties of the dynamics of matter: $MP \Rightarrow SP \Rightarrow NS \Rightarrow ONDS$ (e). *ONDS is a set of interacting NS.* Anyway, ONDS can be used to explain the processes of self-organization of the systems, the emergence of order from chaos [9]. Ideas about the use of ONDS as a basic element of matter were expressed in [6, 9, and 10].

If the mechanics for models of bodies in the form of MP, SP, NS are connected in a reductionism manner, then the mechanics of the ONDS should follow in a similar way from the mechanics of the NS. In this case, the following conditions for connections of the bodies' dynamics' laws with dynamics' laws of their elements are exists [16]:

1. The laws of the upper hierarchical level follow from the laws of the lower hierarchical level.

2. The model of the body should include the variables included the upper and lower levels of the description (macro description and micro description).

3. Macro-variables that determine the behavior of the upper hierarchical level of the ONDS should be built from micro-variables that determine the behavior of the ONDS of the lower hierarchical level. In some cases, the macro description should be reduced to a micro description. Thus, the macro description is "embedded" in the micro description.

4. The forces are determined by the nature of the transformation of the corresponding energies.

5. The evolution of ONDS at each hierarchical level is determined based on the PDS.

6. To describe the processes of emergence and evolution of the upper hierarchical level, it is necessary to take into account the structure of the lower hierarchical level.

7. At the transition to the upper hierarchical level, the system of fundamental concepts and definitions of parameters for the lower hierarchical level is supplemented by fundamental concepts and parameters reflecting the new properties of the upper hierarchical level.

These principles follow from the nature of the formation of system properties based on the properties their elements. They correspond to the principles of a causal relationship, determinism and uniqueness of a picture of the world. The commonality of the proposed principles allows to use them for construction of the evolution of the physical picture of the world. Let us show how these principles can be used in practice.

According to the PDS, in order to describe the dynamics of an ONDS, its energy should be divided into the motion energy and internal energy. In turn, the internal energy should be divided into the sum of the energies of the relative motions of ONDS constituent parts and their internal energies. Thus, ONDS consist of structural elements nested in each other, which also represent ONDS and so on to infinity. At the same time, the change of the internal energy of each hierarchical stage of the ONDS is determined by the D-entropy. That is, the work of external forces for each hierarchical stage is divided into work on the motion of the corresponding hierarchical level of ONDS and work on the increment of its D-entropy. This means that hierarchy of energy is built according to the hierarchy of matter. Thus, the energy, which changes D-entropy at the upper hierarchical level, consists of the increments of the motion energies and them internal energies for the constituent parts of the lower hierarchical level. This can be called as the *principle of relativity of energy and D-entropy for all steps of the hierarchical ladder of matter*. For the case when it is possible to confine oneself to the hierarchy of the ONDS consisting from the N steps, this principle can be written as [11]:

$$\Delta E_0 = \Delta E_1^{mot} + \Delta E_1^{\text{int}}; \Delta E_1 = \Delta E_2^{mot} + \Delta E_2^{\text{int}}; \ldots \Delta E_{N-1} = \Delta E_N^{mot} + \Delta E_N^{\text{int}}; \Delta E_N^{\text{int}} = \Delta E_N^{mot} \quad (8a)$$

$$\Delta S_1^d = \Delta E_1^{\text{int}} / E_1^{\text{int}}; \Delta S_2^d = \Delta E_2^{\text{int}} / E_2^{\text{int}}; \ldots \Delta S_{N-1}^d = \Delta E_{N-1}^{\text{int}} / E_{N-1}^{\text{int}}; \Delta S_N^d = 0 \quad (8b)$$

Here (8a, 8b) are chains of increments of energies and D-entropies of the ONDS. The energies of the respective structures consist of the sum of their energies of movement and internal energies, denoted by symbols "*mot*" and "*int*", respectively. If we consistently express S_N^d in the equation (8b) all terms through the motion energy of the corresponding hierarchical level, we obtain the equation:

$$\Delta S_N^d = \sum_{i=1}^{N} \Delta E_i^{mot} / \sum_{i=1}^{R} E_i^{mot}, i = 1, 2, 3 \ldots N \quad (9)$$

That is, at each hierarchical level, D-entropy is determined by changes of the motion energies of all elements of the system, as well as by their total motion energy. Since the matter at each step of the hierarchical ladder is ONDS, the eq. (9) and the corresponding motion equations determines the general evolutionary characteristics of matter.

The recurrent energy equation for ONDS from the N-th levels is: $E_N = E_N\{E_{N-1}\{E_{N-2} \ldots \{E_0\}\}\}, N \to \infty$. The ONDS motion equation can be obtained from its energy equation. These equations depend on the hierarchy of micro - and macro variables, which are determined by the conditions (8a, 8b) for each level of ONDS.

The hierarchy of variables corresponds to the hierarchy of collective forces that determine the motion of the ONDS subsystems and the hierarchy of changes their internal energies. In nature, each hierarchical level of ONDS has its own forces. There are hierarchy molecular, atomic, nuclear and other forces. Fundamental forces considerably differ from each other. Due to this, a stable hierarchy of matter structures are exists: molecules, atoms, nuclei, nucleons, etc. The greater the interaction forces, the deeper the hierarchical level of ONDS.

When external forces are much less than all internal forces, the ONDS motion equation as a rule can be reduced to the Newton motion equation. However, in certain cases, for example, in a case of bifurcation, such reduction is impossible [9]. The chief essence of bifurcation consists in that that in special points of phase space there is a change of topology and the system's dynamics. Therefore, a symmetry violation can be connected with the concept of bifurcation, which leads to the change of the character of system's dynamics.

To solve bifurcation problems, as a rule, the concept of probability is used. However, the infinite divisibility of matter gives us the analytical way to solve this task [16]. It is connected with the fact that when taking into account the hierarchy of matter, as well as taking into account fractality, the bifurcation point acquires structure as a result of the transition from the macro - to the micro description. That is, at the micro-

description level, the bifurcation point is a certain area of the micro-variable space. Thus, the feature at the bifurcation point can be excluded in a result of the transition to a micro-description from the macro-description.

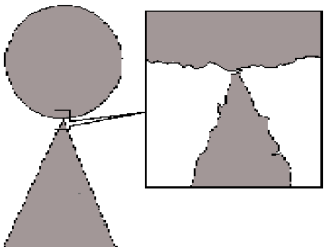


Fig. 2. – *To explanation of the mechanism of bifurcation*

Indeed, let us consider a disk at the apex of a triangle (see Fig. 2). If we accept that the disk and the vertex itself are hierarchical systems, then the problem is transformed to solving of the disk's motion equation, as a system of microparticles with the corresponding microstructure of the apex of a triangle. As a result, due to transition to the micro-description, the bifurcation disappears, but a violation of time symmetry takes place. Thus, the infinite divisibility of matter indicates the need and possibility of describing the processes of evolution in particular points of the macro-equations by transition to a micro-description. This tells us about determinism of the processes of evolution on all level of description of the matter. A similar situation, as in the case of bifurcation occurs in the case of the "butterfly" effect. The use of the above principles of the organization of matter may also be useful for studying of turbulence [9]. Besides, it has also important methodological value. From this example follows, that the area of use of the mathematical description of processes can be not so wide, as it often think. That is, the final word concerning justice of any serious conclusions, which follow from the mathematical description of a problem, belongs to physics.

In according with that that the matter is infinitely divisible and have the evolution's nature, the internal energy for all levels cannot be equal to zero, including the down level ONDS. Therefore we can take an oscillator as the zero level ONDS. It has of the internal and motion energies. Such an oscillator may be a quantum of light [2]. If the quantum particles is ONDS, then their wave–particle duality is inherent properties. This dualism can be explained by the fact that its motion is determined by the internal and motion energies. With the passage of a potential barrier, which have a place, for example, in a case of double-slit experiment for the electrons flow, the trajectories will be determined by the phase of interaction with the barrier [17]. Perhaps this can explain the diffraction pattern on the double-slit screen of the electron flow [15].

Thus, only the use of a body model in the form of ONDS allows us to take into account all the mentioned above principles for analyzing of the evolution processes of the matter within the frame of the physics fundamental laws and for evolution physics construction. But the proof of the possibility of using ONDS as a basic element of matter is faced with the need to prove that ONDS can be in a stationary state. Below we submit to it the necessary arguments.

EXTERNAL CONSTRAINTS AND STATIONARITY ONDS

We will call system stationary if the macro-parameters characterizing this system can be considered as constants during characteristic time of internal processes[16]. This means that topological form of ONDS, which can be a collection of attractors, does not change [9]. Obviously, the stationary states can be created with the help of appropriate types of external constraints, which are able to provide the condition of balance of incoming and outgoing flows of matter, energy, and entropy on all hierarchical levels.

An example of stationary ONDS is Benard convective cells in the liquid [9]. It arises and exists in the presence of heat flux caused by the temperature difference on the boundaries of the system [9]. This heat flux supported by a temperature gradient compensates dissipative processes in cells. That is, external constraints should provide a flow that compensates production of entropy at all hierarchical steps of the ONDS. The higher on the hierarchical ladder of matter is ONDS, the more complexity must be of the external constraints that ensure its stationary state. Therefore, if stationary state for a Benard's convective cells is ensured only by the constancy of the heat flow, then in order to maintain stationary state in more complex ONDS, for example in a living cell, a balanced flow consists from a various types of substances and energy [22].

The states of ONDS at each hierarchical step of ladder are determined by the PDS. The laws defining evolution should be interconnected for all hierarchical levels of the system. Since all systems exist only due to interactions with the outside world, such a interconnection of laws should penetrates the entire Universe. External restrictions which support ONDS in a steady state and allow them to evolve in accordance with their inherent processes can be called *harmonious constraints*.

In according with the laws of classical mechanics of the D-entropy and internal energy of SP only increase. Therefore, the stationary state of ONDS only within the laws of mechanics is impossible. This contradiction is eliminated, for example, because of Planck's thermal radiation [19]. As a result, the entropy produced inside will be "carried away" with the radiation energy.

The stationary states of ONDS is determined by the balance of energy, entropy and matter. The equations defining this balance it is possible to write down so:

$$\dot{E}^{in} + \dot{E}^{out} = 0, \tag{10}$$

$$\dot{S}^{in} + \dot{S}^{pr} - \dot{S}^{out} = 0 \tag{11}$$

$$\dot{\mathrm{P}}^{in} + \dot{\mathrm{P}}^{out} = 0. \tag{12}$$

Here $E^{in} = \sum_{i=1}^{R} e_i^{in}(\lambda_i^e, r, P^{in}, t), E^{out} = \sum_{i=1}^{R} e_i^{out}(\lambda_i^e, r, P^{out}, t), E^{out}$ - are interning and coming out energies for ONDS respectively; R - is a number of hierarchical levels; $S^{pr} = \sum_{i=1}^{R} s_i^{pr}(\lambda_i^s, r, t)$,

$S^{in} = \sum_{i=1}^{R} s_i^{in}(\lambda_i^s, r, P^{in}, E^{in}, t), S^{out} = \sum_{i=1}^{R} s_i^{out}(\lambda_i^s, r, P^{out}, E^{out}, t), S^{in}, S^{pr}, S^{out}$ -are incoming entropy, entropy production inside the system, leaving entropy; $\mathrm{P}^{in} = \sum_{i=1}^{R} \rho_i^{in}(\lambda_i^\rho, r, t)$, $\mathrm{P}^{out} = \sum_{i=1}^{R} \rho_i^{out}(\lambda_i^\rho, r, t)$ - are substances which entering and leaving of the system; $\lambda_i^e, \lambda_i^s, \lambda_i^\rho$ - are characteristic parameters for energy, entropy and substance at the given hierarchical level.

Eq. (10) determines the total balance of the incoming and outgoing energy. Eq. (11) determines the entropy that arrives, is produced, and taken out with a substance or with a flux of radiation. Eq. (12) determines the balance of the substance entering and leaving the ONDS. The incoming substance corresponds to the substance in form of the lower hierarchical level of ONDS.

In the simplest case, it is possible to consider all hierarchical levels ONDS as independent. Then the energy, entropy and substance depend on characteristic parameter for the given hierarchical level: $\lambda_i^e, \lambda_i^s, \lambda_i^\rho$ and the flows of energy, entropy and matter are the sum of the components corresponding to each i-th hierarchical level of the system. In this case the system of eqs. (8-10) takes the form:

$$\dot{e}_i^{in} + \dot{e}_i^{out} = 0 \tag{10a}$$

$$\dot{s}_i^{in} + \dot{s}_i^{pr} - \dot{s}_i^{out} = 0 \tag{11a}$$

$$\dot{\rho}_i^{in} + \dot{\rho}_i^{out} = 0 \tag{12a}$$

It is obvious that for stationarity of complicated ONDS, a balance of flows of all types of matter, energies and entropies is needed. From the standpoint of determinism, all elements of the Universe are interconnected. Therefore, stationary states are possible only with the balance of all energy flows and entropy for all objects of the Universe.

Due to the infinitely divisibility of the matter the number of equations for ONDS is infinite. However, the number of equations in agreement with the task can be truncated. For example, such truncated can be used if our task is to determine the necessary conditions for the stationarity of ONDS without detailed consideration of complex evolutionary processes. Such truncated is also possible for identification of the principles and laws in accordance with which ONDS can arise, evolve and exist.

The conditions for the existence of ONDS become much more complicated when we go up on the hierarchy lader. If for simple ONDS the stationary state can exists due to the flow of energy passing through it, then for the stationary state of the living organisms more complex constraints are required. For example for inverse relationship between the heterogeneous environment and the body, self-reproduction of the systems, mental processes and other complex adaptation properties of highly organized systems very complex constraints are required [22]. However, all these properties, no matter how they are complicated, must follow from the simpler properties of lower-level systems, since simpler systems are the basic elements of complex systems.

Now let's summarize what gives a chain: $MP \Rightarrow SP \Rightarrow NS \Rightarrow ONDS$ for approach to reality. The body model in the form of MP allowed us to find the laws of the movement corresponding to the Galileo's of the principle of relativity. Time for dynamics of MP is reversible. When replacing the model of the body in the form of MP on the SP, we find that taking into account the structure of the body leads to taking into account the irreversibility of the dynamics. The irreversibility is connected with the nonlinear transformation of the motion energy into internal energy. But also in this case, dynamics of each MP from SP, is defined by laws of Newton. In a homogeneous field of forces, the SP behaves like MPs. For the model of the body in the form of NS, irreversibility exists even in a homogeneous space without movement of the NS. It is associated with dissipative processes in NS. That is, the NS model allows us to take into account the fact that the irreversibility of bodies also takes place in the absence of their movement. ONDS allows taking into account all the noted principles of the organization of matter, because it take into account openness, non-equilibriums, and dynamics.

Conclusion

The conclusion that ONDS is the basic element of matter follows from the condition of infinite divisibility of matter. But infinite divisibility of matter follows from existence of DMI.

A characteristic feature of the hierarchical ladder of matter is that the preceding livel of the ONDS serves as a structural element of the subsequent livel. The existence of a connection between the hierarchical steps of an ONDS follows from the deterministic relationship between the laws of dynamics of elements and the evolution laws of the system.

The emergence and evolution of systems that constitute a hierarchy of ONDS are determined by external constraints, based on the PDS, D-entropy and energy. For all hierarchical steps of ONDS, there are a recurrent forms of the energies and D-entropies. Entropy on the upper hierarchical level ONDS is connected with the energy of the lower level hierarchy of the ONDS.

The stationary state of ONDS is achieved due to external constraints. These constraints provide the balance of energy, substance, and entropy flows on all steps of the hierarchical lader of ONDS.

Thus, in according with the DMI existence, we can make the next conclusions:

- for the description of processes of evolution of matter its model should be set in the form of ONDS;

- the ONDS dynamics on all steps of hierarchical ladder of the matter is defined by the principle of dualism of symmetry;

- the "time arrow" ONDS is caused by the possibility of transition of the motion energy of ONDS into the energy of the chaotic motion their elements;

-there are universal principles of transition between adjacent hierarchical steps of lader of matter according to which properties of systems follow in a deterministic way from properties of their elements, though have qualitative differences;

- transition between hierarchical steps of matter is defined by fundamental laws of physics that submits to the principle of causality and can be described within evolutionary physics.

Let us one remark. All conclusions drawn here concerning ONDS are obtained provided that laws of mechanics are fair for any structures of matter within their applicability for the description of its dynamics. Indeed, the complete description of evolution of all variety of structures of matter will require using other fundamental laws of physics, but their use cannot contradict laws of classical mechanics.

The main conclusion consists in that that only use of model of a body in the form of ONDS gives the chance to describe processes of evolution of matter within fundamental laws of physics. In general, the results obtained indicate on the possibility and prospects of building an evolutionary, self-consistent physical picture of the world within the framework of the fundamental laws of physics based on the ONDS, as a basic element of the matter.

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