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Physics of evolution and unity of physics

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Abstract. The article considers the question of the possibility of constructing classical mechanics and empirical branches of physics, such as thermodynamics, statistical physics and kinetics on a general theoretical basis. The principles of constructing mechanics, thermodynamics, statistical physics, and kinetics are briefly given. It is shown how the construction of the above sections of physics on a unified basis became possible, relying on the mechanics of a structured body. The essence of this mechanics is that, unlike Newton's mechanics, built for a body model in the form of a material point, this mechanics is built based on a body model in the form of a structured body. Moreover, the structured body is specified in the form of an equilibrium system of potentially interacting material points. It is shown how the equation of motion of a structured body is derived. The peculiarity of this equation is that it takes into account the transformation of the energy of motion of a structured body into internal energy when it moves in an inhomogeneous field of forces. This makes it possible to describe dissipative processes within the framework of the mechanics of a structured body without invoking statistical laws. Examples are given of how the empirical principles of the phenomenological branches of physics directly follow from the fundamental laws of physics.

1. Introduction

The variety of objects of nature and matter, as well as their forms and physical properties, led to the emergence of existing branches of physics, using, as a rule, various methods of studying natural phenomena. However, such a division of physics, although it simplified its development, encountered great difficulties dictated by the unity of nature and the interconnection of evolutionary processes. For example, the evolution of the Universe is inextricably linked with the movement of its objects in inhomogeneous self-consistent gravitational and other fields of forces created by the objects themselves. On the other hand, the movements of objects are interdependent with their internal states. Therefore, a separate description of the dynamics of objects in the Universe and changes in their internal states faces many problems. For example, the internal state of its objects changes not only due to the exchange of streams of various types of radiation, but also due to their relative movements. It is possible to overcome these problems if only to have a unified physics on a common fundamental basis. However, before creating a unified physics, first need to eliminate the existing contradictions between the branches of physics. For example, according to classical mechanics, the motion of bodies is reversible, and according to the second law of thermodynamics, their motion is irreversible. Moreover, it is necessary to eliminate these contradictions within the framework of the fundamental laws of physics without involving any side probabilistic hypotheses.



The question of building a unified physics has existed for a relatively long time, and attempts have been made repeatedly to build a unified physical theory. We only note that in this regard, "Unified theory", "Unified field theory", "Unified geometrized field theory", "Final theory", "Quantum gravity", "Theory of everything" and others were proposed [1,2]. As a rule, they discussed the question of building a unified fundamental basis of physics, but at the same time, the unified physics itself has not yet been proposed. This is primarily because the process of creating physics on a single basis faces great difficulties. To a certain extent, this is due, as already noted, to the contradictions of the branches of physics, as well as to the fact that theories of the branches of physics were built within the framework of various methods and on the basis of the knowledge possessed by the physicists of the corresponding time.

It is obvious that the construction of a unified physics can be carried out in stages. For example, starting with the unification of classical mechanics, thermodynamics, statistical physics and kinetics. Indeed, the methods for describing matter within the framework of these branches of physics encompass practically all known macroprocesses in nature. In accordance with these methods, two qualitatively different approaches to the study of matter can be distinguished in physics. The first is the approach implemented in classical mechanics. It relies on the fundamental laws of physics. It describes the motion of bodies in space on the basis of the formalisms of classical mechanics. In this case, the processes of changes in the internal states of bodies that arise during their movement are not considered. The second approach is based on phenomenological and statistical methods for studying the internal states of systems. In this case, the movement of bodies is not taken into account. The unification of these branches of physics can be accomplished by finding a way to unite these two approaches.

Relatively recently, the approach was proposed that makes it possible to describe the processes of evolution of matter within the framework of the laws of physics. It relies on the so-called full description of processes in matter, that is, on a joint description of both the dynamics of bodies and the description of their internal microprocesses. This approach is based on the mechanics of structured bodies (SB), where SB are potentially interacting material points (MPs). The mechanics of SB is built by a macro-description of the motion of SB on the basis of a micro-description of the motion of its MPs. This construction is realized using the principle of symmetry dualism (PSD). PSD claims that the dynamics of bodies is determined both by the symmetries of space and by their own symmetries. According to the PSD, the dynamics of SB is determined by the law of conservation of the total energy of the body, which is the sum of the internal energy and the energy of body movement. Such a description is called "full description", since in it the macroparameters that determine the dynamics of bodies are expressed in terms of microparameters that determine the dynamics of their elements. In the general case, SB mechanics allows one to study open nonequilibrium dynamical systems (ONDS) given by a statistical ensemble. Moreover, the statistical ensemble is a set of interacting equilibrium SBs moving relative to each other. Unlike Newtonian mechanics for MPs, this mechanics is based on the equation of motion for a body in the form of a system, which made it possible to take into account the relationship between the dynamics of the system and changes in its internal state [3]. The full description opened up the possibility of constructing "physics of evolution", that is, physics describing the processes of origin, development and decay of systems within the framework of the fundamental laws of physics.

Here we will consider the issue of building a general theoretical basis for classical mechanics and empirical branches, such as thermodynamics, statistical physics and kinetics. Let us show that the creation of such a basis is possible within the framework of the "full description" [3]. For this, we first present and compare the principles of constructing classical mechanics, thermodynamics, statistical physics and kinetics, as well as the principles of constructing the physics of evolution based on the mechanics of SBs. Then consider how the empirical principles of the phenomenological branches of physics directly follow from the laws of physics. This will allow combining the two approaches to the study of matter mentioned above on a single basis of the fundamental laws of physics.

2. Principle of constructing classical mechanics

The foundations of modern classical mechanics were laid by Newton. The key for it is Newton's equation of motion for MP:

$$m\ddot{\vec{r}} = -\frac{\partial U}{\partial \vec{r}} \quad (1)$$

Here m is the mass of MP, \vec{v} is the velocity, U is the potential energy, and \vec{r} is the MP's coordinates.

Equation (1) follows from the law of conservation of energy of motion, which is associated with the symmetry of space. Moreover, the energy of motion is the sum of the kinetic and potential energies of the MP. Equation (1) is reversible. The motion of the MP is uniquely determined by the points of the phase space (PS).

In classical mechanics, systems of MPs are described by canonical formalisms obtained under the condition of holonomic connections and potentiality of collective forces [4-6]. These formalisms make it possible to obtain the equations of motion for systems of MPs in full accordance with Newton's laws. Within the framework of the formalisms of mechanics, the Liouville equation is derived for the distribution function of SB in the phase space:

$$\frac{df}{dt} = \frac{\partial f}{\partial t} + \sum_{i=1}^N (\dot{R}_i \frac{\partial f}{\partial R_i} + P_i \frac{\partial f}{\partial P_i}) = 0 \quad (2)$$

According to equation (2), due to the law of conservation of energy, the volume of the phase space is conserved, and the dynamics of Hamiltonian systems is reversible.

Newtonian mechanics solved many problems, including the problems of planetary motion. Moreover, the laws of conservation of energy, the principle of least formed the basis of all physics. Hamilton's formalism formed the basis for the Schrödinger equation of quantum mechanics. Therefore, quantum mechanics is also reversible.

As it turned out, the structurelessness of the body model in equation (1), the requirements for the fulfillment of the conditions for the holonomicity of the bonds and the potentiality of collective forces, used in the derivation of the formalisms of classical mechanics, excluded the possibility of taking into account the work of non-potential external forces, such as friction. But it is these forces that are responsible for the change in the internal energy of the SB when it moves in the inhomogeneous fields of external forces and for irreversibility [3]. As a result, classical mechanics contradicts thermodynamics, which is based on the second law. As a consequence, the formalisms of classical mechanics are applicable only for special cases of motion of systems, when changes in their internal energy or states can be neglected.

3. Principle of constructing of thermodynamics

Thermodynamics is a phenomenological science. Its task is to determine the regular connections between such characteristics of bodies as pressure, density, temperature, etc. The fundamentals of thermodynamics are the laws of conservation of energy and the concept of work carried out on a SB by external forces. At the same time, the difference between the concept of work in thermodynamics and the concept of work in classical mechanics is that work in thermodynamics is aimed at changing the internal state of the system, and not at its movement in space. That is, only such processes are considered, determined by external influences on the SB, in which its center of mass is at rest.

From experience, it follows that the work of external forces performed on a stationary SB is determined by the following equation [7, 8]:

$$dE = dQ - PdY, \quad (3)$$

Here P is the pressure, Y is the volume and Q is a heat.

Equation (3) is the principle of energy in thermodynamics. It uses parameters that are absent in classical mechanics, which characterize the collective states of the elements of the body, such as pressure, heat, temperature and entropy. According to equation (3), the work of forces carried out on the

SB falls into two parts. The work, determined by the first term on the right side of equation (3), goes to heating the SB. For systems close to equilibrium, this term (3) can be represented as follows:

$$dQ = TdS \quad (4)$$

Here T is the temperature, S is the entropy.

According to the second law of thermodynamics, the following inequality takes place:

$$dS/dt \geq 0 \quad (5)$$

Condition (5) indicates the irreversibility of thermodynamic processes, which contradicts classical mechanics.

The second term in equation (3) determines the work that goes to change the volume of SB.

4. Principles of statistical physics

Footnotes should be avoided whenever possible. If required they should be used only for brief notes that do not fit conveniently into the text.

In connection with the difficulties of describing the irreversible dynamics of SB within the framework of reversible classical mechanics, the statistical physics arose. It is based on the proposed and developed by Boltzmann molecular-kinetic theory of the structure of bodies and the corresponding model of statistical ensemble [8]. The main task of the statistical physics is to substantiate thermodynamics within the framework of the molecular kinetic model of the body.

The principles of constructing statistical physics are based on the concept of probability for the states of systems, the distribution function of the elements of the system, the relationship between the concepts of energy and entropy. In statistical physics, the study and description of the internal states of bodies and their changes is based on the laws of statistics. In this case, the question of the motion of systems, which is fundamental for classical mechanics, is excluded from consideration. That is, within the framework of the statistical physics, the internal states of bodies at rest are studied. The statistical method for studying the states of bodies, based on their model in the form of the statistical ensemble, made it possible to substantiate the laws of thermodynamics and explain the nature of the establishment of equilibrium within the framework of statistical laws.

The huge number of elements that make up the bodies served as the basis for the key statement for the statistical physics that it is impossible to use the equations of motion of classical mechanics to describe the behavior and properties of macroscopic bodies. It was this statement that determined the statistical approaches to the development of statistical physics methods. They turned out to be convenient for describing the states of quantum and classical systems based on a distribution function that depends on generalized coordinates and momenta. This made it possible to construct statistical methods based on the representation of the body as a system of structureless elements. In this case, as a rule, the condition is used that the bodies are closed and motionless. To overcome the difficulties associated with the constancy of the energy of a closed body, another key hypothesis is used. It consists in the fact that any closed system can be specified in the form of a statistical ensemble, represented by open equilibrium SBs moving relative to each other. All parameters, including energy, fluctuate in the SB. Moreover, for statistical ensemble close to equilibrium, each SB reflects the ensemble property. This extremely important property of SB equilibrium makes it possible to use the ergodicity condition, according to which averaging over the phase space is equivalent to averaging over time.

Statistical regularities in the statistical physics are introduced using the condition according to which for a closed SB close to equilibrium with time tends $T \rightarrow \infty$ to introduce the concept of the probability that the SB is in a given sufficiently small volume of the phase space.

$$\omega = \lim_{T \rightarrow \infty} \Delta t / T \quad (6)$$

Obviously, equation (6) is valid either for an equilibrium SB, or for an open nonequilibrium dynamical system (ONDS), the stationarity of which is supported by external constraints.

In accordance with equation (6), the concept of probability density ρ is introduced:

$$\omega = \rho(p, q) \Delta p \Delta q \quad (7)$$

Hence, under the accepted restrictions on the system, the following condition holds:

$$\int \rho(p, q) \Delta p \Delta q = 1 \quad (8)$$

Hence, the average value of any function of coordinates and impulses is equal to:

$$\bar{f} = \int f(p, q) \rho(p, q) \Delta p \Delta q \quad (9)$$

According to equation (9), the averaging over the phase space is equal to the averaging over time, which corresponds to the condition of the ergodicity of the process. Within the framework of the accepted restrictions for the statistical ensemble, the Liouville equation is fulfilled:

$$\frac{d\rho}{dt} = \sum_{i=1}^s \left(\frac{\partial \rho}{\partial q_i} \dot{q}_i + \frac{\partial \rho}{\partial p_i} \dot{p}_i \right) = 0 \quad (10)$$

Here p_i, q_i are momenta and coordinates of one of the subsystems of the statistical ensemble, ρ is the probability density.

The Liouville equation is valid for Hamiltonian systems, which is true near the equilibrium state of the system. From equation (10) it follows that the volume of the phase space is conserved along the phase trajectory. Conservation of the probability density along the phase trajectory means that ρ is a function of the integrals of motion. That is, the additive integrals of motion completely determine the statistical properties of the system. Hence follows the main microcanonical distribution of the system for the statistical physics:

$$\rho = \text{const} \delta(E - E_0) \quad (11)$$

Emphasize that the probability density " ρ " is used for classical systems. For quantum systems, it is necessary to take into account the discreteness of microstates. Therefore, instead of a phase space $\Delta p \Delta q$ element, a quantity $\Delta \Gamma_\alpha$ is introduced for them, which determines the number of quantum states in the α -th SB. In this case, the following condition is valid for the probability $d\omega$ of finding the system in any state $d\Gamma$:

$$d\omega = \text{const} \delta(E - E_0) \prod_{\alpha} d\Gamma_{\alpha} \quad (12)$$

This expression takes place when the SBs interactions can be neglected for the statistical ensemble. For the number of microstates in an infinitely small range of SB energies $d\Gamma$, the following condition is fulfilled: $d\Gamma h \prod_{\alpha} d\Gamma_{\alpha}$. The relationship between the number of quantum states $\Delta \Gamma$ and the classical volume of the phase space is defined as follows:

$$\Delta \Gamma = \frac{\Delta p \Delta q}{(2\pi\hbar)^s} \quad (13)$$

Hence, based on Boltzmann's idea of the probability of filling quantum states through the *statistical weight* $\Delta \Gamma$, the concept of entropy is introduced:

$$S = \ln \Delta \Gamma \quad (14)$$

From (14), the probability $d\omega$ of the state of the system is determined:

$$d\omega = \text{const} \delta(E - E_0) e^{S(E)} \prod_{\alpha} dE_{\alpha} \quad (15)$$

Under the accepted conditions, the entropy of the system is expressed in terms of its energy. It is important to note that this is true only for statistical ensemble near equilibrium, when SBs interactions

can be neglected. It is these conditions that lead to the possibility of constructing thermodynamics within the framework of the statistical physics.

The statistical foundation of thermodynamics is based on the Gibbs distribution or canonical distribution. It determines the probability for a SB to have energy determined by its microstates:

$$\omega_n = A \exp\left(-\frac{E_n}{T}\right) \quad (16)$$

Here the temperature "T" appears as a derivative of the entropy of the system with respect to energy (it is believed that the temperatures of the statistical ensemble and all SBs are the same).

The statistical theory of statistical physics fluctuations is based on the Gaussian distribution for fluctuations of physical quantities. It is constructed from the considerations that entropy is uniquely determined not only by energy, but also by some quantity x that uniquely depends on energy. In this case, for x can be written

$$\omega(x) = \text{Const} e^{S(x)} \quad (17)$$

Taking into account that the entropy near equilibrium is maximum, it can be represented as follows: $S(x) = S(0) - \left(\frac{\beta}{2}\right)x^2$. Hence, we have:

$$\omega(x)dx = \sqrt{\frac{\beta}{2\pi}} \exp\left[-\left(\frac{\beta}{2}\right)x^2\right] dx \quad (18)$$

This is the Gaussian distribution for the quantity x . The Gaussian distribution for the deviation of a number of thermodynamic quantities from their mean values is built on the basis of entropy $S(x_1, \dots, x_n)$ as a function of these quantities. The expansion of entropy, up to the second order of smallness, has the form:

$$S - S_0 = -\frac{1}{2} \sum_{i,k=1}^n \beta_{ik} x_i x_k \quad (19)$$

From here, under the previously accepted assumptions, we obtain the Gauss formula for several quantities in the form:

$$\omega = \frac{\sqrt{\beta}}{(2\pi)^{\frac{n}{2}}} \exp\left(-\frac{1}{2} \beta_{ik} x_i x_k\right) \quad (20)$$

An important aspect for statistical physics is the possibility of studying the states of incomplete equilibrium, when the deviation of the value x significantly exceeds its average fluctuation value, but the relaxation time of fluctuations for the establishment of incomplete equilibrium is much less than the time for establishing the equilibrium value of the value x itself. Fluctuations of such quantities are called quasistationary. If in the process of approaching the statistical ensemble to complete equilibrium at each moment of time its state is determined by the value x , then for small values x one can write [6]:

$$\dot{x}_i = -\lambda_{ik} x_k \quad (21)$$

This equation describes the relaxation of a weakly nonequilibrium statistical ensemble.

The statistical physics solves the problem of describing the dynamics of the SB taking into account friction, when the energy of motion of the SB is converted into heat. This problem has no solution within the framework of classical mechanics due to its reversibility.

With dissipation, there is no canonical Lagrange function for the macroscopic motion of a body. But for sufficiently small velocities of the body \dot{Q}_i , when the motion of the SB is small oscillations in the vicinity of equilibrium, when the condition holds $Q_i = 0$ for the coordinates of the SB, the kinetic and potential energies of the SB, as for a pendulum in classical mechanics, are quadratic functions of the velocities and coordinates, respectively. Then the equation of motion of the SB has the form:

$$\dot{P}_i = -\frac{\partial U}{\partial Q_i} - \sum_{k=1}^s \gamma_{ik} \frac{\partial K}{\partial P_k} \quad (22)$$

Here Q_i are the coordinates of SB, \dot{Q}_i are the velocities, $i = 1, 2, 3 \dots 2s$ is the number of degrees of freedom, $U(Q_i)$ is the potential energy of SB, $K(P_i)$ is the kinetic energy of SB, the constants γ_{ik} are the coefficients for which the condition $\gamma_{ik} = \gamma_{ki}$ is valid. But since $\frac{\partial K}{\partial P_k} = \dot{Q}_k$, we have:

$$\dot{P}_i = -\frac{\partial U}{\partial Q_i} - \sum_{k=1}^s \gamma_{ik} \dot{Q}_k \quad (23)$$

According to the proved in statistical physics condition: $\gamma_{ik} = \gamma_{ki}$. And the forces of friction can be written as follows: $f = \frac{1}{2} \sum_{i,k} \gamma_{ik} \dot{Q}_i \dot{Q}_k$, where f_i is called the *dissipative function*. Then the equation of motion of the SB takes the form:

$$\dot{P}_i = -\frac{\partial U}{\partial Q_i} - \frac{\partial f}{\partial \dot{Q}_i} \quad (24)$$

The first term on the right side of equation (24) determines the resulting force. The second is associated with dissipative processes determined by the internal properties of SB.

5. Principles of constructing kinetics, including nonequilibrium thermodynamics

Equilibrium or stationary statistical ensemble near equilibrium are studied in the framework of statistical physics. A significantly difficult task, which also relies on molecular-kinetic theory, is the study of nonequilibrium statistical ensembles and equilibrium establishment processes. Two approaches have emerged here.

The first approach is phenomenological. It relies on the use of the equations of nonequilibrium thermodynamics, which are a system of the equations of hydrodynamics, augmented with terms describing the flows of various thermodynamic quantities-energy, momentum, mass, charge, etc. These terms, which are empirical, characterize nonequilibrium systems.

The second approach uses statistical methods to describe nonequilibrium processes. Here, as in statistical physics, they rely on molecular - kinetic theory. It also uses the concept of the distribution function of SBs elements in phase space. However, since the statistical ensemble is nonequilibrium, thus, in contrast to SB, here the statistical ensemble - the distribution function does not coincide with the equilibrium distribution functions in statistical physics. Within the framework of this approach, calculations of diffusion, thermal conductivity, viscosity, electrical conductivity are being performed.

The complexity of describing the evolution of nonequilibrium statistical ensemble by constructing a particle distribution function in the phase space leads to the need to introduce serious restrictions even for the simplest systems, such as a monatomic gas. Here, we rely on the concept of the probability of transition of particles from one volume of phase space to another, using Boltzmann's idea of considering changes in the distribution function as a result of particle collisions. This probability is defined as follows:

$$d\omega = W(y, x / \tau, t) dy \quad (25)$$

Here t is the exit time of the imaging point from x , W is the probability density of transition to the point in time τ .

If the density of particles is high, then for each particle the external field of forces does not depend on its motion, and the motion of particles is stochastic. Considering the process as Markovian, considering the transition of a particle from x to y through points z , one arrives at the nonlinear Smoluchowski integral equation [8, 9]:

$$W(y, x/t + \tau, t_0) = \int dz W(y, z/\tau, t_0 + t) W(z, x/t, t_0) \quad (26)$$

Transforming equation (26) into a linear differential equation produces the Fokker-Planck equation from which diffusion equations can be obtained. Assuming τ is small and decomposing by it the transition probability density equation (25), we obtain the kinetic balance equation. Planck's formula follows from this equation.

The Boltzmann equation is derived from the Liouville equation by adding the collision integral to its right-hand side. The essence of this integral is that it describes the transition of particles from one cell of phase space to another as a result of pair collisions. The Boltzmann equation describes quite well the processes of establishing equilibrium in various environments, including plasma, although it has a number of disadvantages [8]. In order to eliminate these disadvantages, a derivation of the kinetic equation for the distribution function of a system $F^N(x_1, x_2, \dots, x_N, t)$ of N identical particles in a $6N$ -dimensional PS by integrating the Liouville equation was proposed [8, 9]. The method for obtaining a solution to the Liouville equation relies on n -particle gas distribution functions. It leads to the BBGKY equation (Bogoliubov–Born–Green–Kirkwood–Yvon):

$$\begin{aligned} & \frac{\partial F_n(x_1, x_2, \dots, x_n, t)}{\partial t} + \hat{L}_n F_n(x_1, x_2, \dots, x_n, t) = \\ & = - \frac{N - n}{V \sum_{i=1}^n w_{i,n+1}} \left[\frac{\partial F_{n+1}(x_1, x_2, \dots, x_{n+1}, t)}{\partial v_i} \right] dx_{n+1} \end{aligned} \quad (27)$$

Here $F_n(x_1, x_2, \dots, x_n, t)$ - n - partial distribution function, $\hat{L}_n = \sum v_i \partial / \partial r + \sum w_i \partial / \partial v_i$ - Liouville's operator.

The one-particle and two-particle distribution functions obtained from equation (27) allow finding quantities necessary for gas dynamics description: average particle density, average particle flux velocity, average kinetic energy. Equations of nonequilibrium thermodynamics follow from equation (27). The Boltzmann equation and the Fokker-Planck equation are special cases of the BBGKY equation.

6. The principles of constructing the mechanics of a SB and the basic of the physics of evolution

The main problem in the way of unity of classical mechanics, thermodynamics, statistical physics and kinetics is the problem of explaining the deterministic mechanism of irreversibility (DMI). Although the probabilistic-statistical explanation of irreversibility has been known for a relatively long time [10, 11], the DMI was proposed relatively recently [3]. It follows from the SB motion equation. The basic principle of this equation is the PSD. The PSD is dictated by the fact that all natural bodies have a structure and, therefore, this structure also corresponds to its own symmetry determining the body dynamics. This means that the total energy of a SB should be represented as the sum of the SB motion energy and its internal energy. The energy of SB motion corresponds to the sum of the potential and kinetic energy components of its center of mass. The internal energy corresponds to the potential and kinetic energy determined by the interactions of the SB elements and their motion relative to the SB center of mass. And the total momentum of the elements corresponding to the internal energy is zero. Such a representation of energy can be realized using two groups of variables: micro variables determining the internal energy and macro variables determining the energy of SB motion. Such representation is due to the fact that for the sum of squares of vectors the following equality is fulfilled [3]:

$$N \sum_{i=1}^N v_i^2 = N M_N V_N^2 + \sum_{i=1}^{N-1} \sum_{j=i+1}^N v_{ij}^2 \quad (28)$$

The vectors v_i determine the MPs velocities in the laboratory coordinate system; $i, j = 1, 2, 3 \dots N$ - numbers of interacting MPs; i, j run values from 1 to N and $i \neq j$; $v_{ij} = v_i - v_j$; $V_N = \sum_{j=1}^N v_j / N$ - velocity of the center of mass of the SB; $M_N = Nm$; $m = 1$, and $M_N = N$; $U_N^{int}(r_{ij}) = \sum_{i=1}^{N-1} \sum_{j=i+1}^N U_{ij}(r_{ij})$ - is the potential energy of the interaction of MPs, and $r_{ij} = r_i - r_j$.

This equation represents the connection between the structure of matter, its energy and the geometry of space. The first term in the right part of equation (28) corresponds to the measure of "Order" and the second term to the measure of "Chaos" [3]. The second term is equal to zero when all velocity vectors of MP are equal and coincide in direction. This case takes place for simultaneous movement of all MPs. On the contrary, when the sum of all velocity vectors of MPs is equal to zero, the first term is zero. This case corresponds to the resting SB.

According to the equation (28), the kinetic energy of the SB decomposes into the energy of motion of the SB and the energy of MP motion relative to its center of mass.

$$T_N = \sum_{i=1}^N \frac{mv_i^2}{2} = \frac{M_N V_N^2}{2} + \sum_{i=1}^N \frac{m\tilde{v}_i^2}{2} \quad (29)$$

In this case, the equation of SB dynamics [8, 9]:

$$M_N \dot{V}_N = -F_N^0 - \mu V_N \quad (30)$$

where M_N - mass of the SB consisting of N MP, $F_N^0 = -\sum_{i=1}^N F_i^0$; F_i^0 - external forces acting on the i -th MP; $\mu = \dot{E}_N^{int} / (V_N^{max})^2$; F_{ij} - interaction forces i and j MP; $F_{ij}^0 = F_i^0 - F_j^0$; $\dot{E}_N^{int} = \sum_{i=1}^{N-1} \sum_{j=i+1}^N \tilde{v}_{ij}(m\tilde{v}_{ij} + F_{ij}^0 + NF_{ij})$; $V_N^{max} + \frac{\dot{E}_N^{int}}{F_N^0} = 0$.

Equation (30) follows from the laws of conservation of energy and momentum. According to equation (30), the internal energy of a structured body can change only when the SB moves in inhomogeneous space. The invariance of energy of SB motion is possible in the case of a non-structured body or in the case of motion in homogeneous space, according to equation (30). The invariance of energy of SB motion is possible in the case of a structureless body or when the SB moves in homogeneous space. Equation (30) considers the dissipation that occurs when a SB moves in inhomogeneous fields.

According to equation (30), the PDS is due to the transition of SB motion energy into internal energy, which is determined by the bilinear term equation (30) that depends on micro- and macrovariables. This term itself is due to the entanglement of micro- and macrovariables that occurs when the SB moves in an inhomogeneous field of forces. The bilinear term determines the time symmetry breaking due to transformation of the SB motion energy into its internal energy. The nonlinearity determining the violation of the conservation law of energy of motion is called "evolutionary nonlinearity" [3]. Evolutionary nonlinearity enabled us to introduce the concept of D-entropy as a ratio of increment of the SB internal energy to its value. A particular case of D-entropy for a stationary and inhomogeneous SB is the Clausius entropy. D-entropy, in contrast to the existing entropy concepts, is defined by dynamic parameters of the SB. It allows to describe the evolution processes of the ONDS, which are defined by a complex of SBs moving relative to each other.

An essential conclusion arising from SB mechanics is the infinite separability of matter [3]. It follows from the fact that the energy of motion can decrease only when some structured objects move in inhomogeneous fields of other objects. Only in this case the law of momentum conservation is satisfied by the law of energy conservation. And only in this case attractors arise that are equivalent to new systems. That is, unstructured objects do not evolve and cannot arise, while the structuredness of matter is its inherent property.

Using equation (30), the physics of evolution is constructed. It includes the extended formalisms of classical mechanics, which are based on the extended Lagrange, Hamilton's, Liouville's equations and Poisson's brackets. The construction of formalisms of physics of evolution is accomplished in a similar way as the construction of formalisms of classical mechanics on the basis of the fundamental laws of energy and momentum conservations. Instead of Newton's equation of motion, equation (30) is used.

The advantage of the extended formalism is that it is applicable to the description of dissipative processes, without which the evolution of matter is impossible. In other words, consideration of matter's structuratics opened up the possibility of constructing an evolutionary picture of the world. Without consideration of structure, only a static model of the world can be built.

The physics of evolution is based on the model of bodies, the elements of which are ONDS, because the matter, including the Universe, is an infinite hierarchy of ONDS in the form of a hierarchical ladder. Each of its upper rungs is the ONDS, the elements of which are the ONDS on the lower rung of the ladder. Such hierarchy points to the relativity of the notions of energy and entropy. Energy is a measure of order; entropy is a measure of chaos. The measure of D-entropy of the upper rung of the ladder is the energy of SB motion of the lower rung. It follows from the physics of evolution that there are universal principles that allow us to build a model of matter.

The importance of equation (30) is that it reveals the essence of entropy of dynamical systems, considering the role of motion of bodies in the change of entropy. This cannot be done within classical mechanics or within SP and kinetics. In addition, from equation (30) follows the DMI, the correspondence of the law of energy conservation of the system and the first law of thermodynamics, the universality of the nature of symmetry breaking, the concepts of "chaos" and "order", and how these concepts determine the evolution of matter.

7. Combining physics sections

Difficulties of combining the considered sections of physics are connected with such important reasons. First of all, within the framework of classical mechanics no explanation of DMI was known. Another difficulty is related to the fact that the description of a huge number of particles for liquid and gas is not only impossible, but also senseless. But, as it turned out, the equation of motion of SB in the general case is irreversible, and irreversibility is deterministic. It removes the contradiction between mechanics and thermodynamics.

The second difficulty, related to the huge number of particles in matter, is not really a matter of principle. After all, the equation of SB motion determines the fundamental properties of dynamics. Therefore, the mechanics of SB and the evolution physics based on it allow justifying statistical physics, kinetics and thermodynamics. Indeed, statistical physics and kinetics are constructed based on a model of bodies in the form of the statistical ensemble, the element of which is the SB. The properties of the statistical ensemble are defined by equation (30). The fact that the DMI for the SB follows from equation (30) removes the problem of justification of the second law of thermodynamics. This law is key to evolution because it is impossible without irreversibility, just as equilibrium in natural systems is impossible. According to equation (30), dissipative forces are proportional to gradients of potential forces. They determine the increase of internal energy when the SB moves in a heterogeneous field of external forces. The principles on the basis of which the SB mechanics and evolution physics are built determine the phenomenological principles of thermodynamics. The main one here is PDS, according to which the energy representation corresponds to the first law of thermodynamics [3]. That is the first law of thermodynamics is conditioned by the PDS. In the area of gradients of external potential forces the meshing of micro- and macro-variables arises, which conditions the transformation of the energy of motion, i.e. the energy of "Order" into the internal energy of "Chaos".

The transformation of energy of motion into internal energy determined the concept of D-entropy, defined by the ratio of the increment of the internal energy of the SB to its total value. D-entropy, in contrast to the well-known concepts of entropy, is determined by the dynamic parameters of the SB. Therefore, it is relevant for the description of evolution.

Note that equation (30) is correct for the equilibrium SB. Obviously, the equilibrium SB for which the thermodynamics is defined is a special case of ONDS. Such a representation of bodies is also the basis for the construction of methods for studying SB.

Let us compare equation (24) with equation (30). We see that the first term in the right part of equation (24) corresponds to the first term of the right part of equation (30), which determines the motion of the SB center of mass. The second term in equation (24) corresponds to the dissipative term in

equation (30), which determines the transformation of SB motion energy into internal energy. This term also determines dissipation. But, unlike its statistical analogue, equation (30) follows from fundamental laws of physics. This means that we can use it to find the constants, γ_{ik} , that determine the evolution of the system on the basis of statistical laws.

Similarly, we can compare the Lagrange equation obtained in a statistical way and the one based on SB mechanics. If we introduce the Lagrange function $L=K-U$, the equation of motion (24) can be rewritten as follows:

$$d/dt(\partial L/\partial \dot{Q}_i) - \partial L/\partial Q_i = -\partial f/\partial \dot{Q}_i \quad (31)$$

The Lagrange function for dissipative processes contains a nonzero right part equal to the derivative of the dissipative function. As we see, the form equation (31) coincides completely with the extended Lagrange equation for SB [3]. The difference is that the right part of the extended Lagrange equation is a strict analytic form of coordinates and velocities of MP, while in equation (31) the right part is defined by a dissipative function obtained under a number of restrictions. In general, the statistical theory of fluctuations allows us to determine, within the limits of perturbations, the nature of changes in the internal states of bodies under changes in external influences.

The statistical physics is constructed on the basis of the system model in the form of the statistical ensemble. All SBs included in the statistical ensemble near equilibrium are identical. Near equilibrium, the energy of the statistical ensemble is equal to the sum of energies of the SB. This enabled us to statistically define entropy through energy. It also allowed finding the relationship of internal states of statistical ensemble with external influences in a linear approximation. However, all these formulas follow from the equation of SB dynamics.

In classical mechanics, the dynamics of bodies is also determined by the relationship between the motion of bodies and the nature of external influences exerted on them, but changes in the internal state of the SB were disregarded. In SB mechanics, on the contrary, it is taken into account that the external influence leads both to changes in the system's momentum and to changes in the internal states. In this case, any subsystem of statistical ensemble used in SP for statistical description is just the SB for which the equation of motion in SB mechanics is obtained. As a result, the SB mechanics allows describing the character of state changes of statistical ensemble, including in this case the description of changes of internal states and changes of statistical ensemble motion in space, without using the statistical laws of physics. That is, the full description of dynamics, which takes place for any nonequilibrium systems and not only for statistical ensemble near equilibrium as in statistical physics, is fulfilled. This is what makes the "physics of evolution" built on the basis of SB mechanics universal.

The physics of evolution has great possibilities for describing nonequilibrium statistical ensemble. For example, the extended Liouville equation gives an exact expression for the kinetic Boltzmann equation. Moreover, it is the extended Liouville equation that should be used to find and analyze the distribution function of nonequilibrium statistical ensemble, since the canonical Liouville equation does not account for the dissipative factors that cause statistical ensemble to approach equilibrium. The importance of the generalized Liouville equation also consists in the fact that it allows us to pass from the deterministic description of the evolution processes to its statistical description, due to the averaging operations when determining the moments.

8. Conclusions

The proposed unification of the sections of physics turned out to be possible within the full description, because it allows us to describe the second law of thermodynamics in the framework of the laws of classical mechanics.

From the mathematical point of view, according to the full description, the time symmetry breaking is conditioned by the evolution nonlinearity due to the meshing of micro- and macro variables describing the SB dynamics during its motion in the inhomogeneous field of forces.

The full description allowed us to introduce the concept of D-entropy, defined as the ratio of the increment of the internal energy of the interacting SB to its total value due to the energy of their relative motion. Therefore, the D-entropy is proportional to the potential external force gradients between SB.

D-entropy is necessary to study the evolution of the Universe, because changes in its states are related to the relative motion of its objects. Hence, the advantage of D-entropy over entropies determined statistically is that it takes into account the role of relative motion of interacting objects in changing their internal states.

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