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Systems Energodynamic Approach as an Instrument of Increasing Efficiency of Engineering Developments

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I. INTRODUCTION

The current state of natural science and theoretical physics clearly demonstrates what can be referred to as "epistemological inversion". As R. Feynman figuratively expressed it, it became preferable to "guess equations without paying attention to physical models or physical explanation" of a particular phenomenon. Speculative models and postulates are increasingly replacing experimental facts as the basis for the modern edifice of science. Scientists are no longer burdened by the fact that their theories do not clarify reality, they no longer aim to understand cause and effect relationships. Phenomena explanation is no longer the primary function of science. Therefore, there are more and more statements about the modern crisis of theoretical physics.

The bifurcation of natural science, which occurred between the 19th and 20th centuries, led to the emergence of new branches of classical science. The first is the special and general theory of relativity and quantum mechanics (QM). The secondis general systems theory and computer science. The third is the transformation of classical (equilibrium) thermodynamics into the thermodynamics of irreversible processes and energodynamics. At present, the results of mutually complementary development of these three branches are obvious. The first one led to the appearance of the atomic weapons, ITER, TOKAMAK, CERN. The second one led to the personalization of computers, global informatization and digitalization. The third one led to the personalization of energy consumption, which is struggling to break through.

A. Einstein believed that thermodynamics was a science of principles, and its conclusions would never be refuted, and this idea corresponds to the fact that thermodynamics is the recognized "queen of sciences." The uniqueness of thermodynamics as a systems science is that its starting points naturally lead to the existence of hidden energy carriers, such as electric charge, the nature of which is still not clear, or ether, previously excluded from consideration. The energdynamic concept of a material energy carrier and the generalized law of conservation of energy open up the possibility of quantitatively assessing the result of the transformation of energy from one form to another in conditions of incomplete information about its mechanism. This is where the key to understanding and practical use of the vast factual material accumulated in natural science lies, which cannot be explained by modern science [1]. The purpose of this article is to show a real way to overcome the crisis of theoretical physics by transforming classical thermodynamics into a theory of principles based on a systems approach.

II. METHODOLOGICAL FEATURES OF THE SYSTEMS ENERGODYNAMIC APPROACH

It refers to a comprehensive methodology, which involves combining systems analysis with the highest level of thermodynamics — energodynamics, which expands it to any non-static processes and any forms of energy. The systems approach uses the concept of a system as a set of elements, which has integrity due to system-forming relationships. The property of integrity is reflected in the philosophical thesis of nonadditivity of the whole, which was recognized as early as Aristotle and Plato: the whole is greater than the sum of its parts. Integrity combines the properties of structuredness, self-organization and emergence of the system. Structuredness manifests itself in the hierarchical structure of the system, self-organization — in the occurrence and development of structures in an initially homogeneous environment, emergence — in the spontaneous occurrence of new properties in the system. Gravity, movement,

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emergence of new elements and chemical compounds, and so on are manifestations of these properties in nature. [2-11].

The universal characteristic of an energodynamic system is energy, which is the most general function of its state. Its derivatives determine all other properties of the system by independent arguments. Energy acts as a link between various processes occurring in a thermodynamic system — mechanical, thermal, chemical, electromagnetic, nuclear processes, etc. The basis of energodynamics is the law of conservation and transformation of energy, which has no limitations [12-18].

The analysis is of a deductive nature (from the general to the particular) and relies solely on experience-validated data on natural phenomena, i.e., phenomenology. The systems approach does not exclude from consideration those internal (hidden from the observer) system-forming relationships, through which the system as a whole acquires new properties that its individual parts (elements) did not have and without which the system cannot function fully. Deductive analysis is more challenging for the researcher, yet it allows the results of inductive analysis to be critically evaluated (verified) and therefore brings it closer to reality. For instance, energodynamics does not exclude the study of internal (including dissipative) processes, that classical mechanics usually neglects, limiting itself to "conservative" systems. The discovery of the impossibility to restore the system-forming properties, which were lost when the system was split into volume or mass elements during its analysis, by further integration was "the most profound and the most fruitful that physics has experienced since the time of Newton" [19], according to A. Poincaré.

The energodynamic system is vaster than the mechanical system. Elements of a mechanical system are material points, and elements of an energodynamic system are real processes and their coordinates are material carriers of various forms of energy — the so-called energy carriers. Whereas in mechanics the coordinates of position and velocities of individual material points serve as generalized coordinates of the system state, in energodynamics the coordinates are numerical characteristics of material energy carriers Θ_i and displacements $\mathbf{R}_i$ of their centers in relation to equilibrium, characterizing the system as a whole. The energy U is an extensive characteristic of the system and is a single-valued function of the extensive energy coordinates $U = U(\Theta_i, \mathbf{R}_i)$. For example, in energodynamics, a mechanical process is characterized by mass and displacement of the center of mass, a thermal process is characterized by entropy and displacement of its center; a chemical process is characterized by the amount of a component and displacement of its center; an *electrodynamic* process is characterized by charge and displacement of its center, etc.

The presentation of mechanics in theoretical physics courses is based on the postulates of homogeneity and isotropy of space and homogeneity of time, as well as Lagrange's variational principle of least action, a special case of Gauss's principle of least constraint [20], which is more general. The authors [20] have admitted that space is not homogeneous and isotropic with respect to an arbitrary frame of reference. Thus, if a body does not interact with any other bodies, it does not mean that its various positions and orientations in space are mechanically equivalent. This non-equivalence is clearly manifested when it comes to spatially heterogeneous media, which are anisotropic since a number of properties depending on the gradients of any potentials varies in different directions.

The transition to the energy coordinates of the state (Θ_i, $\mathbf{R}_i$) supplemented by the axiom of process heterogeneity, leads inevitably to an absolute frame of reference [6]. The concept of an energodynamic system, being free from the postulates of homogeneity and isotropy of space and Galileo's principle of relativity, limited to linear and steady motion, is much broader than the concept of a mechanical system, thus, making the mechanical system a special case of an energodynamic system. For energodynamics, mechanics is an "equal" representative among all other, including non-mechanical forms of matter motions. With this view of mechanics, not only does it require a correction of all its laws, but it also provides a natural explanation of the principle of least constraint in mechanics mentioned above.

Being a consistently phenomenological theory, energodynamics relies on experience rather than on models of the mechanisms of natural processes. Its underlying principles are specified on the basis of experimental data on particular properties of the systems under study (including the so-called laws of Newton, Coulomb, Ampere, equations of condition, transfer, mass balance, charge, impulse, momentum, etc.) which are involved as additional single-valued conditions for the completion of the set of equations. Its equations are based on the formalism of differential and integral calculus and mathematical properties of the system energy as a characteristic function of a certain number of state variables reflecting the quantitative and qualitative aspects of the forms of motion under study. Therefore, the consequences of such a theory become fundamental truths within the applicability of single-valued conditions, whereas energodynamics itself becomes a "theory of principles" as Einstein put it [21].

It is known that all conservation laws were formulated for isolated systems. However, none of the fundamental disciplines can study such systems, since their conceptual system and mathematical apparatus are oriented to locally or globally homogeneous (internally equilibrium) macro- or micro-subjects, which have no internal processes, so that any changes in their state are due solely to the action of external forces and external energy exchange. A breakthrough in this direction was made by the thermodynamics of irreversible processes (TIP) [22, 23], which emerged in the first third of the 19th century following quantum mechanics (QM) and the theory of relativity (TR). It enriched the theoretical thought of the 20th century with a number of new principles of general physical nature and made it possible to study the kinetics of internal relaxation processes that occur alongside the processes of external energy exchange in all study subjects without exception.TIP became the third of the above-mentioned theories of a revolutionary nature that changed the image of physics of the 20th century, which was celebrated by awarding Nobel Prizes to L. Onsager and I. Prigozhin.

However, this theory was based on the principle of increasing entropy and therefore excludes from consideration the reversible component of real processes, which does not affect entropy. Meanwhile, the study of processes of useful transformation of energy was the main task of classical thermodynamics. The kinetics (power) of these processes is of primary interest to the engineer. There is a need to develop a unified theory of the rate of energy transfer and transformation, which would not exclude from consideration any (reversible or irreversible) component of real processes. Such a theory was proposed in the works of one of the authors of this paper and was called "thermokinetics" [13]. All its provisions were justified in a purely thermodynamic way (i.e., not involving hypotheses, postulates, modeling representations, and statistical-mechanical nature). Later it was generalized to the processes of transformation of any forms of energy and called "energodynamics" [14].

Unlike other fundamental disciplines, this theory considers isolated systems as the subject of study, which includes the entire complex of interacting (mutually moving) material subjects. Due to this, it is most consistent with both the systems approach and the deductive method of study (from the general to the particular) followed by classical thermodynamics [24]. Energodynamics is characterized by the refusal to use hypotheses and postulates in the foundations of the theory, idealization of systems and working bodies (contained in concepts such as "ideal gas", "equilibrium state", "reversible (quasi-static) process", etc.), as well as speculative models and ideas regarding the atomic and molecular mechanism of processes. Its special feature is the separation of the theoretical part, based solely on principles of general physical nature, from the applied part, using modeling representations, hypotheses and postulates. This allows it to preserve the main advantage of the thermodynamic method — the irreversible validity of its consequences within the limits of applicability of the initial paradigm of natural science. This property is also preserved when the single-valued conditions involved in the applied part of the theory are also reliably established.

Energodynamics is based on two principles: distinguishability of real processes and their counterdirectivity. The first one establishes a necessary and sufficient number of energy arguments as the most general function of the properties of the subject of study (i.e., system). This principle is proved "by contradiction" based on the theorem stating that the number of degrees of freedom of a system (i.e., the number of independent parameters uniquely determining its state) is equal to the number of independent (specific, qualitatively distinguishable and irreducible to others) processes occurring in it. This principle prevents "underdetermination" or "overdetermination" of a system, i.e., it attempts to describe their state by a missing or redundant number of variables, which is the most common cause of fallacy in a majority of theories. Among the latter are those theories where the concept of homogeneity is initially assumed, excluding relaxation processes and everything related to non-equilibrium processes from consideration.

The second principle establishes the fact of opposite direction of non-equilibrium processes, which is the reason for the appearance of new properties in the system. It is sufficient to represent the value of any extensive parameter of the system Θ_i (its mass M, entropy S, electric charge Θ_e, impulse **P**, its momentum **L**, etc.) by integrals of its local $\rho_i = d\Theta_i/dV_i$ and average density $\overline{\rho}_i = \Theta_i/V$ using the expression

$$\Theta_i = \int_V \rho_i dV = \int_V \overline{\rho}_i dV,$$

Hence the identity directly follows:

$$\int_V d(\rho_i - \overline{\rho}_i)/dt\, dV \equiv 0, \qquad (1)$$

which is observed only if the sign of velocity of any process $d(\rho_i - \overline{\rho}_i)/dt$ is opposite at least in some elements of its volume dV, i.e., when these processes are counterdirected. Such counterdirectivity of processes has a general physical nature, i.e., there are always such processes among those occurring in spatially heterogeneous systems, which cause opposite changes of its properties like the process of wave formation. This is evidence of the existence of a natural polarization of nature in the most common sense of this term. It can be considered a physical justification for the law of unity and struggle of opposites. If the properties of an energodynamic system do not differ from the average, then no processes in such a system are impossible. The opposites arise only as a result of deviations from the average value of any properties of the system. Herein lies the emergent nature of the energodynamic system. This property is inherent in all natural phenomena in big and small forms from microto megaworld and serves as the basis of the universe. This property limits numerous fancies about the existence of matter and antimatter, particles and antiparticles, positive and negative energy, positive and negative charges, dark energy and dark matter, and so on and so forth. These two principles were sufficient to create a general theory for all fundamental disciplines, explained using unified concepts and terminology [14]. This approach was celebrated by winning the 1st World Science Championships in Dubai (August 2023) [2].

III. Heterogeneity Parameters of Real Processes and the law of Conservation and Transformation of Energy

For the first time, energodynamics made it possible to study internal processes in locally heterogeneous and isolated systems due to the introduction of missing heterogeneity parameters. These parameters reflect the processes of redistribution of energy carriers Θ_i over the volume of system V in heterogeneous systems, as a result, their densities ρ_i in different parts of the system change in the opposite ways. This leads to a deviation of the position of the center R_i of the value Θ_i from the equilibrium R_{io}(taken as a reference point), which are determined in a system of fixed volume V in a well-known way [14]:

$$\mathbf{R}_i = \Theta_i^{-1}\int\rho_i\mathbf{r}dV; \quad \mathbf{R}_{io} = \Theta_i^{-1}\int\bar{\rho}_i\mathbf{r}\,dV, \qquad (2)$$

where **r** is a running (Eulerian) spatial coordinate.

It follows that when such a system deviates from a homogeneous (“internally equilibrium”) state, a certain “distribution moment” of the energy carrier arises

$$Z_i = \Theta_i(R_i - R_{io}) = \int_V (\rho_i - \bar{\rho}_i)\mathbf{r}dV \qquad (3)$$

with a ratio arm $R_i - R_{io}$, referred to as the “displacement vector” [14]. Since there are no processes in the equilibrium R_{io}, R_{io} can be taken as the reference point of $Z_i = \Theta_i R_i$. Thus, the differential dZ_i can be represented as the sum of three independent components:

$$\mathbf{dZ} = \mathbf{R}d\Theta_i + \Theta_i d\mathbf{r} + d\boldsymbol{\varphi}_i \times \mathbf{Z}_i \qquad (4)$$

where $\boldsymbol{\varphi}_i$ is the spatial (Eulerian) angle of the vector Z_i; $d\mathbf{r}_i$ is the shearing component of dR_i (at $\boldsymbol{\varphi}_i$ = const).

Three components of dZ_i correspond to three independent categories of non-equilibrium processes: 1) emergence of energy carrier Θ_i in the system or its introduction through the system boundary ($d\Theta_i \neq 0$); 2) its redistribution over the system volume ($d\mathbf{r}_i \neq 0$); 3) reorientation of the energy carrierin space ($d\boldsymbol{\varphi}_i \neq 0$). As a result, any i-th form U_i of its own (belonging only to the system) energy[1] U generally becomes a function of three independent parameters: $U_i = U_i(\Theta_i, \mathbf{r}_i, \boldsymbol{\varphi}_i)$. Thus, the total differential dU of the internal energy of the system as a sum of “partial” energies of all its forms $U = \Sigma_i U_i$ can be represented as an identity:

$$dU \equiv \Sigma_i\Psi_i d\Theta_i + \Sigma_i\mathbf{F}_i\cdot d\mathbf{r}_i + \Sigma_i\mathbf{M}_i\cdot d\boldsymbol{\varphi}_i, \quad (i = 1,2,..\ I), \qquad (5)$$

where $\Psi_i \equiv (\partial U_i/\partial\Theta_i)$ — generalized potentials ψ_i averaged over the volume of the system (absolute temperature T and pressure p, chemical potential of the *k*-th component of the system μ_k, its electric potential φ, gravitational potential ψ_g, etc.); $\mathbf{F}_i \equiv (\partial U_i/\partial\mathbf{r}_i)$ — generalized forces (external and internal, mechanical and non-mechanical, useful and dissipative); $\mathbf{M}_i \equiv (\partial U/\partial\boldsymbol{\varphi}_i)$ — moments of these forces.

Identity (5) represents the law of conservation and transformation of energy. According to this law, the energy of any natural system is divided into two parts — irreversible and reversible. The potentials of these two forms of energy differ insignificantly and are similar to the potentials of a calm and wavy ocean. Only the disturbed part, representing the wavy ripples of the ocean, is reversible. This part is characterized by the second and third sums in identity (5). Figuratively speaking, everything that is associated in nature with the energy of disturbed motion is a same fraction of the total energy of the global ocean of the Universe energy.

One of the most important advantages of the identity (5) is the elimination of the uncertainty of the energy concept and its definition as the most general function of the system properties characterizing its ability to perform any type of work. The identity (5) that connects the “conjugate” parameters Ψ_i and Θ_i, F_i and r_i, M_i and $\boldsymbol{\varphi}_i$, defines them regardless of what caused their change: external energy exchange or internal (including relaxation) processes. This prevents the well-known problem of the emergence of thermodynamic inequalities at transition to non-static processes, where the change of these parameters is caused not only by external energy exchange, but also by internal (relaxation) processes. This eliminates a major obstacle to applying the mathematical apparatus of thermodynamics to other fundamental disciplines. For the same reasons, the identity (5) is applicable not only to isolated systems as a whole (for which the volume V is unchanged and all processes are internal), but also to any of its material components, phases or areas, where parameters Θ_i, $\mathbf{r}_i$ and $\boldsymbol{\varphi}_i$ change also due to external energy exchange (heat transfer, mass transfer, diffusion, introduction of a charge into it, etc.).

In homogeneous systems ($\Psi_i = \psi_i$, $F_i = 0$, $M_i = 0$), the second and third sums of identity (5) vanishes, and it transforms into the combined equation of the 1st and 2nd principles of classical thermodynamics in the form of the generalized Gibbs relation [14], which

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[1] It was called internal for a number of historical reasons.

describes the processes of equilibrium energy exchange of the system with the environment. After the introduction of time t as a physical parameter, the identity (5) formulated for isolated systems takes the form of the law of conservation of energy in its nonstationary form:

$$dU/dt \equiv \Sigma_i \Psi_i d\Theta_i/dt + \Sigma_i \mathbf{X}_i \cdot \mathbf{J}_i + \Sigma_i \mathbf{M}_i \cdot \boldsymbol{\omega}_i = 0, \qquad (6)$$

where $\mathbf{X_i} = \mathbf{F}_i/\Theta_i = \nabla\psi_i$ – strengths of field of force, expressed by gradients of generalized potential ψ_i (energodynamic forces) averaged over the system volume; $\mathbf{J}_i = (\partial \mathbf{Z}_i /\partial t)$ – generalized impulses of energy carrier Θ_i, referred to as "flows"; $\boldsymbol{\omega}_i = d\boldsymbol{\varphi}_i/dt$ — angular velocities of rotation (reorientation) of vector $\mathbf{Z}_i$.

In contrast to fundamental disciplines that study the processes of external energy exchange, this law provides an opportunity to consider internal processes in isolated (closed) systems, where the concepts of external energy, external forces, their work, momentum, etc. are meaningless. At the same time, energodynamics reveals the flow of three independent forms of internal work in such systems, performed respectively by "disordered" (scalar) forces, "ordered" (vector) forces and their moments. This radically changes the research methodology of all fundamental disciplines that do not consider internal processes, and makes it possible to move towards the study of internal processes determined by the above-mentioned system-forming connections.

IV. Systems Approach to Equilibrium and Non-Equilibrium Thermodynamics

Of all the fundamental disciplines, classical thermodynamics, being a deductive and phenomenological theory based on the principles of excluded perpetual motion machine of the 1st and 2nd kind, met the requirements of a systems approach to the greatest extent. It provided numerous consequences related to different fields of knowledge and earned the status of "queen of sciences" as a theory "the consequences of which will never be refuted by anyone" [21]. However, as it appeared, it had some known paralogisms when going beyond the strict limits of the validity of its initial concepts of equilibrium and reversibility. Most of them were related to the concept of Clausius entropy, which he introduced as a coordinate of heat transfer that was also dependent on internal heat sources [18].

The theory of irreversible processes (TIP), which emerged on the basis of the principle of increasing entropy using statistical-mechanical considerations and a number of additional hypotheses, did not avoid paralogisms either [25]. I. Prigozhin's local equilibrium hypothesis became the main one [23]. This hypothesis assumed the presence of equilibrium in the continuum elements (despite the relaxation processes occurring in them), the possibility of their description by the same set of variables as in the homogeneous state (despite the presence of potential gradients), and the validity of all equations of equilibrium thermodynamics for them (despite their inevitable transition to inequalities). Despite its inconsistency, this hypothesis made it possible to find the basic values used by TIP theory. However, this deprived TIP of the completeness and rigidity inherent in the classical thermodynamic method. All attempts to overcome these difficulties proved unsuccessful due to the lack of a thorough adjustment of the conceptual foundations and mathematical apparatus of classical thermodynamics.

This problem was solved by introducing additional extensive $\mathbf{Z}_i$ and intensive $\mathbf{X}_i$ parameters of the nonequilibrium state [14], and these parameters changed not only the structure, but also the methodology of explanation of the basics of equilibrium and nonequilibrium thermodynamics. An unconventional consequence of this approach is the proof that the true "dividing line" is not between heat Q and work $W^н$, which are included in the same sum of identity (5), but between different sums of this identity, i.e., technical $W^т$ and non-technical types of work $W^н$, the first ones being quantitative measures of the process of "energy conversion" (with a change in the form of energy), and the second ones — of energy transfer (without changing its form). These two types of work, referred to as "ordered" and "disordered", differ not only in the tensor rank of their coordinates $\mathbf{r}_i$ and Θ_i, but also in the presence or absence of the resulting overcome forces. The fact that "one work is different from the other" leads to the categorization of heat transfer as disordered work. This work is related to the transformation of the impulse of the system elements into a thermal impulse, which loses its vector nature due to thermal (chaotic) movement. Unlike entropy, thermoimpulse in thermally isolated systems can both increase and decrease, making it a true argument of internal thermal energy. Using it as an extensive measure of thermal motion instead of Clausius entropy S (as a coordinate of equilibrium heat transfer) makes it superfluous to interpret the latter as a measure of the thermodynamic probability of a state, which is incompatible with the concept of "entropy flux" used by TIP [26].

Energodynamics radically changed the methodology of nonequilibrium thermodynamics. TIP considers only the relaxation (purely dissipative) part of real processes. Instead, a new method of analyzing real processes was proposed on the basis of law (5) or (6) without excluding any (reversible or irreversible) part of them from consideration [14]. This became possible due to the identity (6), which allows finding the flows $\mathbf{J}_i$ regardless of the reason they are due to — relaxation ($\mathbf{X}_i \cdot d\mathbf{Z}_i < 0$) or performing useful internal work "against equilibrium" in the system ($\mathbf{X}_i \cdot d\mathbf{Z}_i > 0$).

Finding flows $\mathbf{J}_i$ and forces $\mathbf{X}_i$ directly from the identity (6), made it superfluous to formulate cumbersome equations of the mass, charge, momentum, energy and entropy balances for this purpose. This also excluded the arbitrariness characteristic of TIP in dividing the product $\mathbf{J}_i \cdot \mathbf{X}_i$ into factors with different meanings, values, and dimensions. This dramatically facilitated the application of the theory to various physicochemical processes and made it possible to propose a new method for their study. The essence of this method is to translate Onsager's laws from the matrix form-

$$J_i = \Sigma_j L_{ij} \mathbf{X}_j \tag{7}$$

into a diagonal form with a smaller number of coefficients L_{ij} subject to experimental determination. This brought Onsager's laws closer to the equations of heat conduction, electrical conduction, diffusion, etc. Such a form did not need to apply the Onsager's symmetry conditions

$$L_{ij} = L_{ji}, \tag{8}$$

and allowed to reduce the number of coefficients L_{ij} from n(n+1)/2 in TIP to nwhile preserving all information about the “superposition effects” of heterogeneous flows $\mathbf{J}_i$ and $\mathbf{J}_j$. Giving the transfer equations a diagonal form made the application of the Onsager reciprocity relations unnecessary, which significantly extended the scope of application of nonequilibrium thermodynamics owing to the violation of these relations in nonlinear processes. However, the possibility of applying nonequilibrium thermodynamics to non-static (occurring at a finite rate) energy conversion processes, which were previously considered in the so-called “non-dissipative” approximation, turned out to be even more important. This revealed the possibility of taking irreversibility into account in all fundamental disciplines [15].

The application of nonequilibrium thermodynamics to systems performing useful work has revealed the inapplicability of Onsager's “constitutive laws” (7) to such systems. The phenomenological laws of the process of energy conversion from the i-th form to the j-th one take the form in which their off-diagonal components (i ≠ j) have the opposite sign:

$$\mathbf{J}_i = L_{ii}\mathbf{X}_i - L_{ij}\mathbf{X}_j \tag{9}$$

$$\mathbf{J}_j = L_{ji}\mathbf{X}_i - L_{jj}\mathbf{X}_j \tag{10}$$

These laws reflect the interrelation and counterdirectivity of flows J_i and J_j in the processes of conversion of any forms of energy. For such processes, the reciprocity relations (9), (10) have an antisymmetric character $L_{ij} = - L_{ji}$ and requires appropriate proof. Energodynamics leads to more general differential reciprocity relations [14]

$$(\partial \mathbf{X}_i/\partial \mathbf{J}_j) = (\partial \mathbf{X}_j/\partial \mathbf{J}_i \tag{11}$$

Passing for linear processes into the Casimir anti-symmetry conditions $L_{ij} = - L_{ji}$ [27]. These relations required a TIP-independent and consistent thermodynamic justification of all positions of nonequilibrium thermodynamics. The consideration of counterdirectivity of flows at the input and output of the energy converter in relations (11) resulted in the development of original theory of similarity of processes of useful energy conversion. This theory proposed criteria of similarity of energy converters and universal dependences of coefficients of efficiency (COE) on the design perfection and operating mode of power plants. This has greatly improved the efficiency and practical benefits of thermodynamic analysis of thermal and non-thermal, cyclic and non-cyclic, forward and reverse machines in engineering calculations [14].

V. SYSTEMS APPROACH TO CLASSICAL MECHANICS

The presentation of mechanics usually begins with kinematics, which considers the motion of a point in space and time independently of the physical causes of that motion. At the same time, the concepts of motion trajectory, position of a point on it, its speed and acceleration are introduced by pure speculation. Only after that, the concepts of mass and momentum, which are the characteristics of a material point, are introduced, and the transition is made to the study of dynamics, which clarifies the reason for the emergence of this or that motion in various conditions and the laws to which it obeys.

At first glance, this structure of mechanics seems quite natural. However, as L. de Broglie fairly noted, this approach is based on the assumption that the results of abstract kinematic consideration can be further extended to the real motion of more complex mechanical subjects. Meanwhile, this is not always the case, and a systems approach to mechanics proves to be as useful as in other fundamental disciplines. From its perspective, the so-called “laws” of Newton's mechanics appear to be nothing more than postulates, which he called “definitions” for good reason. The limitations of these “definitions” are not always obvious and are sometimes revealed only when considering a more general range of problems [18]. This is, in particular, the Newtonian definition of force $F = dP/dt$ as the time derivative t of the scalar “momentum” $P = M\upsilon$, which applies equally to both chaotic and directed motion. For the latter case, the concept of acceleration $\boldsymbol{a} \equiv d\boldsymbol{\upsilon}/dt$ became relevant to two fundamentally different processes: the change of the velocity modulus without changing its direction, and the change of the direction of the velocity vector without changing its absolute value. The concept of “centripetal acceleration” emerged when a point rotates uniformly around a circle, i.e., in the absence of motion toward the center. This led to the well-known paralogism of Rutherford's model of the atom on the basis of the erroneous statement about the inevitability of the electron falling on the nucleus due to its emission of energy during accelerated motion, despite the constancy of its kinetic energy.

From the perspective of the systems approach, the shortcomings of other initial concepts of mechanics are revealed as well [28]. For example, it is well-known that the motion of a single material point in the absence of external forces acting on it will be rectilinear and uniform (Newton's law of inertia). However, the uniform motion of bodies of finite dimensions "by inertia" can be both translational and rotational. This means that the law of inertia should have been generalized to rotational motion long ago. In that case there would be no reason to deny the existence of predominant reference frames. These examples and a number of others demonstrate the appropriateness of considering mechanics as an equal branch of physical theory like energodynamics as a single doctrine of forces. This approach generalizes all three of Newton's laws: the 1st law (of inertia) — for rotational motion, the 2nd law (of forces) — for forces of any nature ($\mathbf{F}_i \equiv \partial U/\partial \mathbf{r}_i$), the 3rd law (equality of forces of action and reaction) - for the case of simultaneous action of forces of the i-th and j-th nature ($\mathbf{F}_i = -\Sigma_j \mathbf{F}_i$) [28]. Here it follows that the requirement of the directionality of the action and reaction forces, arising from Newton's 3rd law, applies only to the resulting forces $\mathbf{F}_i$.

However, it is even more important to find the law of gravity

$$F = G(Mm/r^2) \tag{12}$$

for the case of continuum media where it is impossible to distinguish neither "field-forming" M, nor "test" m bodies. Such a law can be obtained directly from the equivalence principle of mass M_o and rest energy $U = M_o c^2$ by A. Einstein or from the previously obtained expressions of the ether energy. Expressing this principle through the matter density ρ and energy ρ_u, we have $\rho_u = \rho c^2$. Then, the intensity $\mathbf{X}_g = \rho \boldsymbol{g}$ of the gravitational field $\mathbf{F}_g$ is expressed through the matter density gradient $\nabla\rho$ by a simple relation [29]:

$$\mathbf{X}_g = c^2\nabla\rho \quad \text{or} \quad \mathbf{g} = c^2\nabla\rho/\rho. \tag{13}$$

This law is not a generalization of Newton's law of universal gravitation (12), it is an independent law, which has paradigm (ideological) significance, since it implies the existence of not only the forces of "pushing" ($\nabla\rho > 0$), but also the forces of repulsion ($\nabla\rho < 0$), as well as gravitational equilibrium ($\nabla\rho = 0$). It is also of no less importance that gravitational interaction forces $\mathbf{X}_g$ are the most significant of all kinds of forces at equal density gradients of energy carriers $\nabla\rho$.

VI. SYSTEMS APPROACH TO QUANTUM MECHANICS

Nowadays it is difficult to imagine that the quantum-relativistic revolution could not have taken place if the apparatus of nonequilibrium thermodynamics had been developed in time, and instead of thermostatics the analysis of laws of radiation was based on thermokinetics. Back then, the idea of equilibrium with the cavity of the perfectly black body (PBB) would be replaced by the equality of flows of the absorbed and emitted energy that would immediately lead to understanding that the true radiation quantum is a wave modeled by PBB in the luminiferous medium, discrete both in time and in space. Then Planck's radiation law acquires a thermodynamic justification without involving Planck's postulate [30]. At the same time, the De Broglie relation expressing the wave-particle dualism is also proved, except that it does not refer to the wave properties of a particle, but to the particle-like properties of a soliton as a structurally stable wave. Then the position of E. Schrödinger becomes clear, as he believed until the end of his life that "what we take as particles are actually waves" [31]. According to energodynamics, radiation refers to ordered forms of energy exchange, therefore it must be described by the thermodynamic parameters of the process, not the state. Then the law of thermal radiation naturally follows from the concepts of classical physics without any preliminary postulates, but taking into account the fact that radiant energy is transferred by waves that are discrete in both time and space.

Furthermore, as follows from the principle of state determinism and the energy identity (5), each independent process inherent in the i-th form of energy U_i corresponds to a single state coordinate, i.e., a parameter that necessarily changes in the course of the process and remains unchanged in its absence. As it follows from the principle of counterdirectivity of processes, the deviation of such a value compared to the average value ($\rho_i - \bar{\rho}_i$)) has the opposite sign, as Franklin believed with regard to electric charge. Consequently, the search for an antipode for each energy carrier (like an electron and a positron, a particle and an antiparticle, positive and negative mass, etc.) leads to a redefinition of the system.

Finally, if N. Bohr had followed the systems approach when studying the emission process, he would have considered as a subject of study the entire set of atoms, located in external force fields and oscillating with them, rather than a single atom. Thus, it would become apparent that the emission or absorption of energy by an atom could only occur when the energy state of the electrons was determined by the action of external (non-central) forces F. Therefore, the reason of quantization of the emission energy is not the instantaneous "jump" of the electron from one stable orbit to another, but is the reaction of the electron to the influence of the external force field on it.

Thus, the contradiction between classical and quantum mechanics declared at the beginning of the twentieth century does not actually exist. It disappears in the light of the energy-dynamic concept: changes in energy in nature are caused by a discrete flow of energy carriers in the form of single waves. This means that there is no specific quantum physics with its own special laws, but there is a branch of unified physics that studies discrete (wave) processes. In this case, the true quantum of radiation is an ordinary wave, clearly discrete in both time and space.

Thanks to this approach, it is possible not only to justify the law of formation of spectral series as a consequence of the presence of harmonics of oscillations, but also to obtain the Schrödinger steady-state equation, which does not require comprehension in terms of probability theory [31].

VII. SYSTEMS APPROACH IN ELECTROSTATICS AND ELECTRODYNAMICS

Electrodynamics as a fundamental discipline emerged from electrostatics, which studied the interaction of fixed charges. The Coulomb's law, established experimentally for two macroscopic charges of finite sizes but formulated for two point charges, is one of the initial principles of electrostatics. Hence, this formalization led to infinite values of force and energy when the distance between the charges was reduced to zero.

To eliminate this and other paralogisms, the use of the systems approach made it possible to formulate the mathematical apparatus of electrodynamics as a special case of the energodynamic identities (5) and (6) in their application to "current-carrying" systems [32]. The experimental Coulomb's law has the following form

$$F_e = (1/(4\pi\varepsilon_0)[(qQ_e)/r^2], \qquad (14)$$

where F_e — the modulus of the interaction force of charges q and Q_e; ε_0 — the electrical permittivity of vacuum. It corresponds to the potential of the electrostatic field $\varphi(\mathbf{r})$ as a measure of its potential energy at a point of the field $\mathbf{r}$ at a distance r from the "field-forming" charge Q_e:

$$\varphi(\mathbf{r}) = (1/4\pi\varepsilon_0)(Q_e/\mathbf{r}) \qquad (15)$$

The potential $\varphi(\mathbf{r})$ characterizes the attenuation of the electric field as it moves away from the center of a fixed "field-forming" charge Q_e, but it does not provide an idea of the change in the field potential as a function of the density $\varphi(_e)$ of the charge in it $_e$. At the same time, it is fundamentally important since the "primary cause" of the force $\mathbf{F}_e = -(\partial U_e/\partial \mathbf{r})_V$ is precisely the gradient of the electrostatic energy density $U_e = U_e(\rho_e)$, and the work W_e of moving the charge in the electrostatic field E is solely due to the heterogeneity of the field $\rho_e = \rho_e(\mathbf{r})$. For this purpose, we shall distinguish in space a sphere of unit volume V_0 with radius $r_0 = \mathrm{const}$ and charge density $\rho_e = Q_e/V$, on a surface of which the potential $\varphi(r_0)$ has the same value. Then the expression (15) can be represented as:

$$\varphi(\rho_e) = V_0/(4\pi\varepsilon_0 r_0)\,\rho_e(\mathbf{r}) \qquad (16)$$

Here, the potential $\mathbf{r}$ is expressed as an implicit function of the field coordinate $\varphi(\rho_e)$, i.e., $\varphi(\rho_e) = \varphi[\rho_e(\mathbf{r})]$, and that preserves the meaning of the concept of the electrostatic field strength E as a negative gradient of this potential. Taking into account the constancy of the expression in brackets (16), we have the following

$$\mathbf{E} = -\nabla\varphi(\rho_e) = -(V_0/(4\pi\varepsilon_0 r_0))\nabla\rho_e$$

If we supplement the expression in brackets to the value of the potential of the sphere of unit volume $\varphi_0 = \rho\, V_0/(4\pi\varepsilon_0 r_0)$ or, we find

$$\mathbf{E} = -\varphi_0\, \nabla\rho_e/\rho_e \qquad (17)$$

This relation expresses the field form of Coulomb's law. It describes the electrostatic field as a function of the density gradient $\nabla\rho_e$ of the charge distributed in the field ρ_e. This relation (17) differs from the Poisson equation

$$\nabla^2\varphi = 4\pi\varepsilon_0\rho_e,$$

since it provides a direct relation between the electrostatic field and the local density of the "field-forming" charge ρ_e. It appears completely identical to Newton's law in its field form (13). It is fundamentally important that the generalized form of Newton's and Coulomb's laws (13) and (17) reveals the existence of forces of attraction and repulsion for energy carriers ρ_g and ρ_e of the same sign, demonstrating that this is not about them, but about their distribution in space. It is equally important that these laws reveal the existence of unstable equilibrium in gravitational and electric fields, prerequisite of this unstable equilibrium is the vanishing of the energy carrier density gradient:

$\nabla\rho_g = 0$ — gravitational equilibrium;

$\nabla\rho_e = 0$ — electrostatic equilibrium.

It should be noted that the existence of such equilibrium and the possibility of existence of fields with homogeneous distribution of masses and charges was not implied by the classical laws of Newton and Coulomb, where the forces of attraction or repulsion vanished only at infinity.

The transition to electrodynamics is connected with the interpretation of the electric current as a flow (impulse) of charge $J_e = Q_e\boldsymbol{\upsilon}_e$, conjugated with the electrodynamic force $\mathbf{X}_e = \nabla\boldsymbol{\upsilon}_e$. This force is a tensor in 2 dimensions and can be decomposed into a symmetric and antisymmetric part and a trace of the tensor which respectively form the vortex-free, vortex and scalar magnetic fields respectively. In this case, both torques and Nikolaev's forces arise, and there remains no room for statements that "the magnetic field does not perform work since the Lorentz forces are normally directed along the direction of motion" [33].

The understanding of the electromagnetic field (EMF) as a distribution in space of vectors E and H is fundamentally different from its interpretation by Maxwell as a medium carrying energy "after it has left one body and has not yet reached another one" [34]. It becomes clear why such "materialization" of EMF was not accepted by any of the researchers of that time and, in particular, by W. Thomson, who referred to this field theory as "mathematical nihilism". Indeed, the existence of EMF, "detached" from its source, led to a conflict with the law of conservation of energy, according to which the energy of EMF is equal to the sum $\varepsilon_o E^2/2 + \mu_o H^2/2$, where E and H are the intensities of its electric and magnetic components; ε_o and μ_o are the "electric and magnetic permittivity" of vacuum. In an electromagnetic field, the intensities E and Hchange in-phase, which was proved by Faraday. Therefore, the EMF energy cannot remain constant when isolated from the sources. The transfer of electromagnetic oscillations in the environment discovered by Hertz did not provide a definite answer about the nature of the environmental oscillations themselves. They are not necessarily of electromagnetic nature. Hertz's experiments, revealing the transfer of electromagnetic oscillations in the environment from one body to another, didn't prove that the same kind of oscillations are inherent in the "luminiferous" medium itself. Such transfer can be realizedas a result of conversion of electromagnetic energy of the source into the energy of density oscillations of the "luminiferous" medium with their inverse transformation into electromagnetic oscillations in the radiation detector. This was claimed by N. Tesla, who discovered a special kind of "radiant" ("cold") electricity in the ether [35].

VIII. Systems Approach in Biochemistry and Biophysics

In biological systems, supplementary non-additive properties that require a systems approach are the following: the existence of "active transport" of matters (their transfer to the area of increased concentration), the phenomenon of "conjugation" of chemical reactions (when some of them go in the direction opposite to the chemical equilibrium), their ability to "self-organization" (structure formation), and so on. All phenomena of this kind are anti-dissipative in their nature, and according to I. Prigozhin's fair remark, this fact "flagrantly contradicts to thermodynamics". (I. Prigozhin). Thereby, the thermodynamic analysis of biological systems encounters significant fundamental challenges [36].

One of the ways to overcome these challenges is to consider any biological cell as a complex (polyvariant) system. This approach requires considering its structure (spatial heterogeneity) to the same extent as in macrosystems. Therefore, all the observations made earlier with respect to extensive Z_i and intensive $\mathbf{X}_i$ non-equilibrium parameters of the systems under study are valid for this purpose.

The next step is the refusal to justify the laws of biophysics on the basis of the theory of irreversible processes, since the latter does not consider the reversible component of real processes [17]. The performance of useful work by a biological system is one of the main signs of its vitality. As it is known, the maintenance of the non-equilibrium state of biosystems is accomplished by supplying it with free (ordered) energy from the outside. Therefore, the exclusion of the processes of performing useful work as described by the second sum of identity (1) from consideration is the same as "splashing out the water and the child as well".

Under the systems approach, vector flows J_i and forces $\mathbf{X}_i$ are determined not on the basis of the expression for entropy "production" dS/dt (as it was proposed by I. Prigozhin), but on the more general basis of the law of conservation of energy in the form (6). In this case, the product $J_i\mathbf{X}_i$, which characterizes the power of the process, reflects not only the relaxation processes ($J_i \cdot \mathbf{X}_i < 0$), but also the processes of removing the system from equilibrium by performing the internal work "against equilibrium" in it ($J_i\mathbf{X}_i > 0$). In biological systems, the postulated Onsager-Prigozhin linear kinetic laws (7), (8) are replaced by true «phenomenological» laws (9), (10) and (11), which have a reversible component (with the opposite sign of the off-diagonal components ($i \neq j$). They proved to be valid for processes of "active transport" of matters in biological systems, as well as for "ascending diffusion" in alloys, for electrolysis, dissociation, "self-organization", and so on, i.e., for all processes where the work "against equilibrium" is performed.

The systems approach also makes it possible to eliminate the contradiction of TIP with the Curie principle, according to which the flows J_j can depend only on thermodynamic forces X_i of the same (or even) tensor. In particular, scalar chemical reactions referred to in TIP as $\Sigma_r A_r d\xi_r$ (where A_r is the standard chemical affinity of the *r*-th chemical reaction, ξ_r is the degree of its completeness) cannot interact with metabolic processes of vector nature. Meanwhile, these are precisely the processes that play a key role in supporting the vital activity of biosystems. Prigozhin's hypothesis of "steady-state conjugation", which he put forward to overcome this difficulty, appeared to be unsatisfactory, since the mentioned interrelation is also preserved in non-stationary behaviors that are typical of biological systems.

Once again, the systems approach becomes useful here. According to this approach, chemical reactions in cell membranes, flow reactors, fuel cells, Van't-Goff boxes, and so on also acquire a vector character, and in this case, the function of the thermodynamic force of the r-th chemical reaction is fulfilled by the value $\mathbf{X}_r = \nabla A_r \xi_r$, conjugated to the flow of reagents J_r involved in it, which corresponds to the Curie principle [14].

Thus, the evidence reveals the limited applicability of the theory of irreversible processes to biological systems and the "inductive" construction of chemical physics and biophysics by extrapolating TIP to biological systems. In this regard, the crucial role is played by the replacement of entropic criteria of evolution by non-entropic ones, which are expressed directly by the moments of distribution of energy carriers Z_i or by forces $\mathbf{X}_i$, capable of increasing and decreasing in real processes. Such criteria can reflect not only the proximity of the system to equilibrium (its involution), but also its removal from it (evolution) [17]:

$d\mathbf{X}_i > 0$ (evolution); $d\mathbf{X}_i < 0$ (involution).

The introduction of more "physical" and intuitive criteria of evolution and involution provides an opportunity to reflect the behavior not only of the system as a whole ($\Sigma_j X_j dZ_j \neq 0$), but also of each degree of its freedom, i.e., it is more informative than entropy. It becomes obvious that the processes of "self-organization" in isolated systems ($dU = 0$) are the ordering of some (*i*-x) degrees of freedom due to the "disordering" of others (j-x) [17].

The systems approach enables to find a law of biological evolution that does not contradict classical thermodynamics. To achieve this, it is sufficient to compare the time it takes for a biosystem to reach a state of internal equilibrium in the presence and absence of evolutionary processes in it $X_j dZ_j > 0$. Then it becomes apparent that the evolutionary processes occurring in biological systems increase the duration of their reproductive periods. Therein lies the reason for the general orientation of the progressive evolution of biological systems, which is understood as a transition from simple to complex. Such a delay in achieving equilibrium in biosystems is close to the Darwinian idea of survival, and therefore it can be considered as an alternative to the rather straightforward idea of the "struggle for existence".

IX. Systems Approach to the Analysis of Physical Vacuum

Until recently, physics, thermodynamics, physical chemistry and other sciences have studied energy transfer in the real (structured) part of matter, which is no more than 5% of the Universe. However, the main energy transfer occurs in the remaining hidden mass of unstructured matter, which has only an oscillatory form of motion with a continual spectrum, which contributes to its invisibility (hence the term "dark" matter) [37]. Therefore, it is only natural to consider the environment in the form of unstructured matter (pre-matter) as a continual set of oscillators with a background frequency spectrum. Pre-matter oscillators are traveling waves that carry energy. Radiators, i.e., oscillators of matter represented as structured forms of baryonic matter (electrons, protons, neutrons, atoms, molecules, nanoparticles, plant cells and living organisms) transform the energy of pre-matter into its other forms as closed (standing) waves, which number is countable [5, 8]. The vibrations of the matter oscillators are transferred to the environment, modulating traveling waves in it with a spectrum different from the continual (background) one, making the structured matter visible ("light"). For an observer, structured matter is perceived by distinguishable radiations: light, thermal, electromagnetic, X-ray, chemiluminescence, photoluminescence, electroluminescence, radiant, torsion, microlepton, chronal, biofields, and others.

The analytical model of the origin of matter oscillators in the form of electron, proton, and neutron from pre-matter was first developed by N. A. Magnitsky (2010) [38-40]. The mechanism of interaction of matter and pre-matter in the form of convolution of a traveling wave into a closed wave of doubled period is proposed, resulting in two elementary particles with rest mass and opposite spins. It is shown that the electron is the first simplest period-doubling bifurcation from an infinite cascade of bifurcations in accordance with the universal Feigenbaum-Sharkovsky-Magnitsky (FSM) theory [40]. According to this theory, the discovered elementary particles are far from exhausting the infinite set of elementary particles that can appear as a result of bifurcations in the nonlinear system of equations of the pre-matter motion dynamics. Hence, two important consequences follow: 1) structured matter emerges from unstructured matter continuously, as does the reverse spontaneous decay of baryonic matter as a result of radioactive emission; 2) attempts to experimentally detect both the simplest (most elementary) and the most complex of elementary particles are unpromising. Instead of the point elementary particle concepts considered in theoretical physics, the wave internal structure of elementary particles as well as atoms and molecules of matter is justified. As a result, for the first time, an analytical description was given, reliably confirmed by experiments, of the structure of atoms of all chemical elements included in the table of D.I. Mendeleev from the positions of classical mechanics, whereas the table itself was returned to its original state [39], which had previously been distorted by numerous adjustments to the unsubstantiated postulates of the traditional quantum theory.

According to energodynamics, any wave (acoustic, hydraulic, electromagnetic, ether, etc.) is similar to a dipole, which determines the force nature of its interaction with the matter. Furthermore, the force manifests itself as a gradient of the amplitude-frequency potential [41]. Due to this, any interactions performed by oscillating intermediate medium, no matter how it is referred to (ether or field) also acquire a force nature, which is determined not by any special nature of acting forces, but by resonance amplification of energy exchange at the frequencies of natural oscillations of various structural elements of interacting agents. In energodynamics, this type of interaction is called resonant selective.

This interaction nature is confirmed by numerous phenomena of resonant absorption or emission observed in all fields of natural science. The resonant selective force interaction in the matter can be performed by the field of any oscillating scalar magnitude, i.e., it is not necessarily electromagnetic. In particular, the following can be considered: resonant absorption of energy of elastic or electromagnetic waves; "indifference" to atoms of a different "type", expressed in the concept of partial pressure; interaction of different chemical reagents in multiples defined for each of them; catalysis in chemical reactions; selective conductivity of membranes against different substances and solutions; selective absorption of certain substances by the surface of bodies; diffusion, osmosis, filtration of substances through semiconductor membranes; synchronization of radiation frequencies in lasers; selective interaction of proteins with RNA and selective effects of pharmaceuticals on the organism; preferential reproduction of certain ones and destruction of others in the processes of evolution, and so on and so forth.[42].

X. SYSTEMS APPROACH TO ASTROPHYSICS AND COSMOLOGY

At present, a true cosmological revolution is taking place, originated by the improvement of technical instruments of observational astronomy and characterized by an avalanche-like growth of new knowledge about the Universe. One of the fundamental results was the confirmation of the presence of two forms of matter in the Universe — observable and unobservable, referred to as ether, and after its expulsion from physics — hidden mass, physical vacuum, dark matter, etc. As it was mentioned above, the "visible" mass is not more than 5% of the matter amount in the Universe, and most of it is "hidden" (dark) and is not involved in electromagnetic interactions. The latter means that among the four types of interaction known to science only gravitational interaction is the only one left for it, so it shall be considered as the main form of energy of the Universe. The transformation of gravitational energy into other forms, discovered as early as in Galileo's experiments, is the basis of all evolutionary processes occurring in it. However, in order to prove it, it is essential to find a "primary" material carrier of gravity, which has an all-pervasive ability and can transform into any other forms of matter of the Universe. At this point, the knowledge that has reached us from the depths of millennia proves to be useful. The knowledge is about the existence of invisible and intangible "subtle" matter, which originally filled all the available space. And from this "subtle" matter the "rough" matter, which has boundaries and is called substance, was formed by compaction. In ancient India this medium was called "Akasha", in Europe of the Middle Ages — ether, and in post-classical physics — "hidden mass", "physical ("cosmic") vacuum", "dark matter", "dark energy", etc. The modern paradigm classifies this form of matter as field matter, which differs from matter in its continuity (lack of structure). All known forms of matter in the universe arose from it. The main feature of the "field medium" is the absence of boundaries, i.e., the ability to occupy the entire space without any voids. This property means that it is an indispensable component of any material system and it is included in identities (5) and (6) along with other material components.

According to modern data, the density of the field medium ρ_o is $\sim 10^{-27}$ g cm^{-3}, which is by dozen orders of magnitude less than the density of white dwarf stars. This is evidence of the heterogeneity of the matter of the Universe and the validity of the principle of counter directivity, with all the following consequences. One of them implies the possibility to consider the identity (6) as an "equation of the Universe", especially since it describes the entire set of processes occurring in it, besides the relationship between the space-time curvature and the energy-momentum tensor. The main advantage of this "equation of the Universe" in comparison with the well-known Einstein-Hilbert-Friedman model is that it does not require any hypotheses and postulates, it does not contain any concepts unfamiliar to classical physics, it does not contradict the law of conservation of energy and does not impose upon the Universe the simultaneous occurrence of the same processes in all its areas ("multiverses"). On the contrary, it indicates the inevitability of the counterdirectivity of the processes of evolution ($dZ_i > 0$) and involution ($dZ_i < 0$) in different areas of the Universe (galaxies and metagalaxies) and the possibility of simultaneous occurrence of such processes in the same areas of the Universe [17].

Another consequence of the systems energodynamic approach to the Universe is the validity of the bipolar law of gravity (8) with all its predictive capabilities [17]. According to this law, gravity is not an "innate property" of hidden matter, but it is due to the uneven distribution of its density in space. Furthermore, according to (8), the action of the gravitational forces $\mathbf{F}_g$ at a given point of space is directed along the density gradient of the latent mass $\nabla\rho_o$ in it. This means that in the area $\rho_0 > \bar{\rho}_0$, any material point is subject to "pushing" forces acting towards the area of increased density, which intensify the field heterogeneity spontaneously arisen in it. On the contrary, where $\rho_0 > \bar{\rho}_0$, there are "repulsion" forces, aiming to "move apart" such areas. Similar to the behavior of grease spots on the water surface, this results in the emergence of "voids" and explains the "scattering" of galaxies from each other as they compact without increasing the already infinite space of the Universe. This made it possible to construct a theory of gravity that predicts the formation of local condensations of hidden matter as spherical solitons forming the nuclei of future atoms, the formation of spherical shells of atoms of various substances around them, their combination into molecules, gases, liquids, solids, and so forth up to galaxies and their clusters [43]. This evolutionary branch of the Universe matter circulation comes to an end when the compression forces of the star, weakening with increasing density ρ, can no longer restrain the growth of internal pressure under the influence of thermonuclear reactions. This is when the "supernova explosion" occurs, which means the beginning of its involution and decay up to the initial state.

Another most important consequence of law (13) is the acknowledgment of gravity as the strongest of all interactions. It follows from the fact that the proportionality coefficient c^2 in (13) is at its maximum near the hidden mass, decreasing in optically dense matter by its refractive index. For this reason, Coulomb forces are weaker than gravitational ones, especially since the density of charges in a matter ρ_e is less than its density ρ. This turns the hidden mass into the "fuel of the Universe", since the energy $c^2\,\Delta M_o$ released during "condensation" (realification) is 931.5 MeV/a.m.u., which is orders of magnitude less than the heat release of thermonuclear reactions. The evidence of this is the higher temperature of the photosphere.

Other consequences of the law of gravity (8) are also experimentally verified: the character of their rotational curves due to the density gradient of the matter of spiral galaxies, the existence of autonomous gravity zones near the Earth and the Moon (gravity funnels with different sign $\boldsymbol{\nabla}\rho_0$), the matter flowing over from one galaxy to another (with larger $\boldsymbol{\nabla}\rho$) in the absence of convergence of their centers, the concentric arrangement of star clusters at a certain distance from the central ones, indicating their gravitational equilibrium, etc. [17].

The consequences of the systems energodynamic approach question the scenario of the origin and death of the Universe, derived from the analysis of the well-known Einstein-Hilbert-Friedman equation of the Universe. Indeed, it is sufficient to present this equation in the form of an integral taken over space (taking into account the spatial heterogeneity of the Universe), as it becomes obvious that all the consequences of its analysis should be attributed only to some of its areas. The nonstationary behavior of the Universe as a whole, the counterdirectivity and non-synchronism of processes due to delayed perturbations become obvious as well as the possibility of functioning of the Universe unlimited by time and space, bypassing the equilibrium state [44].

XI. CONCLUSION

A system-energodynamic approach to the construction of fundamental disciplines on a unified basis is formulated. This allows us to get rid of many paralogisms caused by the inductive nature of the construction of physics, based on a postulative (model) approach to describing the mechanisms of natural phenomena. The combination of inductive and deductive research methods significantly expands the horizons of natural science, in particular, it enriches the methodological base of engineering disciplines, opening up new ways and methods for solving practical problems.

REFERENCES

1. Koltovoi N. A. Scientific research into anomalous phenomena. Book 1–14. Moscow. 2023. Electronic edition. URL: https://koltovoi.nethouse.ru (In Russian).
2. Dorokhov I. N., Etkin V. A. System-energydynamic approach as a means of overcoming the crisis of theoretical physics. 1 World Science Championship in Dubai (August 2023) // Bulletin of the International Academy of System Research. Computer science, ecology, economics. RKhTUim. D. I. Mendeleeva, 2023. T.25. Part 2. S. 3–26. (In Russian).
3. Dorokhov I. N. Energy concept of the universe // Bulletin of the International Academy of System Research. Computer science, ecology, economics. RKhTUim. DI. Mendeleeva, 2021. T.23. pp. 3–78. (In Russian).
4. Dorokhov I. N. System analysis of natural and technological processes: textbook, allowance. M.: RKhTUim. D. I. Mendeleeva, 2022. – 260 p. (In Russian).

5. Dorokhov I. N. System-energydynamic analysis of natural and technological processes. – M. LENAND, 2023. – 336 p. (In Russian).
6. Dorokhov I. N. Inhomogeneity Axiom and Generalized Energy Conservation and Transformation Law. //ISSN 0040-5795. Theoretical Foundations of Chemical Engineering, 2023, Vol. 57, No. 3, pp. 327–337.
7. Dorokhov I. N. The Role of Energodynamics in the Scientific Bases of Chemical Technology. // ISSN 0040-5795. Theoretical Foundations of Chemical Engineering, 2023, Vol. 57, No. 5, pp. 563–580.
8. Dorokhov I. N. Energy dynamics of radiation and chemical bonding as a resonant-selective interaction.//ISSN 0040-5795. Theoretical Foundations of Chemical Engineering, 2023, Vol. 57, No. 6, pp. 708–719.
9. Dorokhov I. N. System-energydynamic approach to the convergence of natural sciences. // Bulletin of the International Academy of System Research. Computer science, ecology, economics. RKhTUim. D. I. Mendeleeva, 2023. T.25. Part 1. pp. 44–54. (In Russian).
10. Dorokhov I. N. Convergence of sciences as a result of the use of the apparatus of generalized functions in natural science. // Bulletin of the International Academy of System Research. Computer science, ecology, economics. RKhTUim. DI. Mendeleeva, 2022. T.24. pp. 24–49. (In Russian).
11. Kafarov V. V., Dorokhov I.N. System analysis of chemical technology processes. Basics of strategy. M.: Nauka, 1976. 500 p. (In Russian).
12. Etkin V. A. Fundamentals of energy dynamics. Togliatti: Publishing house Tol.PI, 1992.– 120 p. (In Russian).
13. Etkin V. A. Thermokinetics (thermodynamics of energy transfer and conversion processes). – Tolyatti: "Acad. business, 1999.– 228 pp. (In Russian); Etkin V. Thermokinetics (Synthesis of Heat Engineering Theoretical Grounds). - Haifa, Lulu Inc. Publ., 2010.– 334 p.
14. Etkin V. A. Energy dynamics (synthesis of theories of energy transfer and transformation) - St. Petersburg; "Science", 2008.- 409 pp. (In Russian).; Etkin V. Energodynamics (Thermodynamic Fundamentals of Synergetics). - N.Y., Lulu Inc. Publ., 2011.- 480 p.
15. Etkin V. A. Synthesis of the fundamentals of engineering disciplines (energy-dynamic approach to knowledge integration). – Lambert Acad. Publ., Saarbrücken, 2011, 290 pp. (In Russian); Etkin V. Energodynamics (Thermodynamic Fundamentals of Synergetics). - New York, 2011.- 480 p.
16. Etkin V. A. Theoretical foundations of fuel-free energy. Canada: Altaspera, 2013. 155 p. (In Russian).
17. Etkin V. A. Nontrivial consequences of energy dynamics. Haifa, 2020. LuluInc.(USA). 155 p. (In Russian).
18. Etkin V. Paralogisms of thermodynamics. Saarbrucken: Palmarium Ac. Publ., 2015. (In Russian).
19. Poincare A. Selected works. - M.: "Science", 1974. P. 429–433. (In Russian).
20. Landau L. D., Lifshits E.M. Theoretical physics. T.1. Mechanics. M.: Nauka, 1973. 208 p. T. 2. Field theory.: M.: Nauka, 1973. 504 p. (In Russian).
21. Einstein A. Creative biography // In the book "Physics and Reality". – M.: "Science", 1985. P. 131–166. (In Russian).
22. Onsager L. Reciprocal relations in irreversible processes. //Phys. Rev., 1931. – 237(14). P.405–426; 238(12). P.2265–2279.
23. Prigogine I. Introduction to thermodynamics of irreversible processes. – M.: "Publishing house of foreign, lit.", 1947. (In Russian).
24. Bazarov I.P. Thermodynamics. Ed. 4th. M.: Higher School, 1991. (In Russian).
25. De Groot S., Mazur R. Nonequilibrium thermodynamics. M.: Mir, 1964. (In Russian). De Groot S., Mazyr R. Non-Equilibrium Thermodynamics: Amsterdam, 1962.
26. Etkin V. Thermoimpulse as a True Extensive Measure of Heat. // Global Journal of Research in Engineering: G Industrial Engineering, 23(1)2023. P.21-31.
27. Etkin V. A. Reciprocity relations of reversible processes. //Sib. Phys.-Techn. zhurn., 1(1993). 2117-2121. (In Russian); Etkin V. Reciprocal relations of irreversible processes. // Soviet Journal of Appl. Physics, 1(1993).P. 62-64.
28. Etkin V. A. Correction and generalization of the principles of mechanics. //Reports of independent authors, 51(2021). 84-104. (In Russian); Etkin V. A. Synthesis of Thermodynamics and Continuum Mechanics. //Global Journal of Science Frontier Research: A Physics and Space Science, 22(4).2022. Online ISSN: 2249-4626 & Print ISSN: 0975-5896.
29. Etkin V. A. Bipolar law of gravity. //Reports of independent authors, 53(2021). 144-156. (In Russian); Etkin V. Gravitational repulsive forces and evolution of the universe. // Journal of Applied Physics (IOSR-JAP), 8(6), 2016. 43-49 (DOI: 10.9790/4861-08040).
30. Etkin V. A. Rethinking the foundations of quantum mechanics.//Problems of modern science and education, 12(132).2018, 6–14. DOI from 10.20861/2304-2338-2018-132-003. (In Russian). Etkin, V. A. Rethinking Quantum Mechanics. /IOSR Journal of Applied Physics (IOSR-JAP),10(6).2018.1-8. DOI: 10.9790/4861-1006010108.

31. Schrödinger E. New paths in physics. – M.: Nauka, 1971. (In Russian).
32. Etkin V. A. Correction of electrodynamics from the perspective of energy dynamics. // Reports of independent authors. 34(2015).193-208. (In Russian).; V. A. Etkin. Correction of Electrodynamics in the Question of the Magnetic Field Work. //Journal of Applied Physics (IOSR-JAP), 9(5). 2017. 71-75 DOI: 10.9790/4861-0905037175.
33. Landau L. D., Livshits E.M. Theoretical physics. T.8. Electrodynamics of continuous media. – M., Nauka, 1982, p.166. (In Russian).
34. Maxwell J. K. Treatise on electricity and magnetism. – M.: Nauka, 1989, T.1,2. (In Russian).
35. Tesla N. Lectures. Articles. – M., Tesla Print. - 2003. 386 p. (In Russian).
36. Etkin V. A. Towards an energy-dynamic theory of evolution. // Danish Scientific Journal, 21(1), 2019 45-50; Etkin V. A. Elimination of the Contradiction between Thermodynamics and Evolution. // Global Journal of Science Frontier Research: A Phys. and Space Science, 22(6)2022.P. 45-56.
37. Etkin V. A. On Wave Nature of Matter // World Scientific News. 69. 2017. P. 220–235.
38. Magnitsky N. A. Mathematical theory of physical vacuum. // Proceedings of NewInflow. M.: Institute of Microeconomics. 2010. 24 p. (In Russian).
39. Magnitsky N. A. The theory of compressible oscillating ether. M.: LENNAND. 2021, 216 p. (In Russian).
40. Magnitsky N. A. Dynamic chaos theory. M.: URSS, 2022. 320 p. (In Russian).
41. 41. Etkin V. A. On the potential and driving force of radiant heat transfer // Bulletin of the Haifa House of Scientists, 2010. T.XX. P.2–6. (In Russian).
42. Etkin V. A. On selective interaction / Bulletin of the House of Scientists of Haifa, 2012. T.29. P.2–8. (In Russian).
43. Etkin V. A. Criteria for the evolution of the Universe. // Problems of science, (2)38, 2019. 5-17. (In Russian); Etkin V. A. On the Dialectic Unity of Evolution and Involution. //Global Journal of Science Frontier Research: A. Physics and Space Science. 20(10)2020. P. 9-17.
44. Etkin V. A. Perpetual motion machine of the Universe. // Bulletin of the House of Scientists of Haifa, 52(2022). 4-19. (In Russian).; V. A. Etkin. Perpetual Movement of the Universe. //Aeronautics and Aerospace Open Access Journal, 6(2). 2022. P. 29–36.