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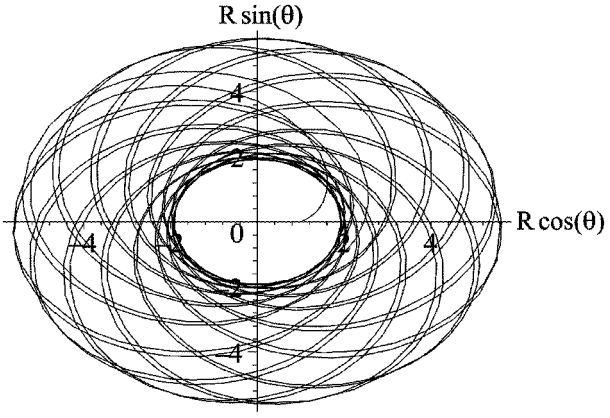
International Physical Journal



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EXTERIOR AND EVOLUTIONARY SKEW-SYMMETRIC DIFFERENTIAL FORMS AND THEIR ROLE IN MATHEMATICAL PHYSICS

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At present the theory of skew-symmetric exterior differential forms has been developed [1–6]. Th closed exterior differential forms may possess the invariant, group, tensor, structural and other properties that are of great functional and utilitarian importance. The operators of the exterior differential form theory lie at the basis of the differential and integral operators of the field theory. However, the theory of exterior differential forms, being invariant one, does not answer the questions related to the evolutionary processes. In the work the readers are introduced to the skew-symmetric differential forms that possess evolutionary properties [7,8]. They were called evolutionary ones. The mathematical apparatus of exterior and evolutionary differential forms allows description of discrete transitions, quantum steps, evolutionary processes, generation of various structures. These are radically new possibilities of the mathematical physics. In the paper is shown that a role of exterior and evolutionary differential forms in the mathematical physics is conditioned by the fact that they reflect properties of the conservation laws and allow elucidate a mechanism of evolutionary processes in material media, which lead to the rise of physical fields and formatting physical fields and phenomena.

Introduction

Development of the differential and integral calculus in 17 centure gave rise to a development of mathematical physics. Differential equations, boundary and initial problems enable one to describe many physical processes and phenomena. However, since the beginning of the 20th century a close connection of the differential and integral calculus and differential equations with physics has become weak. In mathematical physics it has arose the problem of invariant (independent of the choice of the coordinate system) description of physical phenomena. As the result, formalisms based on the tensor, group, variational methods, on the theories of the symmetries, transforms and so on with the basic requirement of invariance have been developed in physics. In particular, it is most evident in branches of physics that are related to field theories.

It turns out that the closed exterior differential forms possess by all the same properties (invariant, group, tensor, structural, and other ones) that lie at the basis that of all invariant approaches in the mathematical physics [9-13]. The role of differential forms in physics relates to that the closed differential forms reflect the properties of conservation laws and potentials. Invariant properties of closed exterior differential forms explicitly or implicitly manifest themselves essentially in all formalisms of the field theory, such as the Hamilton formalism, tensor approaches, group methods, quantum mechanics equations, the Yang-Mills theory and others. The exterior differential forms integrate the algebraic and geometric approaches in physics.

However, the invariant methods of the mathematical physics with all their significance nevertheless do not solve all the problems of methematical physics. They do not answer the question of related to the evolutionary processes, origination of various physical structures, formatting physical fields, a causality of physical phenomena, and so on. To answer these questions one again is forced to apply to the differential methods of investigations of the mathematical physics. And for these investigations the evolutionary differential forms appear to be necessary. They make it possible to keep track of the conjugacy of the equations, which describe physical processes that are necessary for investigating the evolutionary processes.

A significance of the evolutionary differential forms for mathematical physics, as well as of the exterior differential forms, is related to the fact that they reflect properties of the conservation laws. And, whereas properties of the closed differential forms correspond to the conservation laws for physical fields, properties of the evolutionary forms correspond to the conservation laws

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for material media.

The existence of the skew-symmetric differential forms (forms with exterior multiplication), which possess the evolutionary properties, has been established by the author while studying the problems of stability and generation of various physical structures. Investigation of these problems showed that there exists an unique mathematical apparatus of differential forms that makes it possible to elucidate the mechanism of evolutionary processes.

1. Properties and specific features of the exterior differential forms

The exterior differential form of degree p (p-form on the differentiable manifold) can be written as [5,6,11]

$$\theta^p = \sum_{i_1 \ldots i_p} a_{i_1 \ldots i_p} dx^{i_1} \wedge dx^{i_2} \wedge \ldots \wedge dx^{i_p}; \quad 0 \le p \le n. \tag{1.1}$$

Here $a_{i_1 \ldots i_p}$ are the functions of the variables x^{i_1}, x^{i_2}, $\ldots$, x^{i_p}, n is the dimension of space, $\wedge$ is the operator of exterior multiplication, dx^i, $dx^i \wedge dx^j$, $dx^i \wedge dx^j \wedge dx^k$, $\ldots$ is the local basis which satisfies the condition of exterior multiplication:

$$\begin{aligned} &dx^i \wedge dx^i = 0; \\ &dx^i \wedge dx^j = -dx^j \wedge dx^i, \quad i \ne j. \end{aligned} \tag{1.2}$$

[From here on the symbol $\sum$ will be omitted and it will be implied that the summation is performed over double indices. Besides, the symbol of exterior multiplication will be also omitted for the sake of presentation convenience].

The local domains of manifold are the basis of the exterior form.

It should be emphasized that the exterior differential forms and their operators are considered locally.

The differential of the (exterior) form θ^p is expressed as

$$d\theta^p = \sum_{i_1 \ldots i_p} da_{i_1 \ldots i_p} dx^{i_1} dx^{i_2} \ldots dx^{i_p}. \tag{1.3}$$

From definition of a differential one can see that, firstly, the differential of the exterior form is also the exterior form (but with the degree $(p+1)$), and, secondly, he can see that the components of the differential form commutator are coefficients of the form differential. Thus, the differential of the first-degree form $\omega = a_i dx^i$ can be written as $d\omega = K_{ij} dx^i dx^j$ where K_{ij} are the components of the commutator for the form ω that are defined as $K_{ij} = (\partial a_j / \partial x^i - \partial a_i / \partial x^j)$.

Closed exterior differential forms

In physical applications the closed differential forms with invariant properties appear to be of greatest practical utility.

A form is called a closed one if its differential is equal to zero:

$$d\theta^p = 0. \tag{1.4}$$

From condition (1.4) one can see that the closed form is a conservative quantity. This means that it can correspond to the conservation law, namely, to some conservative physical quantity.

The differential of the form is a closed form. That is

$$dd\omega = 0, \tag{1.5}$$

where ω is an arbitrary exterior form.

The form which is the differential of some other form

$$\theta^p = d\theta^{p-1} \tag{1.6}$$

is called an exact form. The exact forms prove to be closed automatically [9]

$$d\theta^p = dd\theta^{p-1} = 0. \tag{1.7}$$

Here it is necessary to pay attention to the following points. In the above presented formulas it was implicitly assumed that the differential operator d is the total one (that is, the operator d acts everywhere in the vicinity of the point considered locally), and therefore it acts on the manifold of the initial dimension n. However, the differential may be internal. Such a differential acts on some structure with the dimension being less than that of the initial manifold. The structure, on which the exterior differential form may become a closed inexact form, is a pseudostructure with respect to its metric properties. {Cohomology, sections of cotangent bundles, the eikonal surfaces and so on may be regarded as examples of pseudostructures.} The properties of pseudostructures will be considered later.

If the form is closed on a pseudostructure only, the closure condition is written as

$$d_\pi \theta^p = 0. \tag{1.8}$$

And the pseudostructure π obeys the condition

$$d_\pi {}^*\theta^p = 0, \tag{1.9}$$

where ${}^*\theta^p$ is the dual form. (For the properties of dual forms see [12]).

¿From conditions (1.8) and (1.9) one can see that the form closed on pseudostructure (a closed inexact form) is a conservative object, namely, this quantity conserves on pseudostructure. This can also correspond to some conservation law, i.e. to conservative object. (These are precisely the objects which are physical structures that form physical fields.)

The exact form is, by definition, a differential (see condition (1.6)). In this case the differential is total. The closed inexact form is a differential too. The closed inexact form is an interior (on pseudostructure) differential, that is

$$\theta^p_\pi = d_\pi \theta^{p-1}. \tag{1.10}$$

And so, any closed form is a differential of the form of a lower degree: the total one $\theta^p = d\theta^{p-1}$ if the form is exact, or the interior one $\theta^p = d_\pi \theta^{p-1}$ on pseudostructure if the form is inexact. From this it follows that the form of lower degree may correspond to the potential, and the closed form by itself may correspond to the potential force.

Invariant properties of closed exterior differential forms. Conjugacy of the exterior differential forms

Since the closed form is a differential (a total one if the form is exact, or an interior one on the pseudostructure if the form is inexact), then it is obvious that the closed form proves to be invariant under all transforms that conserve the differential. The unitary transforms (0-form), the tangent and canonical transforms (1-form),the gradient and gauge transforms (2-form) and so on are examples of such transforms. *These are gauge transforms for spinor, scalar, vector, tensor (3-form) fields.* (It is to be pointed out that just such transforms are used in field theory).

As mentioned above, from the closure condition it follows that the closed exterior differential forms are conservative objects. As the result, the closed form is a conservative invariant object. The covariance of the dual form is directly connected with the invariance of the exterior closed inexact form. This property of closed exterior differential forms and dual forms plays an essential role in describing the conservation laws and lies at the basis of the field theory.

The closure of the exterior differential forms and hence their invariance result from the conjugacy of elements of the exterior or dual forms.

From the definition of the exterior differential form one can see that the exterior differential forms have complex structure. The specific features of the exterior form structure are homogeneity with respect to the basis, skew-symmetry, the integration of terms each consisting of two objects of different nature (the algebraic nature for the form coefficients, and the geometric nature for the base components). Besides, the exterior form depends on the space dimension and on the manifold topology. The closure property of the exterior form means that any objects, namely, elements of the exterior form, components of elements, elements of the form differential, exterior and dual forms and others, turn out to be conjugated. It is the conjugacy that leads to realization of the invariant and covariant properties of the exterior and dual forms that have a great functional and applied importance. The variety of objects of conjugacy leads to the fact that the closed forms can describe a great number of different physical and spatial structures, and this fact once again emphasizes great mathematical potentialities of the exterior differential forms.

Operators of the theory of exterior differential forms

In differential calculus the derivatives are basic elements of the mathematical apparatus. By contrast, the differential is an element of mathematical apparatus of the theory of exterior differential forms. It enables one to analyze the conjugacy of derivatives in various directions, which extends potentialities of differential calculus.

The operator of exterior differential d (exterior differential) is an abstract generalization of ordinary mathematical operations of the gradient, curl, and divergence in the vector calculus [6]. If, in addition to the exterior differential, we introduce the following operators: (1) δ for transforms that convert the form of $p+1$ degree into the form of p degree, (2) δ' for cotangent transforms, (3) Δ for the $d\delta - \delta d$ transform, (4) Δ' for the $d\delta' - \delta' d$ transform, then in terms of these operators that act on the exterior differential forms one can write down the operators in the field theory equations. The operator δ corresponds to Green's operator, δ' does to the canonical transform operator, Δ does to the d'Alembert operator in 4-dimensional space, and Δ' corresponds to the Laplace operator [11-13]. It can be seen that the operators of the exterior differential form theory are connected with many operators of mathematical physics.

Identical relations of exterior differential forms

In the theory of exterior differential forms the closed forms that possess various types of conjugacy play a principal role. Since the conjugacy is a certain connection between two operators or mathematical objects, it is evident that relations can be used to express conjugacy mathematically. Just such relations constitute the basis of the mathematical apparatus of the exterior differential forms. This is an identical relation.

The identical relations for exterior differential forms reflect the closure conditions of the differential forms, namely, vanishing the form differential (see formulas (1.4), (1.8), (1.9)) and the conditions connecting the forms of consequent degrees (see formulas (1.6), (1.10)).

The importance of the identical relations for exterior differential forms is manifested by the fact that practically in all branches of physics, mechanics, thermodynamics one faces such identical relations. One can present the following examples:

a) the Poincare invariant $ds = -H\,dt + p_j\,dq_j$,

b) the second principle of thermodynamics $dS = (dE + p\,dV)/T$,

c) the vital force theorem in theoretical mechanics: $dT = X_i dx^i$, where X_i are the components of the potential force, and $T = mV^2/2$ is the vital force,

d) the conditions on characteristics [14] in the theory of differential equations, and so on.

The identical relations in differential forms express the fact that each closed exterior form is a differential of some exterior form (with the degree less by one). In general form such an identical relation can be written as

$$d_\pi \phi = \theta^p_\pi . \tag{1.11}$$

In this relation the form in the right-hand side has to be a *closed* one. (As it will be shown below, the identical relations are satisfied only on pseudostructures).

In identical relation (1.11) in one side it stands the closed form and in other side does the differential of some differential form of the less by one degree, which is the closed form as well.

In addition to relations in the differential forms from the closure conditions of the differential forms and the conditions connecting the forms of consequent degrees the identical relations of other types are obtained. The types of such relations are presented below.

1. *Integral identical relations.*

The formulas by Newton, Leibnitz, Green, the integral relations by Stokes, Gauss-Ostrogradskii are examples of integral identical relations.

2. *Tensor identical relations.*

From the relations that connect exterior forms of consequent degrees one can obtain the vector and tensor identical relations that connect the operators of the gradient, curl, divergence and so on.

From the closure conditions of exterior and dual forms one can obtain the identical relations such as the gauge relations in electromagnetic field theory, the tensor relations between connectednesses and their derivatives in gravitation (the symmetry of connectednesses with respect to lower indices, the Bianchi identity, the conditions imposed on the Christoffel symbols) and so on.

3. *Identical relations between derivatives.*

The identical relations between derivatives correspond to the closure conditions of exterior and dual forms. The examples of such relations are the above presented Cauchi-Riemann conditions in the theory of complex variables, the transversality condition in the calculus of variations, the canonical relations in the Hamilton formalism, the thermodynamic relations between derivatives of thermodynamic functions [15], the condition that the derivative of implicit function is subjected to, the eikonal relations [16] and so on.

Nondegenerate transforms

One of the fundamental methods in the theory of exterior differential forms is application of *nondegenerate* transforms (below it will be shown that *degenerate* transforms appear in the mathematical apparatus of the evolutionary forms).

Nondegenerate transforms, if applied to identical relations, enable one to obtain new identical relations and new closed exterior differential forms.

In the theory of exterior differential forms the nondegenerate transforms are those that conserve the differential. The examples of nondegenerate transforms are unitary, tangent, canonical, gradient, and gauge transforms.

From description of operators of exterior differential forms one can see that those are operators that execute some transforms. All these transforms are connected with the above listed nondegenerate transforms of exterior differential forms.

Thus, even from this brief description of the properties and specific features of the exterior differential forms can clearly see wide functional and utilitarian potentialities of exterior differential forms.

Before going to description of a new evolutionary differential forms it should dwell on the properties of manifolds on which skew-symmetric differential forms are defined.

2. Some properties of manifolds

In the definition of exterior differential forms a differentiable manifold was mentioned. Differentiable manifolds are topological spaces that locally behave like Euclidean spaces [9,17].

But differentiable manifolds are not a single type of manifolds on which the exterior differential forms are defined. In the general case there are manifolds with structures of any types. The theory of exterior differential forms was developed just for such manifolds. They may be the Hausdorff manifolds, fiber spaces, the comological, characteristical, configuration manifolds and so on. These manifolds and their properties are treated in [2,4,9,11] and in some other works. Since all these manifolds possess structures of any types, they have one common property, namely, locally they admit one-to-one mapping into the Euclidean subspaces and into other manifolds or submanifolds of the same dimension [9].

While describing the evolutionary processes in material system one is forced to deal with manifolds which do not allow one-to-one mapping described above. The manifolds that can be called accompanying manifolds are variable manifolds. The differential forms that arise when evolutionary processes are being described can be defined on manifolds of this type.

What are the characteristic properties and specific features of accompanying manifolds and of evolutionary differential forms connected with them?

To answer this question, let us analyze some properties of metric forms.

Assume that on the manifold one can set the coordinate system with base vectors $\mathbf{e}_\mu$ and define the metric forms of manifold [18]: $(\mathbf{e}_\mu \mathbf{e}_\nu)$, $(\mathbf{e}_\mu \mathbf{dx}^\mu)$, $(d\mathbf{e}_\mu)$. The metric forms and their commutators define the metric and differential characteristics of the manifold.

If metric forms are closed (the commutators are equal to zero), then the metric is defined $g_{\mu\nu} = (\mathbf{e}_\mu \mathbf{e}_\nu)$ and the results of translation over manifold of the point $d\mathbf{M} = (\mathbf{e}_\mu \mathbf{dx}^\mu)$ and of the unit frame $d\mathbf{A} = (\mathbf{de}_\mu)$ prove to be independent of the curve shape (the path of integration).

The closed metric forms define the manifold structure, and the commutators of metric forms define the manifold differential characteristics that specify the manifold deformation: bending, torsion, rotation, twist.

It is evident that manifolds that are metric ones or possess the structure have closed metric forms. It is with such manifolds that the exterior differential forms are connected.

If the manifolds are deforming manifolds, this means that their metric form commutators are nonzero. That is, the metric forms of such manifolds turn out to be unclosed. The accompanying manifolds appearing to be deforming are the examples of such manifolds.

The skew-symmetric evolutionary differential forms whose basis are accompanying deforming manifolds are defined on manifolds with unclosed metric forms.

What are the characteristic properties and specific features of such manifolds and the related differential forms?

For description of the manifold differential characteristics and, correspondingly, the metric forms commutators one can use the connectednesses [2,5,9,18].

Let us consider the affine connectednesses and their relations to commutators of metric forms.

The components of metric forms can be expressed in terms of connectedness $\Gamma^\rho_{\mu\nu}$ [18]. The expressions $\Gamma^\rho_{\mu\nu}$, $(\Gamma^\rho_{\mu\nu} - \Gamma^\rho_{\nu\mu})$, $R^\mu_{\nu\rho\sigma}$ are components of the commutators of the metric forms of zero- first- and third degrees. (The commutator of the second degree metric form is written down in a more complex manner [18], and therefore it is not given here).

As it is known [18], for the Euclidean manifold these commutators vanish identically. For the Riemann manifold the commutator of the third-degree metric form is nonzero: $R^\mu_{\nu\rho\sigma} \neq 0$.

Commutators of interior metric forms vanish in the case of manifolds that allow local one-to-one mapping into subspaces of the Euclidean space. In other words, the metric forms of such manifolds turn out to be closed.

With the metric form commutators the topological properties of manifolds are connected. The metric form commutators specify the manifold distortion. For example, the commutator of the zero degree metric form $\Gamma^\rho_{\mu\nu}$ characterizes the bend, that of the first degree form $(\Gamma^\rho_{\mu\nu} - \Gamma^\rho_{\nu\mu})$ characterizes the torsion, the commutator of the third -degree metric form $R^\mu_{\nu\rho\sigma}$ determines the curvature.

As it will be shown in the next section, it is with the properties of the metric form commutators that the characteristic properties of differential forms whose basis are manifolds with unclosed metric forms are connected.

3. Evolutionary differential forms

Thus, the exterior differential forms are skew-symmetric differential forms defined on manifolds, submanifolds or on structures with closed metric forms. The evolutionary differential forms are skew-symmetric differential forms defined on manifolds with metric forms that are unclosed.

Let us point cut some properties of evolutionary forms and show what their difference from exterior differential forms is manifested in. An evolutionary differential form of degree p (p-form), as well as an exterior differential form, can be written down as

$$\omega^p = \sum_{\alpha_1 \ldots \alpha_p} a_{\alpha_1 \ldots \alpha_p} dx^{\alpha_1} \wedge dx^{\alpha_2} \wedge \ldots \wedge dx^{\alpha_p}; \quad 0 \leq p \leq n, \tag{3.1}$$

where the local basis obeys the condition of exterior multiplication

$$dx^\alpha \wedge dx^\alpha = 0;$$
$$dx^\alpha \wedge dx^\beta = -dx^\beta \wedge dx^\alpha, \quad \alpha \neq \beta$$

(the summation over repeated indices is implied).

But the evolutionary form differential cannot be written similarly to that presented for exterior differential forms (see formula (1.3)). In the evolutionary form differential there appears an additional term connected with the fact that the basis of the form changes. For the differential forms defined on the manifold with unclosed metric form one has $d(dx^{\alpha_1} dx^{\alpha_2} \ldots dx^{\alpha_p}) \neq 0$. For this reason the differential of the evolutionary form ω^p can be written as

$$d\omega^p = \sum_{\alpha_1 \ldots \alpha_p} da_{\alpha_1 \ldots \alpha_p} dx^{\alpha_1} dx^{\alpha_2} \ldots dx^{\alpha_p} + \sum_{\alpha_1 \ldots \alpha_p} a_{\alpha_1 \ldots \alpha_p} d(dx^{\alpha_1} dx^{\alpha_2} \ldots dx^{\alpha_p}), \tag{3.2}$$

where the second term is connected with the differential of the basis. That is expressed in terms of the metric form commutator. For the manifold with a closed metric form this term vanishes.

For example, let us consider the first-degree form $\omega = a_\alpha dx^\alpha$. The differential of this form can be written as $d\omega = K_{\alpha\beta} dx^\alpha dx^\beta$, where $K_{\alpha\beta} = a_{\beta;\alpha} - a_{\alpha;\beta}$ are the components of the commutator of the form ω, and $a_{\beta;\alpha}$, $a_{\alpha;\beta}$ are the covariant derivatives. If we express the covariant derivatives in terms of the connectedness (if it is possible), then they can be written as $a_{\beta;\alpha} = \partial a_\beta / \partial x^\alpha + \Gamma^\sigma_{\beta\alpha} a_\sigma$, where the first term results from differentiating the form coefficients, and the second term results from differentiating the basis. (In the Euclidean space the covariant derivatives coincide with ordinary ones since in this case the derivatives of the basis vanish). If we substitute the expressions for covariant derivatives into the formula for the commutator

components, then we obtain the following expression for the commutator components of the form ω:

$$K_{\alpha\beta} = \left(\frac{\partial a_\beta}{\partial x^\alpha} - \frac{\partial a_\alpha}{\partial x^\beta}\right) + (\Gamma^\sigma_{\beta\alpha} - \Gamma^\sigma_{\alpha\beta})a_\sigma. \qquad (3.3)$$

Here the expressions $(\Gamma^\sigma_{\beta\alpha} - \Gamma^\sigma_{\alpha\beta})$ entered into the second term are just the components of commutator of the first-degree metric form.

That is, the corresponding metric form commutator will enter into the differential form commutator.

Thus, the differentials and, correspondingly, the commutators of exterior and evolutionary forms are of different types.

Nonclosure of evolutionary differential forms

The evolutionary differential form commutator, in contrast to that of the exterior one, cannot be equal to zero because it involves the metric form commutator being nonzero. This means that the evolutionary form differential is nonzero. Hence, the evolutionary differential form, in contrast to the case of the exterior form, cannot be closed.

Since the evolutionary differential forms are unclosed, the mathematical apparatus of evolutionary differential forms does not seem to possess any possibilities connected with the algebraic, group, invariant and other properties of closed exterior differential forms. However, the mathematical apparatus of evolutionary forms proves to be significantly wider due to the fact that evolutionary differential forms can generate closed exterior differential forms. The mathematical apparatus of evolutionary differential forms includes, as it will be shown below, some new unconventional elements.

Nonidentical relations of evolutionary differential forms

Above it was shown that the identical relations lie at the basis of the mathematical apparatus of exterior differential forms.

In contrast to this, nonidentical relations lie at the basis of the mathematical apparatus of evolutionary differential forms.

The nonidentical relation is a relation between a closed exterior differential form, which is a differential and is a measurable quantity, and an evolutionary form that is an unmeasurable quantity.

Nonidentical relations of such type appear in descriptions of the physical processes. They may be written as

$$d\psi = \omega^p. \qquad (3.4)$$

Here ω^p is the p-degree evolutionary form that is nonintegrable, ψ is some form of degree $(p-1)$, and the differential $d\psi$ is a closed form of degree p.

This relation is an evolutionary relation as it involves an evolutionary form.

In the left-hand side of this relation it stands the form differential, i.e. a closed form that is an invariant object. In the right-hand side it stands the nonintegrable unclosed form that is not an invariant object. Such a relation cannot be identical.

One can see a difference of relations for exterior forms and evolutionary ones. In the right-hand side of identical relation (1.11) it stands a closed form, whereas the form in the right-hand side of nonidentical relation (3.4) is an unclosed one.

How is this relation obtained?

Let us consider this by the example of the first degree differential forms. A differential of the function of more than one variables can be an example of the first degree form. In this case the function itself is the exterior form of zero degree. The state function that specifies the state of a material system can serve as an example of such function. When the physical processes in a material system are being described, the state function may be unknown, but its derivatives may be known. The values of the function derivatives may be equal to some expressions that are obtained from the description of a real physical process. And it is necessary to find the state function.

Assume that ψ is the desired state function that depends on the variables x^α and also assume that its derivatives in various directions are known and equal to some quantities a_α, namely:

$$\frac{\partial\psi}{\partial x^\alpha} = a_\alpha. \qquad (3.5)$$

Let us set up the differential expression $(\partial\psi/\partial x^\alpha)dx^\alpha$ (here the summation over repeated indices is implied). This differential expression is equal to

$$\frac{\partial\psi}{\partial x^\alpha}dx^\alpha = a_\alpha dx^\alpha. \qquad (3.6)$$

Here the left-hand side of the expression is a differential of the function $d\psi$, and in the right-hand side it stands the differential form $\omega = a_\alpha dx^\alpha$. Relation (3.6) can be written as

$$d\psi = \omega. \qquad (3.7)$$

It is evident that relation (3.7) is of the same type as (3.4) under the condition that the differential form degrees are equal to 1.

This relation is nonidentical because the differential form ω is an unclosed differential form. The commutator of this form is nonzero since the expressions a_α for the derivatives $(\partial\psi/\partial x^\alpha)$ are nonconjugated quantities. They are obtained from the description of an actual physical process and are unmeasurable quantities.

One can come to relation (3.7) by means of analyzing the integrability of the partial differential equation. An equation is integrable if it can be reduced to the form $d\psi = dU$. However it appears that, if the equation is not subjected to an additional condition (the

integrability condition), it is reduced to the form (3.7), where ω is an unclosed form and it cannot be expressed as a differential. The first principle of thermodynamics is an example of nonidentical relation.

How to work with nonidentical relation?

While investigating real physical processes one often faces the relations that are nonidentical. But it is commonly believed that only identical relations can have any physical meaning. For this reason one immediately attempts to impose a condition onto the nonidentical relation under which this relation becomes identical, and it is considered only that can satisfy the additional conditions. And all remaining is rejected. It is not taken into account that a nonidentical relation is often obtained from a description of some physical process and it has physical meaning at every stage of the physical process rather than at the stage when the additional conditions are satisfied. In essence the physical process does not considered completely.

This approach does not solve the evolutionary problem.

Below we present the evolutionary approach to the investigation of the nonidentical relation.

At this point it should be emphasized that the nonidentity of the evolutionary relation does not mean the imperfect accuracy of the mathematical description of a physical process. The nonidentical relations are indicative of specific features of the physical process development.

Selfvariation of the evolutionary nonidentical relation

The evolutionary nonidentical relation is selfvarying, because, firstly, it is nonidentical, namely, it contains two objects one of which appears to be unmeasurable, and, secondly, it is an evolutionary relation, namely, the variation of any object of the relation in some process leads to variation of another object and, in turn, the variation of the latter leads to variation of the former. Since one of the objects is an unmeasurable quantity, the other cannot be compared with the first one, and hence, the process of mutual variation cannot stop. This process is governed by the evolutionary form commutator.

Varying the evolutionary form coefficients leads to varying the first term of the commutator (see (3.3)). In accordance with this variation it varies the second term, that is, the metric form of the manifold varies. Since the metric form commutators specifies the manifold differential characteristics that are connected with the manifold deformation (for example, the commutator of the zero degree metric form specifies the bend, that of second degree specifies various types of rotation, that of the third degree specifies the curvature), then it points to the manifold deformation. This means that it varies the evolutionary form basis. In turn, it leads to variation of the evolutionary form, and the process of intervariation of the evolutionary form and the basis is repeated. The processes of variation of the evolutionary form and the basis are governed by the evolutionary form commutator and it is realized according to the evolutionary relation.

Selfvariation of the evolutionary relation goes on by exchange between the evolutionary form coefficients and the manifold characteristics. This is an exchange between physical quantities and space-time characteristics. (This is an exchange between quantities of different nature).

The process of the evolutionary relation selfvariation cannot come to an end. This is indicated by the fact that both the evolutionary form commutator and the evolutionary relation involve unmeasurable quantities.

The question arises whether an identical relation can be obtained from this nonidentical selfvarying relation, which would allow determination of the desired differential form under the differential sign.

It appears that it is possible under the degenerate transform.

Degenerate transforms.

To obtain an identical relation from the evolutionary nonidentical relation, it is necessary that a closed exterior differential form should be derived from the evolutionary differential form that is included into evolutionary relation.

However, as it was shown above, the evolutionary form cannot be a closed form. For this reason the the transition from an evolutionary form is possible only to an *inexact* closed exterior form that is defined on pseudostructure.

To the pseudostructure there corresponds a closed dual form (whose differential vanishes). For this reason a transition from an evolutionary form to a closed exterior form proceeds only when the conditions of vanishing the dual form differential are realized, in other words, when the the metric form differential or commutator becomes equal to zero.

The conditions of vanishing the dual form differential (additional conditions) determine the closed metric form and thereby specify the pseudostructure (the dual form).

In this case the closed exterior (*inexact*) form is formed. The evolutionary form commutator and, correspondingly, the evolutionary form differential vanish on the pseudostructure.

At this point it should be emphasized that the commutator, that equals zero, (and the differential) is an interior one. This commutator is defined only on the pseudostructure, the total commutator being nonzero.

The evolutionary form remains to be unclosed.

Since the evolutionary form differential is nonzero, whereas the closed exterior form differential is zero, then a passage from the evolutionary form to the closed exterior form is allowed only under *degenerate transform*.

The conditions of vanishing the dual form differential (an additional condition) are the conditions of degenerate transform.

Additional conditions can be realized, for example, if it will appear any symmetries of the evolutionary form coefficients or its commutator. This can happen under selfvariation of the nonidentical relation. (Whyle describing material system such additional conditions are related, for example, to additional degrees of freedom).

Mathematically to the conditions of degenerate transform there corresponds a requirement that some functional expressions become equal to zero. Such functional expressions are Jacobians, determinants, the Poisson brackets, residues, and others.

Obtaining an identical relation from a nonidentical one

Assume that the nonidentical relation has the form of (3.4) and from the evolutionary form ω^p the differential form closed on pseudostructure was obtained. Since the closed exterior form is a differential, in this case the evolutionary relation (3.4) becomes identical on the pseudostructure. From this relation one can find the desired differential $d_\pi \psi$ that is equal to the closed exterior differential form derived. One can obtain the desired form ψ from this differential.

It can be shown that all identical relations of the exterior differential form theory are obtained from nonidentical relations (that contain the evolutionary forms) by applying the degenerate transform.

Under degenerate transform the evolutionary form differential vanishes only on pseudostructure. The total differential of the evolutionary form is nonzero. The evolutionary form tremains unclosed.

Integration of the nonidentical evolutionary relation

Under degenerate transform from the nonidentical evolutionary relation one obtains a relation being identical on pseudostructure. It is just a relation that one can integrate and obtain the relation with the differential forms of less by one degree.

The relation obtained after integration proves to be nonidentical as well.

The obtained nonidentical relation of degree $(p-1)$ can be integrated once again if the corresponding degenerate transform is realized and the identical relation is formed.

By sequential integrating the evolutionary relation of degree p (in the case of realization of the corresponding degenerate transforms and forming the identical relation), one can get closed (on the pseudostructure) exterior forms of degree k, where k ranges from p to 0.

In this case one can see that under such integration closed (on the pseudostructure) exterior forms, which depend on two parameters, are obtained. These parameters are the degree of evolutionary form p (in the evolutionary relation) and the degree of created closed forms k.

In addition to these parameters, another parameter appears, namely, the dimension of space. If the evolutionary relation generates the closed forms of degrees $k=p$, $k=p-1$, ..., $k=0$, to them there correspond the pseudostructures of dimensions $(N-k)$, where N is the space dimension. It is known that to the closed exterior differential forms of degree k there correspond skew-symmetric tensors of rank k and to corresponding dual forms there do the pseudotensors of rank $(N-k)$, where N is the space dimensionality. The pseudostructures correspond to such tensors, but only on the space formed.

The properties of pseudostructures and closed exterior forms. Forming fields and manifolds

As mentioned before, the additional conditions, namely, the conditions of degenerate transform, specify the pseudostructure. But at every stage of the evolutionary process it is realized only one element of pseudostructure, namely, a certain minipseudostructure. The additional conditions determine the direction (a derivative that specifies the minipseudostructure) on which the evolutionary form differential vanishes. (However, in this case the total differential of the evolutionary form is nonzero). The closed exterior form is formed along this direction.

While varying the evolutionary variable the minipseudostructures form the pseudostructure.

The example of minipseudoctructure is the wave front. The wave front is the eikonal surface (the level surface), i.e. the surface with a conservative quantity. The direction that specifies the pseudostructure is a connection between the evolutionary and spatial variables. It gives the rate of changing the spatial variables. Such a rate is a velocity of the wave front translation. While its translation the wave front forms the pseudostructure.

The manifolds with closed metric forms are formed by pseudostructures. They are obtained from manifolds with unclosed metric forms. In this case the initial manifold (on which the evolutionary form is defined) and the formed manifold with closed metric forms (on which the closed exterior form is defined) are different spatial objects.

It takes place a transition from the initial manifold with unclosed metric form to the pseudostructure, namely, to the created manifold with closed metric forms. Mathematically this transition (degenerate transform) proceeds as a transition from one frame of reference to another, nonequivalent, frame of reference.

The pseudostructures, on which the closed *inexact* forms are defined, form the pseudomanifolds (integral surfaces, pseudo-Riemann and pseudo-Euclidean spaces are the examples of such manifolds). In this process the dimensions of formed manifolds are connected with the evolutionary form degree (This will be shown in sections 5 and 6).

To the transition from pseudomanifolds to metric manifolds there corresponds the transition from closed *inexact* differential forms to *exact* exterior differential forms. (Euclidean and Riemann spaces are the examples of metric manifolds).

Here it is to be noted that the examples of pseudometric spaces are the potential surfaces (the surfaces of a simple layer, a double layer and so on). In these cases a type of the potential surfaces is connected with the above listed parameters.

The fields of conservative quantities (the physical fields) are formed from closed exterior forms at the same time when the manifolds are created from the pseudoctructures. The specific feature of the manifolds with closed metric forms that have been formed is that they can carry some information.

Since the closed metric form is dual with respect to some closed exterior differential form, the metric forms cannot become closed by themselves, independently of the exterior differential form. This proves that the manifolds with closed metric forms are connected with the closed exterior differential forms. This indicates that the fields of conservative quantities are formed from closed exterior forms at the same time when the manifolds are created from the pseudoctructures. The specific feature of the manifolds with closed metric forms that have been formed is that they can carry some information.

That is, the closed exterior differential forms and manifolds, on which they are defined, are mutually connected objects. On the one hand, this shows duality of these two objects (the pseudostructure and the closed inexact exterior form), and, on the other hand, this means that these objects constitute a unified whole. This whole is a new conjugated object. This is an example of the differential and geometrical structure (G-Structure). Such binary object can be named as Bi-Structure.

Characteristics of the Bi-Structure

Since the closed exterior differential form that corresponds to the arisen Bi-Structure was obtained from the nonidentical relation that involves the evolutionary form, it is evident that the Bi-Structure characteristics must be connected with those of the evolutionary form and of the manifold on which this form is defined, with the conditions of degenerate transform and with the values of commutators of the evolutionary form and the manifold metric form.

While describing the mechanism of Bi-Structure origination one can see that at the instant the Bi-Structure originates there appear the following typical functional expressions and quantities: (1) the condition of degenerate transform, i.e. vanishing of the interior commutator of the metric form; (2) vanishing of the interior commutator of the evolutionary form; (3) the value of the nonzero total commutator of the evolutionary form that involves two terms, namely, the first term is composed of the derivatives of the evolutionary form coefficients, and the second term is composed of the derivatives of the coefficients of the dual form that is connected with the manifold (here we deal with a value that the evolutionary form commutator assumes at the instant of Bi-Structure origination). They determine the following characteristics of the Bi-Structure. The conditions of degenerate transform, as it was said before, determine the pseudostructures. The first term of the evolutionary form commutator determines the value of the discrete change (the quantum), which the quantity conserved on the pseudostructure undergoes at the transition from one pseudostructure to another. The second term of the evolutionary form commutator specifies a characteristic that fixes the character of the initial manifold deformation that took place before the Bi-Structure arose. (Spin is such an example).

A discrete (quantum) change of a quantity proceeds in the direction that is normal (more exactly, transverse) to the pseudostructure. Jumps of the derivatives normal to the potential surfaces are examples of such changes.

Bi-Structure may carry a physical meaning. Such bynary objects are the physical structures from which the physical fields are formed. (About this it will be written below).

Transition from nonconjugated operators to conjugated operators

The mathematical apparatus of the evolutionary differential forms reveals the process of conjugating the operators. A mutual variations of the evolutionary form coefficients (which have the algebraic nature) and the manifold characteristics (which have the geometric nature) and the realization of the degenerate transform as well is the mechanism of this process. Hence one can see that the process of conjugating the operators is a mutual exchange between the physical and spatial quantities (between the quantities of different nature) and the degenerate transform under additional conditions.

The evolutionary differential form is an unclosed form, that is, it is the form whose differential is not equal to zero. The differential of the exterior differential form equals zero. To the closed exterior form there correspond conjugated operators, whereas to the evolutionary form there correspond nonconjugated operators. The transition from the evolutionary form to the closed exterior form is that from nonconjugated operators to conjugated ones. This is expressed mathematically as the transition from a nonzero differential (the evolutionary form differential is nonzero) to a differential that equals zero (the closed exterior form differential equals zero), and this is effected as a transition from one coordinate system to another (nonequivalent) coordinate system.

In conclusion of this section it is essential to emphasize the following. By comparing the exterior and evolutionary forms one can see that they possess the opposite properties. Yet it was shown that the evolutionary differential forms generate the closed exterior differential forms. This elucidates that the exterior and evolutionary differential forms are the unified whole.

4. Role of exterior and evolutionary forms in mathematical physics

The role of exterior and evolutionary differential forms in mathematical physics is due to the fact that the mathematical apparatus of these forms make it possible to keep track of the conjugacy of the equations that describe physical processes. The functional properties of the solutions of differential equations are just depend on whether or not the conjugacy conditions are satisfied. If these equations (or derivatives with respect to different variables) be not conjugated, then the solutions to corresponding equations prove to be noninvariant: they are functionals rather then functions. The realization of the conditions (while varying variables), under which the equations become conjugated ones, leads to that the relevant solution becomes invariant. The transition to the invariant solution, which can be obtained only with the help of evolutionary forms, describes the various evolutionary transition.

In field theory only invariant solutions (to which the closed exterior forms correspond), and the evolutionary process is thereby not considered.

An investigation of differential equations, which decribe physical processes, by means of the exterior and evolutionary differential forms allows to understand a mechanism of the evolutionary processes and origination of physical structures (of which the physical fields are formed) and explains such processes as fluctuations, pulsations, creation of massless particles, emergence of waves, vortices and so on.

{It can be shown that the exterior and evolutionary differential forms allow to investigate a conjugacy of any differential equations. Ant this lies at the basis of the qualitive theory of differential equations. The conjugacy of equations points to integrability of equations.}

The basic idea of the investigation of the conjugacy of differential equations can be clarified by the example of the first-order partial differential equation.

Let

$$F(x^i, u, p_i) = 0, \quad p_i = \partial u/\partial x^i \tag{4.1}$$

be the partial differential equation of the first order. Let us consider the functional relation

$$du = \theta, \tag{4.2}$$

where $\theta = p_i\, dx^i$ (the summation over repeated indices is implied). Here $\theta = p_i\, dx^i$ is the differential form of the first degree.

The left-hand side of this relation involves the differential, and the right-hand side includes the differential form $\theta = p_i\, dx^i$.

In the general case, from equation (4.1) it does not follow (explicitly) that the derivatives $p_i = \partial u/\partial x^i$ that obey to the equation (and given boundary or initial conditions of the problem) make up a differential. The commutator of the differential form θ defined as $K_{ij} = \partial p_j/\partial x^i - \partial p_i/\partial x^j$ is not equal to zero. The form $\theta = p_i\, dx^i$ proves to be unclosed and is not a differential like the left-hand side of relation (4.2). The functional relation (4.2) appears to be nonidentical: the left-hand side of this relation is a differential, but the right-hand side is not a differential. The form $\theta = p_i\, dx^i$ is an example of the evolutionary form, whereas functional relation (4.2) is an example of the evolutionary relation.

The nonidentity of functional relation (4.2) points to a fact that without additional conditions the derivatives of the initial equation do not make up a differential (they are nonconjugated). This means that the corresponding solution to the differential equation u will not be a function of x^i. It will depend on the commutator of the form θ, that is, it will be a functional.

To obtain the solution that is the function (i.e., the derivatives of this solution format a differential), it is necessary to add a closure condition for the form $\theta = p_i dx^i$ and for the dual form (in the present case the functional F plays a role of the form dual to θ) [2]:

$$\begin{cases} dF(x^i, u, p_i) = 0; \\ d(p_i\, dx^i) = 0. \end{cases} \tag{4.3}$$

If we expand the differentials, we get a set of homogeneous equations with respect to dx^i and dp_i (in the $2n$-dimensional space – initial and tangential):

$$\begin{cases} \left(\dfrac{\partial F}{\partial x^i} + \dfrac{\partial F}{\partial u} p_i\right) dx^i + \dfrac{\partial F}{\partial p_i}\, dp_i = 0; \\ dp_i\, dx^i - dx^i\, dp_i = 0. \end{cases} \tag{4.4}$$

The solvability conditions for this set (vanishing of the determinant composed of the coefficients at dx^i, dp_i) have the form:

$$\frac{dx^i}{\partial F/\partial p_i} = \frac{-dp_i}{\partial F/\partial x^i + p_i \partial F/\partial u}. \tag{4.5}$$

These conditions determine an integrating direction, namely, a pseudostructure, on which the form $\theta = p_i\, dx^i$ turns out to be closed one, i.e. it becomes a differential, and from relation (4.2) the identical relation is produced. If conditions (4.5), that may be called conjugacy conditions (integrability conditions), are satisfied, the derivatives constitute a differential $\delta u = p_i dx^i = du$ (on the pseudostructure), and the solution becomes a function. Just such solutions, namely, functions on the pseudostructures formed by the integrating directions, are the so-called generalized solutions [19]. The derivatives of the generalized solution form the exterior form that is closed on the pseudostructure.

If conditions (4.5) are not satisfied, that is, the derivatives do not form a differential, the solution that corresponds to such derivatives will depend on the differential form commutator formatted by derivatives. That means that the solution is a functional rather then a function.

Since the functions that are the generalized solutions are defined only on the pseudostructures, they have discontinuities in derivatives in the directions that are transverse to the pseudostructures. The order of derivatives with discontinuities is equal to the exterior form degree. If the form of zero degree is involved in the functional relation, then the function itself, being a generalized solution, will have discontinuities.

If we find the characteristics of equation (4.1), it appears that conditions (4.5) are the equations for the characteristics [14]. That is, the characteristics are the examples of the pseudostructures on which the derivatives of the differential equation form the closed forms and the solutions prove to be the functions (generalized solutions). (The characteristic manifolds of equation (4.1) are the pseudostructures π on which the form $\theta = p_i dx^i$ becomes a closed form: $\theta_\pi = du_\pi$).

Here it is worth noting that the coordinates of the equations for characteristics are not identical to the independent coordinates of the initial space on which equation (4.1) is defined. The transition from the initial space to the characteristic manifold appears to be a *degenerate* transform, namely, the determinant of the set of equations (4.4) becomes zero. The derivatives of equation (4.1) are transformed from the tangent space to the cotangent one.

Similar functional properties have the solutions to all differential equations and a system of partial differential equations.

Differential equations of mathematical physics, which describe physical processes, are those on which the invariance requirements (conjugacy conditions) are not inposed. Therefore they can have solutions that are functionals (their derivatives do not make up a differential). The solutions prove to be exact (generalized, not functionals) only under realization of the additional requirements, namely, the conditions of degenerate transforms: vanishing the determinants, Jacobians and so on, that define the integral surfaces. The characteristic manifolds, the envelopes of characteristics, singular points, potentials of simple and double layers, residues and others are the examples of such surfaces.

Since the closed forms correspond to the physical structures that form the physical fields, it is evident that only the equations with additional conditions (the integrability conditions) can be the equations of the field theory.

Let us consider how such an equation can be obtained and to do so we return to equation (4.1).

Assume that it does not explicitly depend on u and it is solved with respect to some variable, for example t, that is, it has the form of

$$\frac{\partial u}{\partial t} + E(t, x^j, p_j) = 0, \quad p_j = \frac{\partial u}{\partial x^j}. \tag{4.6}$$

Then integrability conditions (4.5) (the closure conditions of the differential form $\theta = p_i dx^i$ and the corresponding dual form) can be written as (in this case $\partial F/\partial p_1 = 1$)

$$\frac{dx^j}{dt} = \frac{\partial E}{\partial p_j}, \quad \frac{dp_j}{dt} = -\frac{\partial E}{\partial x^j}. \tag{4.7}$$

These are the characteristic relations (equations of characteristics) for equation (4.6). As it is well known, the canonical relations have just such a form.

Equation (4.6) provided with the supplementary conditions, namely, the canonical relations (4.7), is called the Hamilton-Jacobi equation [14]. The equations of field theory

$$\frac{\partial s}{\partial t} + H\left(t, q_j, \frac{\partial s}{\partial q_j}\right) = 0, \quad \frac{\partial s}{\partial q_j} = p_j \tag{4.8}$$

belong to this type. Here s is the field function for the action functional $S = \int L\, dt$. L is the Lagrange function, H is the Hamilton function: $H(t, q_j, p_j) = p_j \dot{q}_j - L$, $p_j = \partial L/\partial \dot{q}_j$. The closed form $ds = -H\, dt + p_j\, dq_j$ (the Poincare invariant) corresponds to equation (4.8).

Here the degenerate transform is a transition from the Lagrange function to the Hamilton function. The equation for the Lagrange function, that is the Euler variational equation, was obtained from the condition $\delta S = 0$, where S is the action functional. In the real case, when forces are nonpotential or couplings are nonholonomic, the quantity δS is not a closed form, that is, $d\,\delta S \neq 0$. But the Hamilton function is obtained

from the condition $d\,\delta S = 0$ which is the closure condition for the form δS. The transition from the Lagrange function L to the Hamilton function H (the transition from variables q_j, $\dot{q}_j$ to variables q_j, $p_j = \partial L/\partial \dot{q}_j$) is the transition from the tangent space, where the form is unclosed, to the cotangent space with a closed form. One can see that this transition is a degenerate one.

In quantum mechanics (where to the coordinates q_j, p_j the operators are assigned) the Schrödinger equation [20] serves as an analog to equation (4.8), and the Heisenberg equation serves as an analog to the relevant equation for the canonical relation integral. Whereas the closed exterior differential form of zero degree (the analog to the Poincare invariant) corresponds to the Schrödinger equation, the closed dual form corresponds to the Heisenberg equation.

The invariant field theories used only nondegenerate transformations that conserve the differential. By the example of the canonical relations it is possible to show that nondegenerate and degenerate transformations are connected. The canonical relations in the invariant field theory correspond to nondegenerate tangent transformations. At the same time, the canonical relations coincide with the characteristic relation for equation (4.8), which the degenerate transformations correspond to. The degenerate transformation is a transition from the tangent space $(q_j, \dot{q}_j))$ to the cotangent (characteristic) manifold (q_j, p_j). On the other hand, the nondegenerate transformation is a transition from one characteristic manifold (q_j, p_j) to the other characteristic manifold (Q_j, P_j).

The investigations conducted show that one must separate out two types of differential equations, namely, differential equations, that describe physical processes, and the invariant equations of the field theory, that describe physical structures forming physical fields. As the investigations conducted show these equations are connected between themselves. Invariant equations are obtained from equations that describe physical processes on which there are imposed additional conditions, namely, the conditions of existence of closed forms (invariants).

A connection of two types of equations of mathematical physics elucidates a relation between physical fields and material media. Differential equations that describe physical processes are equations of the conservation laws for material media whereas invariant equations of the field theory are equations (more presicely, relations) of the conservation laws for physical fields. Below with it will be shown that material media generate physical fields. And this process is controlled by the conservation laws.

5. Conservation laws

One has to distinguish two types of the conservation laws that for convenience can be called the exact conservation laws and the balance ones.

Exact conservation laws

The exact conservation laws are those that state the existence of conservative physical quantities or objects. The exact conservation laws are related to physical fields. {The physical fields [21] are a special form of the substance, they are carriers of various interactions such as electromagnetic, gravitational, wave, nuclear and other kinds of interactions.}

The closed exterior differential forms correspond to the exact conservation laws. Indeed, from the closure conditions of the exterior differential form (see Section 1, formulas (1.4), (1.8), (1.9)) it is evident that a closed differential form is a conservative quantity. In this case the closed inexact differential form and the corresponding dual form describe a conservative object, namely, there is a conservative quantity only on some pseudostructure π. From this one can see that the closed exterior differential form can correspond to the exact conservation law.

The closure conditions for the exterior differential form $(d_\pi\,\theta^p = 0)$ and the dual form $(d_\pi\,{}^*\theta^p = 0)$ are mathematical expressions of the exact conservation law.

In section 1 and 3 it was mentioned that the pseudostructure and the closed exterior form defined on the pseudostructure make up a binary structure (Bi-Structure). It is evident that such a structure does correspond to the exact conservation law.

It is such structures (pseudostructures with a conservative physical quantity) that corresponding to exact conservation law that are the physical structures from which physical fields are formed. The problem of how these structures arise and how physical fields are formed will be discussed below.

Equations for the physical structures $(d_\pi\,\theta^p = 0$, $d_\pi\,{}^*\theta^p = 0)$ turn out to coincide with the mathematical expression for the exact conservation law.

The mathematical expression for the exact conservation law and its connection with physical fields can be schematically written in the following manner

$$\begin{cases} d_\pi\theta^p = 0 \\ d_\pi{}^*\theta^p = 0 \end{cases} \mapsto \begin{cases} \theta^p \\ {}^*\theta^p \end{cases} \quad —$$

— physical structures $\mapsto$ physical fields

It is seen that the exact conservation law is that for physical fields.

It should be emphasized that the closed *inexact* forms correspond to the physical structures that form

physical fields. The *exact* forms correspond to the material system elements. (About this it will be said below).

It can be shown that the field theories, i.e. the theories that describe physical fields, are based on the invariant and metric properties of the closed exterior differential and dual forms that correspond to exact conservation laws.

Balance conservation laws

The balance conservation laws are those that establish the balance between the variation of a physical quantity and the corresponding external action. These are the conservation laws for the material systems (material media).

{A material system is a variety of elements which have internal structure and interact to one another. As examples of material systems it may be thermodynamic, gas dynamical, cosmic systems, systems of elementary particles and others. The physical vacuum in its properties may be regarded as an analogue of the material system that generates some physical fields. Any material media are such material systems. Examples of elements that constitute the material system are electrons, protons, neutrons, atoms, fluid particles, cosmic objects and others}.

The balance conservation laws are the conservation laws for energy, linear momentum, angular momentum, and mass.

In the integral form the balance conservation laws express the following [22]: a change of a physical quantity in an elementary volume over a time interval is counterbalanced by the flux of a certain quantity through the boundary surface and by the action of sources. Under transition to the differential expression the fluxes are changed by divergences.

The equations of the balance conservation laws are differential (or integral) equations that describe a variation of functions corresponding to physical quantities [16,22-24].

It appears that, even without knowledge of the concrete form of these equations, with the help of the differential forms one can see specific features of these equations that elucidate the properties of the balance conservation laws. To do so it is necessary to study the conjugacy (consistency) of these equations.

Equations are conjugate if they can be contracted into identical relations for the differential, i.e. for a closed form.

Let us analyze the equations that describe the balance conservation laws for energy and linear momentum.

We introduce two frames of reference: the first is an inertial one (this frame of reference is not connected with the material system), and the second is an accompanying one (this system is connected with the manifold built by the trajectories of the material system elements). The energy equation in the inertial frame of reference can be reduced to the form:

$$\frac{D\psi}{Dt} = A_1, \tag{5.1}$$

where D/Dt is the total derivative with respect to time, ψ is the functional of the state that specifies the material system, A_1 is the quantity that depends on specific features of the system and on external energy actions onto the system. {The action functional, entropy,wave function can be regarded as examples of the functional ψ. Thus, the equation for energy presented in terms of the action functional S has a similar form: $DS/Dt = L$, where $\psi = S$, $A_1 = L$ is the Lagrange function. In mechanics of continuous media the equation for energy of an ideal gas can be presented in the form [23]: $Ds/Dt = 0$, where s is entropy. In this case $\psi = s$, $A_1 = 0$. It is worth noting that the examples presented show that the action functional and entropy play the same role.}

In the accompanying frame of reference the total derivative with respect to time is transformed into the derivative along the trajectory. Equation (5.1) is now written in the form

$$\frac{\partial\psi}{\partial\xi^1} = A_1, \tag{5.2}$$

here ξ^1 is the coordinate along the trajectory.

In a similar manner, in the accompanying frame of reference the equation for linear momentum appears to be reduced to the equation of the form

$$\frac{\partial\psi}{\partial\xi^\nu} = A_\nu, \quad \nu = 2, \ldots \tag{5.3}$$

where ξ^ν are the coordinates in the direction normal to the trajectory, A_ν are the quantities that depend on the specific features of the system and external force actions.

Eqs. (5.2), (5.3) can be convoluted into the relation

$$d\psi = A_\mu\, d\xi^\mu, \quad (\mu = 1, \nu), \tag{5.4}$$

where $d\psi$ is the differential expression $d\psi = (\partial\psi/\partial\xi^\mu)d\xi^\mu$.

Relation (5.4) can be written as

$$d\psi = \omega, \tag{5.5}$$

here $\omega = A_\mu\, d\xi^\mu$ is the differential form of the first degree.

Since the balance conservation laws are evolutionary ones, the relation obtained is also an evolutionary relation.

Relation (5.5) was obtained from the equation of the balance conservation laws for energy and linear momentum. In this relation the form ω is that of the first degree. If the equations of the balance conservation laws

for angular momentum be added to the equations for energy and linear momentum, this form in the evolutionary relation will be the form of the second degree. And in combination with the equation of the balance conservation law of mass this form will be the form of degree 3.

Thus, in the general case the evolutionary relation can be written as

$$d\psi = \omega^p, \tag{5.6}$$

where the form degree p takes the values $p = 0, 1, 2, 3..$ (The evolutionary relation for $p = 0$ is similar to that in the differential forms, and it was obtained from the interaction of energy and time.)

In relation (5.5) the form ψ is the form of zero degree. And in relation (5.6) the form ψ is the form of $(p-1)$ degree.

Let us show that *the evolutionary relation obtained from the equation of the balance conservation laws proves to be nonidentical.*

To do so we shall analyze relation (5.5).

A relation may be identical one if this is a relation between measurable (invariant) quantities or between observable (metric) objects, in other words, between quantities or objects that are comparable.

In the left-hand side of evolutionary relation (5.5) there is a differential that is a closed form. This form is an invariant object. Let us show that the differential form ω in the right-hand side of relation (5.5) is not an invariant object because in real processes this form proves to be unclosed.

For the form to be closed the differential of the form or its commutator must be equal to zero (the elements of the form differential are equal to the components of its commutator).

Let us consider the commutator of the form $\omega = A_\mu d\xi^\mu$. The components of the commutator of such a form (as it was pointed above) can be written as follows:

$$K_{\alpha\beta} = \left(\frac{\partial A_\beta}{\partial \xi^\alpha} - \frac{\partial A_\alpha}{\partial \xi^\beta}\right) \tag{5.7}$$

(here the term connected with the nondifferentiability of the manifold has not yet been taken into account).

The coefficients A_μ of the form ω have been obtained either from the equation of the balance conservation law for energy or from that for linear momentum. This means that in the first case the coefficients depend on the energetic action and in the second case they depend on the force action. In actual processes energetic and force actions have different nature and appear to be inconsistent. The commutator of the form ω constructed from the derivatives of such coefficients is nonzero. This means that the differential of the form ω is nonzero as well. Thus, the form ω proves to be unclosed and is not a measurable quantity.

This means that the evolutionary relation involves an unmeasurable term. Such a relation cannot be an identical one. (In the left-hand side of this relation it stands a differential, whereas in the right-hand side it stands an unclosed form that is not a differential.)

Hence, without knowledge of a particular expression for the form ω, one can argue that for actual processes the evolutionary relation proves to be nonidentical because of inconsistency of the external action.

The nonidentity of the evolutionary relation means that equations of the balance conservation laws turn out to be nonconjugated (thus, if from the energy equation we obtain the derivative of ψ in the direction along the trajectory and from the momentum equation we find the derivative of ψ in the direction normal to the trajectory and then we to calculate their mixed derivatives, then from the condition that the commutator of the form ω is nonzero it follows that the mixed derivatives prove to be noncommutative). One cannot convolute them into an identical relation and obtain a differential.

The nonconjugacy of the balance conservation law equations reflects the properties of the balance conservation laws that have a governing importance for the evolutionary processes, namely, their noncommutativity.

6. Evolutionary processes in material media and origination of physical structures

It was shown above that the evolutionary relation that was obtained from the balance conservation law equations proves to be nonidentical. This points to the noncommutativity of the balance conservation laws. By analyzing the behavior of the nonidentical evolutionary relation one can understand to what result the noncommutativity of the balance conservation laws leads.

Let us consider evolutionary relation (5.6).

In the left-hand side of the evolutionary relation there is the functional expression $d\psi$ that determines the state of the material system, and in the right-hand side there is the form ω^p whose coefficients depend on external actions and the material system characteristics.

The evolutionary relation gives a possibility to determine either presence or absence of the differential (the closed form). And this allows us to recognize whether the material system state is in equilibrium, in local equilibrium or not in equilibrium. If it is possible to determine the differential $d\psi$ (the state differential) from the evolutionary relation, this indicates that the system is in equilibrium or locally equilibrium state. And if the differential cannot be determined, then this means that the system is in a nonequilibrium state.

It is evident that if the balance conservation laws be commutative, the evolutionary relation would be identical and from that it would be possible to get the differ-

ential $d\psi$, this would indicate that the material system is in the equilibrium state.

However, as it has been shown, in real processes the balance conservation laws are noncommutative. The evolutionary relation is not identical and from this relation one cannot get the differential $d\psi$. This means that the system state is nonequilibrium. It is evident that a magnitude of internal force, which gives rise to the nonequilibrium, is described by the evolutionary form commutator.

Selfvariation of nonequilibrium state of material system. (Selfvariation of the evolutionary relation)

What does the material system nonequilibrium indicated by the nonidentity of the evolutionary relation results in?

As it was shown in Section 3, if the relation is evolutionary and nonidentical, it is a selfvarying relation, that is, a change of one object in the relation leads to a change of the other object, and in turn a change of the latter leads to a change of the former and so on. Such a specific feature of the evolutionary relation explains the particulars of the material system, namely, *the selfvariation of its nonequilibrium state.*

The selfvariation mechanism of the *nonequilibrium* state of the material system can be understood if analyze the properties of the evolutionary form commutator.

The evolutionary form in the evolutionary relation is defined on the accompanying manifold that for real processes appears to be the deformable manifold because it is formed simultaneously with a change of the material system state and depends on the physical processes. Such a manifold cannot be a manifold with closed metric forms. Hence, as it was already noted in Section 3, the term containing the characteristics of the manifold will be included into the evolutionary form commutator in addition to the term connected with derivatives of the form coefficients. The interaction between these terms of different nature describes a mutual change of the state of the material system.

The emergence of the second term under deformation of the accompanying manifold can only change the commutator and cannot make it zero (because the terms of the commutator have different nature). In the material system the internal force will continue to act even in the absence of external actions. The further deformation (torsion) of the manifold will go on. This leads to a change of the metric form commutator, produces a change of the evolutionary form and its commutator and so on. Such a process is governed by the nonidentical evolutionary relation and, in turn, produces a change of the evolutionary relation.

The process of selfvariation of the commutator controlled by the nonidentical evolutionary relation specifies a change of the internal force that acts in the material system. This points to a change of the material system state. But the material system state remains nonequilibrium in this process because the internal forces do not vanish due to the evolutionary form commutator remaining nonzero.

At this point it should be emphasized that such selfvariation of the material system state proceeds under the action of internal (rather than external) forces. That will go on even in the absence of external forces. That is, the selfvariation of the nonequilibrium state of the material system takes place.

It is the selfvariation of the nonidentical evolutionary relation obtained from the balance conservation laws for material systems that describes the selfvaration of the nonequilibrium state of material system.

Here it should be noted that in a real physical process the internal forces can be increased (due to the selfvariation of the nonequilibrium state of the material system). This can lead to the development of instability in the material system [25]. {For example, this was pointed out in the works by Prigogine [26]. "The excess entropy" in his works is analogous to the commutator of a nonintegrable form for the thermodynamic system. "Production of excess entropy" leads to the development of instability}.

Transition of the material system into a locally equilibrium state. (Degenerate transform)

Now the question arises whether the material system can got rid of the internal force and transfer into the equilibrium state?

The state of material system is equilibrium one if the state differential exists.

The state differential is included into the nonidentical evolutionary relation. But one cannot get the state differential from *nonidentical* relation. This points to that the material system cannot come to the equilibrium state. However, as it was shown in Section 3, under degenerate transform the identical relation can be obtained from the nonidentical evolutionary relation. From such a relation one can obtain the state differential. But to this differential there corresponds the *inexact* closed exterior form. this means that the state differential acts only locally. The availability of such state diferential points not to the equilibriun state but to the locally equilibrium state of material system. Under this condition the total state of material system remains to be nonequilibrium.

How does the transition of the material system from the nonequilibrium state to a locally equilibrium one go on?

Let us consider nonidentical evolutionary relation (5.6).

As it was shown in Section 3, from the nonidentical evolutionary relation it can be obtained the identical

relation if from the evolutionary unclosed relation the inexact closed exterior form can be obtained.

Since the evolutionary differential form ω^p is unclosed, the commutator, and hence the differential, of this form is nonzero. That is,

$$d\omega^p \neq 0. \tag{6.1}$$

The unclosed inexact exterior form, which can be obtained from the evolutionary form, must satisfy the closure conditions:

$$\begin{cases} d_\pi \omega^p = 0; \\ d_\pi{}^* \omega^p = 0. \end{cases} \tag{6.2}$$

That is, the differential of this form must be equal to zero. It is evident that a passage from condition (6.1) to condition (6.2) is allowed only as the degenerate transform. If such a transform takes place, on the pseudostructure π evolutionary relation (5.6) transforms into the relation

$$d_\pi \psi = \omega^p_\pi, \tag{6.3}$$

which proves to be the identical relation. Indeed, since the form ω^p_π is a closed one, on the pseudostructure it turns out to be a differential of some differential form. In other words, this form can be written as $\omega^p_\pi = d_\pi \theta$. Relation (6.3) is now written as

$$d_\pi \psi = d_\pi \theta.$$

There are differentials in the left-hand and right-hand sides of this relation. This means that the relation is an identical one.

It is from such a relation that one can find the state differential $d_\pi \psi$.

The emergence of the differential $d_\pi \psi$ indicates that the material system changes into the locally equilibrium state. *But in this case the total state of the material system turns out to be nonequilibrium.*

Here the following detail should be taken into account. The evolutionary differential form is defined on the accompanying manifold. The evolutionary relation has been obtained under the condition that the coordinate frame is tied to the accompanying manifold. This coordinate system is not an inertial or locally inertial system because the metric forms of the accompanying manifold are not closed ones. Condition (6.1) relates to the system tied to the accompanying manifold, whereas condition (6.2) may relate only to the coordinate system that is tied to a pseudostructure. The second condition in formula (6.2) being the equation for the pseudostructure points to this fact. It is only the locally inertial coordinate system that can be such a coordinate system. From this it follows that *the degenerate transform is realized as the transition from the accompanying noninertial coordinate system to the locally inertial that.*

To the degenerate transform it must correspond vanishing of some functional expressions. As it was already mentioned in Section 3, such functional expressions may be Jacobians, determinants, the Poisson brackets, residues and others. Vanishing of these functional expressions is the closure condition for a dual form.

The conditions of degenerate transform are connected with symmetries that can be obtained from the coefficients of evolutionary and dual forms and their derivatives. Since the evolutionary relation describes the material systems and the coefficients of the form ω^p depend on the material system characteristics, it is obvious that the additional condition (the condition of degenerate transform) has to be due to the material system properties. This may be, for example, the availability of any degrees of freedom in the system. The translational degrees of freedom, internal degrees of freedom of the system elements, and so on can be examples of such degrees of freedom.

The availability of the degrees of freedom in the material system indicates that it is allowed the degenerate transform, which, in turns, allows the state of the material systems to be transformed from a nonequilibrium state to a locally equilibrium state. But, for this to take place in reality it is necessary that the additional conditions connected with the degrees of freedom of the material system be realized. It is selfvariation of the nonequilibrium state of the material system described by the selfvarying evolutionary relation that could give rise to realization of the additional conditions. This can appear only spontaneously because it is caused by internal (rather than external) reasons (the degrees of freedom are the characteristics of the system rather than of external actions).

7. The origination of the physical structures. Formation of physical fields and manifolds. The causality.

The identical relation (6.3) obtained from the nonidentical evolutionary relation (under degenerate transform) integrates the state differential and the closed inexact exterior form. The availability of the state differential indicates that the material system state becomes a locally equilibrium state (that is, the local domain of the system under consideration changes into the equilibrium state). The availability of the exterior closed inexact form means that the physical structure is present. This shows that the transition of material system into the locally equilibrium state is accompanied by the origination of physical structures.

Since closed inexact exterior forms corresponding to physical structure are obtained from the evolutionary relation for the material system, it follows that physical structures are generated by the material systems. (This is controlled by the conservation laws.)

In this manner the crated physical structures are

connected with the material system, its elements, its local domains.

In the material system origination of a physical structure reveals as a new measurable and observable formation that spontaneously arises in the material system. {*As the examples it can be fluctuations, pulsations, waves, vortices, creating massless particles.*}.

In the physical process this formation is spontaneously extracted from the local domain of the material system and so it allows the local domain of material system to get rid of an internal force and come into a locally equilibrium state.

The formation created in a local domain of the material system (at the cost of an unmeasurable quantity that acts in the local domain as an internal force) and liberated from that, begins acting onto the neighboring local domain as a force. This is a potential force, this fact is indicated by the double meaning of the closed exterior form (on the one hand, a conservative quantity, and, on other hand, a potential force). (This action was produced by the material system in itself, and therefore this is a potential action rather than an arbitrary one). The transition of the material system from nonequilibrium into a locally equilibrium state (which is indicated by the formation of a closed form) means that the unmeasurable quantity described by the nonzero commutator of the nonintegrable differential form ω^p , that acts as an internal force, transforms into the measurable quantity. It is evident that it is just the measurable quantity that acts as a potential force. In other words, the internal force transforms into a potential force.

The neighboring domain of the material system works over this action that appears to be external with respect to that. If in the process the conditions of conjugacy of the balance conservation laws turn out to be satisfied again, the neighboring domain will create a formation by its own, and this formation will be extracted from this domain. In such a way the formation can move relative to the material system. (Waves are the example of such motions).

Characteristics of a created formation: intensity, vorticity, absolute and relative speeds of propagation of the formation.

Analysis of the formation and its characteristics allows a better understanding of the specific features of physical structures.

It is evident that the characteristics of the formation, as well as those of the created physical structure, are determined by the evolutionary form and its commutator and by the material system characteristics.

The following correspondence between the characteristics of the formations emerged and characteristics of the evolutionary forms, of the evolutionary form commutators and of the material system is established:

1) an intensity of the formation (a potential force) $\leftrightarrow$ *the value of the first term in the commutator of a nonintegrable form* at the instant of the formation is created;

2) vorticity $\leftrightarrow$ *the second term in the commutator that is connected with the metric form commutator*;

3) an absolute speed of propagation of the created formation (the speed in the inertial frame of reference) $\leftrightarrow$ *additional conditions connected with degrees of freedom of the material system*;

4) a speed of the formation propagation relative to the material system $\leftrightarrow$ *additional conditions connected with degrees of freedom of the material system and the velocity of the local domain elements.*

Characteristics of physical structures

Analysis of formations originated in the material system that correspond to physical structures allows us to clarify some properties of physical structures.

The observed formation and the physical structure are not identical objects. If the wave be such a formation, the structures formed by the wave front elements while its translation are examples of the physical structure. (In this case the wave element is a minipseudostructure. Under this translation such element forms a line or some surface, which are examples of the pseudostructure.) The observed formations are assigned to material systems, and the physical structures do to physical fields. In this case they are mutually connected. As it was already noted, the characteristics of physical structure, as well as the characteristics of the formation, are determined by the evolutionary form and its commutator and by the material system characteristics.

The originated physical structure is a realized pseudostructure and a corresponding inexact closed exterior form. What determines the characteristics of these objects?

The equation of the pseudostructure is obtained from the condition of degenerate transform and is dictated by a degree of freedom of material system. The pseudostructure is connected with the absolute speed of propagation of the created formation (see point 3 in the preceding section).

A closed exterior form corresponding to a physical structure is a conservative quantity that the state differential corresponds to. The differentials of entropy, action, potential and others are the examples of such differentials. These conservative quantities describe certain charges.

A physical structure possesses two more characteristics. This is connected with the fact that *inexact* closed forms correspond to these structures. Under transition from one structure to another the conservative quantity corresponding to the closed exterior form discretely changes, and the pseudostructure also changes discretely.

Discrete changes of the conservative quantity and pseudostructure are determined by the value of the evolutionary form commutator, which the commutator has at the instant when the physical structure originates. The first term of the evolutionary form commutator obtained from the derivatives of the evolutionary form coefficients controls the discrete change of the conservative quantity. As a corresponding characteristics of the created formation it serves the intensity of created formation (see point 1). The second term of the evolutionary form commutator obtained from the derivatives of the metric form coefficients of the initial manifold controls the pseudostructure change. Spin is the example of the second characteristics. As a corresponding characteristics of the created formation it serves the vorticity of created formation (see point 2). Spin is a characteristics that determines a character of the manifold deformation before origination of the quantum. (The spin value depends on the form degree.)

A discrete change of the conservative quantity and that of the pseudostructure produce the quantum that is obtained while going from one structure to another. The evolutionary form commutator formed at the instant of the structure origination determine characteristics of this quantum.

Breaks of the derivatives of the potential along the direction normal to the potential surface, breaks of the derivative in transition throughout the characteristic surfaces and in transition throughout the wave front, and others are the examples of such discrete changes.

The duality of the closed inexact form as a conservative quantity and as a potential force shows that the potential forces are the action of formations corresponding to the physical structures onto the material system elements.

Here the following should be pointed out. The physical structures are generated by local domains of the material system. They are the elementary physical structures. By combining with one another they can form the large-scale structures and physical fields.

Classification of physical structures. Formation of physical fields. (Parameters of the closed and dual forms)

Since the physical structures are generated by numerous local domains of the material system and at numerous instants of realizing various degrees of freedom of the material system, it is evident that they can generate fields. In this manner physical fields are formatted. To obtain the physical structures that form a given physical field one has to examine the material system corresponding to this field and the appropriate evolutionary relation. In particular, to obtain the thermodynamic structures (fluctuations, phase transitions, etc) one has to analyze the evolutionary relation for the thermodynamic systems, to obtain the gas dynamic ones (waves, jumps, vortices, pulsations) one has to employ the evolutionary relation for gas dynamic systems, for the electromagnetic field one must employ a relation obtained from equations for charged particles.

Closed forms that correspond to physical structures are generated by the evolutionary relation having the parameter p that defines a number of interacting balance conservation laws, that ranges from 0 to 3. Therefore, the physical structures can be classified by the parameter p. The other parameter is a degree of closed forms generated by the evolutionary relation. As it was shown above, the evolutionary relation of degree p can generate the closed forms of degree $0 \leq k \leq p$. Therefore, physical structures can be classified by the parameter k as well.

In addition, closed exterior forms of the same degree realized in spaces of different dimensions prove to be distinguishable because the dimension of the pseudostructures, on which the closed forms are defined, depends on the space dimension. As a result, the space dimension also specifies the physical structures. This parameter determines the properties of the physical structures rather than their type.

What is implied by the concept "space"?

While deriving the evolutionary relation two frames of reference were used and, correspondingly, two spatial objects . The first frame of reference is the inertial one that is connected with the space where the material system is situated and is not directly connected with the material system. This is an inertial space, it is a metric space. (As it will be shown below, this space is also formed by the material system itself.) The second frame of reference is the proper one, it is connected with the accompanying manifold, which is not a metric manifold.

If the dimension of the initial inertial space is n, then while generating closed forms of sequential degrees $k = p$, $k = p - 1$, ..., $k = 0$ the pseudostructures of dimensions $(n + 1 - k)$: 1, ..., $n + 1$ are obtained. As a result of transition to the exact closed form of zero degree the metric structure of the dimension $n + 1$ is obtained. Under the influence of an external action (and in the presence of degrees of freedom) the material system connected with the accompanying manifold can transfer the initial inertial space into the space of the dimension $n+1$. {It is known that the skew-symmetric tensors of the rank k correspond to the closed exterior differential forms, and the pseudotensors of the rank $(N - k)$, where N is the space dimension, correspond to the relevant dual forms. The pseudostructures correspond to such tensors, but on the space formed with the dimension $n + 1$. That is, $N = n + 1$}.

Hence, from the analysis of the evolutionary relation one can see that the type and the properties of the physical structures (and, accordingly, of physical fields) for a given material system depend on a number of interacting balance conservation laws p, on the degree of

realized closed forms k, and on the space dimension.

The connection between the field theory equations and closed exterior forms presented in Section 1 shows that it is possible to classify physical fields according to the degree of exterior differential form. But within the framework of only exterior differential forms one cannot understand how this classification is explained. This can be elucidated only by application of evolutionary differential forms.

By introducing a classification with respect to p, k, and a space dimension we can understand the internal connection of various physical fields and interactions. So one can see a correspondence between the degree k of the closed forms realized and the type of interactions. Thus, $k = 0$ corresponds to the strong interaction, $k = 1$ corresponds to the weak interaction, $k = 2$ corresponds to the electromagnetic interaction, and $k = 3$ corresponds to the gravitational interaction.

Causality

The mathematical apparatus of evolutionary differential forms describing the balance conservation laws in the material systems explains the causality of the evolutionary processes in material systems, which lead to emergence of physical structures.

The evolutionary process in the material system and the emergence of physical structures can take place, if

1) the material system is subjected to an external action (*the evolutionary form commutator in the evolutionary relation obtained from the balance conservation laws is nonzero*),

2) a material system possesses the degrees of freedom (*there are the conditions of degenerate transform, under which from the nonidentical evolutionary relation an identical relation is obtained*),

3) the degrees of freedom of the material system have to be realized, that is possible only under selfvariations of the nonequilibrium state of material system (*the conditions of the degenerate transform have to be satisfied, this is possible under selfvariation of the nonidentical evolutionary relation*).

If these conditions (causes) are fulfilled, in the material system physical structures arise (*this is indicated by the presence of closed inexact form obtained from the identical relation*).

It is these structures that form physical fields.

Note that to each physical field it is assigned its own material system. The question of what physical system corresponds to a particular physical field is still an open question. Examples of such material systems are the thermodynamic, gas dynamical, the system of charged particles, cosmological systems, and so on. Maybe, for elementary particles the physical vacuum is such a system.

The evolutionary process may lead to creation of elements of its own material system (*while obtaining the exact form of zero degree*). (In this case the numbers are the analog of dual forms).

The emergence of physical structures in the evolutionary process proceeds spontaneously and is manifested as an emergence of certain observable formations. In this manner the causality of emerging various observable formations in material media is explained. Such formations and their manifestations are fluctuations, turbulent pulsations, waves, vortices, creating massless particles and others.

Here the role of the conservation laws in evolutionary processes should be emphasized once again. The noncommutativity of the balance conservation laws leads to the nonequilibrium state of the material system (subjected to external actions). The interaction of the noncommutative balance conservation laws controls the process of selfvarying the nonequilibrium state of the material system that leads to the realization of the degrees of freedom of the material system. This allows the material system to transform into the locally equilibrium state, which is accompanied by emergence of physical structures. The exact conservation laws correspond to the physical structures. Here one can see a connection between the balance and exact conservation laws. The physical structures that correspond to the exact conservation laws are produced by material system in the evolutionary processes based on the interaction of the noncommutative balance conservation laws [31].

The noncommutativity of the balance conservation laws and their controlling role in the evolutionary processes, that are accompanied by emerging physical structures, practically have not been taken into account in the explicit form anywhere. The mathematical apparatus of evolutionary differential forms enables one to take into account and describe these points.

The existing field theories that are invariant ones are based on some postulates. The investigation performed allows us to make the following conclusion. The postulates, which lie at the basis of the existing field theories, correspond to the statement about the conjugacy of the balance conservation laws for material systems that generate physical structures forming physical fields.

It can be shown that any material system and any physical field is subjected to the above described regularities, which were obtained with thw help of the mathematical apparatus of the exterior and evolutionary differential forms. Let us consider some material systems and physical fields.

1. *The thermodynamic systems*

The thermodynamics is based on the first and second principles of thermodynamics that were introduced as postulates [15]. The first principle of thermodynam-

ics, which can be written in the form

$$dE + dw = \delta Q \tag{7.1}$$

follows from the balance conservation laws for energy and linear momentum (but not only from the conservation law for energy). This is analogous to the evolutionary relation for the thermodynamic system. Since δQ is not a differential, relation (7.1) which corresponds to the first principle of thermodynamics, as well as the evolutionary relation, appears to be a nonidentical relation. This points to a noncommutativity of the balance conservation laws (for energy and linear momentum) and to a nonequilibrium state of the thermodynamic system.

If condition of the integrability be satisfied, from the nonidentical evolutionary relation, which corresponds to the first principle of thermodynamics, it follows an identical relation. It is an identical relation that corresponds to the second principle of thermodynamics.

If $dw = p\,dV$, there is the integrating factor θ (a quantity which depends only on the characteristics of the system), where $1/\theta = pV/R$ is called the temperature T [15]. In this case the form $(dE + p\,dV)/T$ turns out to be a differential (interior) of some quantity that referred to as entropy S:

$$(dE + p\,dV)/T = dS. \tag{7.2}$$

If the integrating factor $\theta = 1/T$ has been realized, that is, relation (7.2) proves to be satisfied, from relation (7.1), which corresponds to the first principle of thermodynamics, it follows

$$dS = \delta Q/T. \tag{7.3}$$

This is just the second principle of thermodynamics for reversible processes. It takes place when the heat influx is the only action onto the system.

If in addition to the heat influx the system experiences a certain mechanical action (for example, an influence of boundaries), then we obtain

$$dS > \delta Q/T \tag{7.4}$$

that corresponds to the second principle of thermodynamics for irreversible processes.

In the case examined above a differential of entropy (rather than entropy itself) becomes a closed form. {In this case entropy manifests itself as the thermodynamic potential, namely, the function of state. To the pseudostructure there corresponds the state equation that determines the temperature dependence on the thermodynamic variables}.

2. *The gas dynamical systems*

We take the simplest gas dynamical system, namely, a flow of ideal (inviscous, heat nonconductive) gas [23].

Assume that gas (the element of gas dynamic system) is a thermodynamic system in the state of local equilibrium (whenever the gas dynamic system itself may be in nonequilibrium state), that is, it is satisfied the relation [15]

$$Tds = de + pdV, \tag{7.5}$$

where T, p and V are the temperature, the pressure and the gas volume, s, e are entropy and internal energy per unit volume.

Let us introduce two frames of reference: an inertial one that is not connected with the material system and an accompanying frame of reference that is connected with the manifold formed by the trajectories of the material system elements.

The equation of the balance conservation law of energy for ideal gas can be written as [23]

$$\frac{Dh}{Dt} - \frac{1}{\rho}\frac{Dp}{Dt} = 0, \tag{7.6}$$

where D/Dt is the total derivative with respect to time (if to designate the spatial coordinates by x_i and the velocity components by u_i, $D/Dt = \partial/\partial t + u_i\partial/\partial x_i$). Here $\rho = 1/V$ and h are respectively the mass and the entalpy densities of the gas.

Expressing entalpy in terms of internal energy e with the help of formula $h = e + p/\rho$ and using relation (7.5) the balance conservation law equation (7.6) can be put to the form

$$\frac{Ds}{Dt} = 0. \tag{7.7}$$

And respectively, the equation of the balance conservation law for linear momentum can be presented as [23,27]

$$\operatorname{grad} s = (\operatorname{grad} h_0 + \mathbf{U}\times\operatorname{rot}\mathbf{U} - \mathbf{F} + \partial\mathbf{U}/\partial t)/T, \tag{7.8}$$

where $\mathbf{U}$ is the velocity of the gas particle, $h_0 = (\mathbf{U}\cdot\mathbf{U})/2 + h$, $\mathbf{F}$ is the mass force. The operator *grad* in this equation is defined only in the plane normal to the trajectory.

Since the total derivative with respect to time is that along the trajectory, in the accompanying frame of reference equations (7.7) and (7.8) take the form:

$$\frac{\partial s}{\partial \xi^1} = 0; \tag{7.9}$$

$$\frac{\partial s}{\partial \xi^\nu} = A_\nu, \quad \nu = 2, \ldots \tag{7.10}$$

where ξ^1 is the coordinate along the trajectory, $\partial s/\partial\xi^\nu$ is the left-hand side of equation (7.8), and A_ν is obtained from the right-hand side of relation (7.8).

Equations (7.9) and (7.10) can be convoluted into the equation

$$ds = A_\mu d\xi^\mu, \tag{7.11}$$

where $A_\mu d\xi^\mu = \omega$ is the first degree differential form (here $A_1 = 0, \mu = 1, \nu$).

Relation (7.11) is an evolutionary relation for gas dynamic system (in the case of local thermodynamic equilibrium). Here $\psi = s$. {It worth notice that in the evolutionary relation for thermodynamic system the dependence of entropy on thermodynamic variables is investigated (see relation (7.5)), whereas in the evolutionary relation for gas dynamic system the entropy dependence on the space-time variables is considered}.

Relation (7.11) appears to be nonidentical. To make it sure that this is true one must inspect a commutator of the form ω.

Nonidentity of the evolutionary relation points to the nonequilibrium and a development of the gas dynamic instability. Since the nonequilibrium is produced by internal forces that are described by the commutator of the form ω, it becomes evident that a cause of the gas dynamic instability is something that contributes into the commutator of the form ω.

One can see (see (7.8)) that the development of instability is caused by not a simply connectedness of the flow domain, nonpotential external (for each local domain of the gas dynamic system) forces, a nonstationarity of the flow.

{In the case when gas is nonideal equation (7.9) can be written in the form

$$\frac{\partial s}{\partial \xi^1} = A_1,$$

where A_1 is an expression that depends on the energetic actions (transport phenomena: viscous, heat-conductive). In the case of reacting gas extra terms connected with the chemical nonequilibrium are added. These factors contributes into the commutator of the form ω.}

All these factors lead to emergence of internal forces, that is, to nonequilibrium and to development of various types of instability.

And yet for every type of instability one can find an appropriate term giving contribution into the evolutionary form commutator, which is responsible for this type of instability. Thus, there is an unambiguous connection between the type of instability and the terms that contribute into the evolutionary form commutator in the evolutionary relation. {In the general case one has to consider the evolutionary relations that correspond to the balance conservation laws for angular momentum and mass as well}.

As it was shown above, under realization of additional degrees of freedom it can take place the transition from the nonequilibrium state to the locally equilibrium one, and this process is accompanied by emergence of physical structures. The gas dynamic formations that correspond to these physical structures are shocks, shock waves, turbulent pulsations and so on. Additional degrees of freedom are realized as the condition of the degenerate transform, namely, vanishing of determinants, Jacobians of transforms, etc. These conditions specify the integral surfaces (pseudostructures): the characteristics (the determinant of coefficients at the normal derivatives vanishes), the singular points (Jacobian is equal to zero), the envelopes of characteristics of the Euler equations and so on. Under passing throughout the integral surfaces the gas dynamic functions or their derivatives suffer breaks.

3. *Electromagnetic field*

The system of charged particles is a material medium, which generates electromagnetic field.

If to use the Lorentz force $\mathbf{F} = \rho(\mathbf{E} + [\mathbf{U} \times \mathbf{H}]/c)$, the local variation of energy and linear momentum of the charged matter (material system) can be written respectively as [24]: $\rho(\mathbf{U} \cdot \mathbf{E})$, $\rho(\mathbf{E} + [\mathbf{U} \times \mathbf{H}]/c)$. Here ρ is the charge density, $\mathbf{U}$ is the velocity of the charged matter. These variations of energy and linear momentum are caused by energetic and force actions and are equal to values of these actions. If to denote these actions by Q^e, $\mathbf{Q}^i$, the balance conservation laws can be written as follows:

$$\rho\,(\mathbf{U} \cdot \mathbf{E}) = Q^e; \tag{7.12}$$

$$\rho\,(\mathbf{E} + [\mathbf{U} \times \mathbf{H}]/c) = \mathbf{Q}^i. \tag{7.13}$$

After eliminating the characteristics of the material system (the charged matter) ρ and $\mathbf{U}$ by application of the Maxwell-Lorentz equations [24], the left-hand sides of equations (7.12), (7.13) can be expressed only in terms of the strengths of electromagnetic field, and then one can write equations (7.12), (7.13) as

$$c\,\mathrm{div}\mathbf{S} = -\frac{\partial}{\partial t} I + Q^e; \tag{7.14}$$

$$\frac{1}{c}\frac{\partial}{\partial t}\mathbf{S} = \mathbf{G} + \mathbf{Q^i}, \tag{7.15}$$

where $\mathbf{S} = [\mathbf{E} \times \mathbf{H}]$ is the Pointing vector, $I = (E^2 + H^2)/c$, $\mathbf{G} = \mathbf{E}\,\mathrm{div}\mathbf{E} + \mathrm{grad}(\mathbf{E} \cdot \mathbf{E}) - (\mathbf{E} \cdot \mathrm{grad})\mathbf{E} + \mathrm{grad}(\mathbf{H} \cdot \mathbf{H}) - (\mathbf{H} \cdot \mathrm{grad})\mathbf{H}$.

Equation (7.14) is widely used while describing electromagnetic field and calculating energy and the Pointing vector. But equation (7.15) does not commonly be taken into account. Actually, the Pointing vector $\mathbf{S}$ must obey two equations that can be convoluted into the *relation*

$$d\mathbf{S} = \omega^{\mathbf{2}}. \tag{7.16}$$

Here $d\mathbf{S}$ is the state differential being 2-form and the coefficients of the form ω^2 (the second degree form) are the right-hand sides of equations (7.14), (7.15). It is just the evolutionary relation for the system of charged particles that generate electromagnetic field.

By analyzing the coefficients of the form ω^2 (obtained from equations (7.14), (7.15), one can assure oneself that the form commutator is nonzero. This means

that from relation (7.16) the Pointing vector cannot be found. This points to the fact that there is no such a measurable quantity (a potential).

Under what conditions can the Pointing vector be formed as a measurable quantity?

Let us choose the local coordinates l_k in such a way that one direction l_1 coincides with the direction of the vector $\mathbf{S}$. Because this chosen direction coincides with the direction of the vector $\mathbf{S} = [\mathbf{E} \times \mathbf{H}]$ and hence is normal to the vectors $\mathbf{E}$ and $\mathbf{H}$, one obtains that $\mathrm{div}\mathbf{S} = \partial s/\partial l_1$, where S is a module of $\mathbf{S}$. In addition, the projection of the vector $\mathbf{G}$ on the chosen direction turns out to be equal to $-\partial I/\partial l_1$. As a result, after separating from vector equation (7.15) its projection on the chosen direction equations (7.14), (7.15) can be written as

$$\frac{\partial S}{\partial l_1} = -\frac{1}{c}\frac{\partial I}{\partial t} + \frac{1}{c}Q^e; \tag{7.17}$$

$$\frac{\partial S}{\partial t} = -c\frac{\partial I}{\partial l_1} + c\mathbf{Q}'^i; \tag{7.18}$$

$$0 = -\mathbf{G}'' - c\mathbf{Q}''^i.$$

Here the prime relates to the direction l_1, double primes relate to the other directions. Under the condition $dl_1/dt = c$ from equations (7.17), (7.18) it is possible to obtain the relation in differential forms

$$\frac{\partial S}{\partial l_1}dl_1 + \frac{\partial S}{\partial t}dt =$$

$$= -\left(\frac{\partial I}{\partial l_1}dl_1 + \frac{\partial I}{\partial t}dt\right) + (Q^e\,dt + \mathbf{Q}'^i\,dl_1). \tag{7.19}$$

Because the expression within the second braces in the right-hand side is not a differential (the energetic and force actions have different nature and cannot be conjugated), one can obtain a closed form only if this term vanishes:

$$(Q^e\,dt + \mathbf{Q}'^i\,dl_1) = 0 \tag{7.20}$$

that is possible only discretely (rather than identically).

In this case $dS = 0$, $dI = 0$ and the modulus of the Pointing vector S proves to be a closed form, i.e. a measurable quantity. The integrating direction (the pseudostructure) will be

$$-\frac{\partial S/\partial t}{\partial S/\partial l_1} = \frac{dl_1}{dt} = c. \tag{7.21}$$

The quantity I is the second dual invariant.

Thus, the constant c involving into the Maxwell equations is defined as the integrating direction.

4. *Gravitational field*

Material system (medium), which generates gravitational field, is cosmological system. What can be said about the pseudo-Riemann manifold and Riemann space? The distinctive property of the Riemann manifold is an availability of the curvature. This means that the metric form commutator of the third degree is nonzero. Hence, it does not equal zero the evolutionary form commutator of the third degree $p = 3$, which involves into itself the metric form commutator. That is, the evolutionary form that enters into the evolutionary relation is unclosed, and the relation is nonidentical.

When realizing pseugostructures of the dimensions 1, 2, 3, and 4 and obtaining the closed inexact forms of the degrees $k = 3$, $k = 2$, $k = 1$, $k = 0$, the pseudo-Riemann space is formed, and the transition to the exact form of zero degree corresponds to the transition to the Riemann space.

It is well known that while obtaining the Einstein equations it was suggested that there are fulfilled the conditions [28]: the Bianchi identity is satisfied, the coefficients of connectedness are symmetric, the condition that the coefficients of connectedness are the Christoffel symbols, and an existence of the transformation, under which the coefficients of connectedness vanish. These conditions are the conditions of realization of the degenerate transformations for nonidentical relations obtained from the evolutionary relation of the degree $p = 3$ and after going to the exact relations. In this case to the Einstein equation there corresponts the identical equation of the first degree.

In conclution we can mention the following.

Physical fields are described by invariant field theory that is based on exact conservation laws. The properties of closed exterior differential forms lie at the basis of mathematical apparatus of the invariant theory. The mechanism of *forming* physical fields can be described only by evolutionary theory. The evolutionary theory that is based on the balance conservation laws for material systems is just such a theory. It is evident that as the common field theory it must serve a theory that involves the basic mathematical foundations of the evolutionary and invariant field theories.

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CRITICAL COMMENTS TO RELATIVISTIC DYNAMICS

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The paper is devoted to systematic criticism of some aspects of the special relativity theory (SRT). The main attention is given to the inconsistency and groundlessness in a seemingly "working" section of this theory – the relativistic dynamics.

1. Introduction

Though the technology achievements have been quite impressive in the elapsed century, the achievements of science should be recognized to be much more modest (contrary to "circumscientific" advertising). All these achievements can be attributed, most likely, to efforts of the experimenters and inventors, rather than to "breakthroughs" in the theoretical physics. The "value" of "post factum arguments" is well-known. Besides, it is desirable to evaluate substantially the "losses" from similar "breakthroughs" of the theorists. The major "loss" of the past century is the loss of unity and interdependence in physics as a whole (the unity in the scientific ideology and in the approach to various areas of physics). The modern physics obviously represents by itself a "raglish blanket", which is tried to be used for covering boundless "heaps" in separate investigations and unbound facts. Contrary to the artificially maintained judgement, that the modern physics rests upon some well-verified fundamental theories, too frequently the ad hoc hypotheses appear (for a certain particular phenomenon), as well as science-like adjustments of calculations to the "required result", similarly to students' peeping at an a priori known answer to the task. The predictive force of fundamental theories in applications occurs to be close to zero (contrary to allegations of "showman from science"). This relates, first of all, to the special relativity theory (SRT): all practically verifiable "its" results were obtained either prior to developing this theory or without using its ideas, and only afterwards, by the efforts of "SRT accumulators", these results have been "attributed" to achievements of this theory. The relativists try to magnify the significance of their theory by co-ordinating with it as many theories as possible, including those in absolutely non-relativistic areas. The artificial character of such a globalistic "web" of interdependencies is obvious. We shall leave for conscience of "showman from science" their intention to deceive or to be deceived (to their personal interests) and shall try to impartially analyze some doubtful aspects of SRT.

It is well known a philosophical statement (legibly applicable to SRT): "we can see that thing in the experiment we want to see there." Such an attitude is prepared and the situation is aggravated by the theorists, who are "stewed in their own juice" and ready to see in every experiment only confirmation to their tricks with mathematical symbols (although the author belongs to theorists as well). The existing uncertainties of the theory (carefully masked in SRT) allow the theorists to vary interpretation of experiments within considerable limits. And, afterwards, the incompleteness of experiments is masked "in a proper manner" by statistical "adjustment" of the data (data "truncation" under the desirable result).

In deriving the equations of motion of an electric charge and the field equations in theoretical physics' courses an attempt is made to cause an illusion of an "unequivocal idyll." But in such a case the Maxwell equations would be the equations of any fields, and all forces would be of Lorentz type and would have the form of Coulomb's law in a static case. Such an alternative of the general relativity theory (GRT) can be discussed (with some supplementation and modifications) for the gravitational field. However, the situation is different in the general case: for example, the nuclear forces are not proportional to R^{-2}. There exist many counterexamples of various fields and forces. Therefore, the theoretical physics (including the SRT approach) cannot determine all existing phenomena proceeding from their own principles only. This is an exclusive prerogative of the experiment. (The experimenter should be principally prepared to the fact that any theory can occur to be inaccurate or even wrong).

Also surprising is the apologetic advertising of SRT. For example, the pathos's assertion of [1], that "the relationship between the mass and energy underlies the

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entire nuclear power engineering" is groundless both in the historical and in the practical respect. This relationship bears no relation either to discovery of elementary particles and radioactivity, or to studying the spontaneous and forced decaying of uranium nuclei, or to determining the stability of nuclei, or to finding possible channels of nuclear reactions and possibility of practical choice between them, or to the isotope separation technology, or to practical utilization of released energy, etc. And (as paradoxical it may seem) this relationship bears no relation even to determining the released energy in any particular well-known reaction. This is because all things have historically happened just in the opposite order: at first, some reaction has been found, which was detected from the energy release exactly. And then the calculational functions – the combinations from mathematical symbols – can be derived by various methods. As a rule, it is technically impossible to determine the mass variation in a nuclear reaction directly. Even if one uses doubtful theoretical interpretations, the attempt to determine the mass variation will occur to be a rather rough and costly pleasure. Thus, the relationship between the mass and energy plays, in the practical respect, a part of scholar mathematical exercises for reverse substitutions, since desirable results can always be "derived" from the calculated data, which were tabulated post factum.

In the previous works we have proved the inconsistency of kinematic concepts of SRT [2-4,6], the groundlessness of GRT [5], the erroneousness of dynamical concepts of SRT [7], the invalidity of relativistic interpretations of some experiments [2,8]. The present paper supplements to the aforementioned systematic criticism of the relativity theory. The main purpose of this paper is to demonstrate that even in a seemingly unique practical SRT section, namely, in the relativistic dynamics, there exist numerous questions, compelling one to doubt in the validity of relativistic ideas and in interpreting their results.

2. Criticism of Some SRT Aspects

We shall begin with some general remarks. The group properties of mathematical equations, as the transformations with mathematical symbols, do not bear any relation to any physical principles or postulates; that is, the group properties can be found without additional physical hypotheses. For example, the Lorentz transformation laws, which reflect the group properties of the Maxwell equations in vacuum (or of the classical wave equation, including that in the acoustics), are not bound at all with SRT's postulate of constancy of the speed of light or with the relativity principle.

SRT tries to fight, from principal grounds, "against the windmills": for example, against the notion of absolute rigid body. In the classical physics, however, nobody assigns a literal sense in the abstraction of absolutely rigid body. It is obvious for everybody, that there are no absolutely rigid bodies even at absolutely non-relativistic velocities (we shall mention the role of accelerations, or, more correctly, of forces, in this issue by remembering usual collisions of cars on roads). Simply, in describing some motions the influence of strains is negligible or unessential for the phenomenon under study, and then, only for the sake of simplifying mathematical derivations, the absolutely rigid body abstraction is applied. SRT principally tries to consider elementary particles to be points [9] and immediately encounters another principal problem – the singularity of some quantities.

It is very "fashionable" to investigate any phenomenon by means of the fine Mossbauer effect. It is rather strange, however, to attribute the temperature effect on the resonance frequency shift to SRT's time slowdown effect – this is a clear speculation. Temperature variations influence, to a higher or lower extent, all physical phenomena without exception. The SRT time bears no relation to an obviously classical field of investigation. Otherwise, if we extrapolate the global claim of relativists quite slightly into a close field – up to melting of a specimen (where the effect itself vanishes), then – what should be declared in this case: the time has stopped its running, the time became singular, or some other delirium?

Though the contradictions of the relativistic kinematics have been analyzed in detail earlier [2-6], this issue needs additional investigation. We shall consider now the relativistic effect of contraction of distances. We shall "agree in advance" about the following mental experiment. Let a beacon, disposed at the middle of a segment, to send a signal toward its ends. Let segment's length be one million light years. At the time of arrival of a flash two pedestrians at segment's ends begin to walk at equal velocity toward the same preselected side, along the straight line containing the given segment, and they will be walking for several seconds. The moving segment (a system of two pedestrians) should be contracted relative to the ends of a motionless segment by some hundreds kilometers. However, none of pedestrians will "fly away" for hundreds kilometers during these seconds. The moving segment could not also be torn off at the middle, because the Lorentz transformation laws are continuous. So, where has this segment been contracted in such a case?

Let us make some comment on "astonishingness" of the relativistic law of "addition" of velocities. We pay attention to the obvious fact: for exchanging information the signals should be sent necessarily in the direction of an object, rather than in the opposite direction. Therefore, there is nothing surprising in exchanging the signals, where in the classical case it occurs also that, as a result of formal addition of velocities, $v_1 + v_2 > v_{signal}$. Let two airplanes to take off

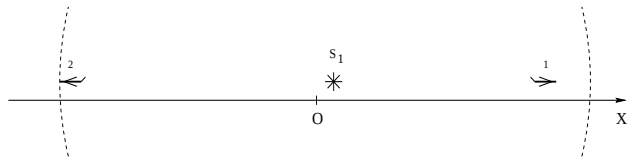

Figure 1: Exchange of a signal.

from the aerodrome O at velocities of $0.9v_{sound}$ and fly away from each other in the opposite directions of axis X. Whether the exchanging of signals between them is possible? Certainly yes! Because the sound wave propagates in air irrespective of the velocity of source S_1 at signal issuing time, the first airplane (which has sent a signal) will catch up the wave front propagating in the positive direction of axis X, whereas the second airplane will "compete" with the wave front propagating in the negative direction of axis X. Both airplanes are moving slower as compared to propagation of corresponding wave front sections nearest to them (see Fig. 1). Thus, the sum of velocities is compared (in a complicated manner), in reality, with quantity $2v_{sound}$, rather than with the speed of sound.

Now we shall proceed to the relativistic dynamics. SRT is completely inconsistent in considering accelerations and the dynamics of particles in general. The Lorentz transformations (from which the entire SRT issues) cannot impose any limitations on accelerations of bodies (as well as on studying accelerated systems). However, in such a case some SRT mismatches with the experiment would become too noticeable. As a result, SRT artificially declares that the study of accelerated (non-inertial) systems is a prerogative of GRT. But the successive application of this declaration would remain from SRT only the Lorentz transformations themselves and the velocity addition law (that is, a part of kinematics). To rise the "significance" of the theory, at first, in SRT the 4-acceleration is calculated formally mathematically, and then the relativistic dynamic equations are formally "derived." But what about the transformation of forces? In this case, contrary to SRT's own declaration, it is necessary to transform one accelerated particle (for $v \neq 0$) into "another" accelerated particle (for $v = 0$). The transformation of electromagnetic fields also contradicts the declared self-limitations, since the fields, introduced in a conventional manner, reflect nothing but the action of electromagnetic forces (the force approach). It would seem that the declaring of equivalence of SRT and GRT approaches could rise the "significance" of the theory. However, in some problems the application of SRT and GRT leads to different quantitative results. These mismatches result in the necessity of sacrificing any of the relativistic theories (or, more correctly, both of them).

In the classical physics all concepts have a clearly definite sense, and they should not be replaced with

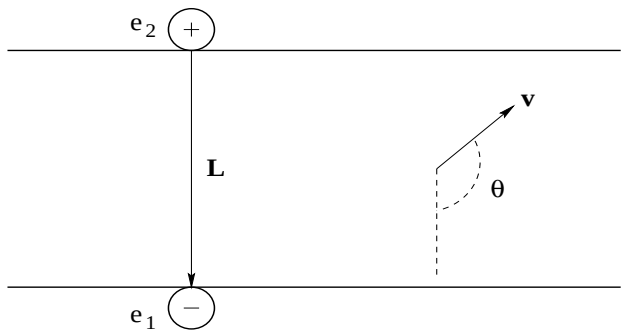

Figure 2: Paradox of transformation of forces.

ersatzes. Let the relativists be inventing other names to their new concepts (or, more correctly to combinations of symbols). The relativistic definition of coordinates of the center of inertia [9]:

$$\mathbf{R} = \frac{\sum E\mathbf{r}}{\sum E}$$

has no physical sense, since in SRT the center of inertia of the same system of moving particles occurs to be different in various frames of reference. Therefore, it does not fulfill its functional designation of the center of equilibrium. Let we have a massive planar box, in which the massive balls are moving. Let in the classical case the center of inertia of the whole system (in the course of motion and collisions of balls) be always coinciding with the center of a box. Then in the classical case we can balance it (for example, in the Earth's field of gravity or in some other field) on a support of small cross section, and the equilibrium will be kept. In SRT, on the opposite, if we only shall look at this system from a rapidly moving relativistic missile, then the center of inertia can appear to be not above a support, and the equilibrium will be violated. A remarkable objectivity of SRT: in order that the equilibrium of plasma in a controlled thermonuclear fusion not be disturbed, we ask the relativistic missiles not to fly and not to "spy" upon the experiment.

Consider now a paradox of transformation of forces. Let we have two charges e_1 and e_2 of opposite sign, which are at rest and separated by two parallel planes being at distance L apart of each other (see Fig. 2). Owing to attraction to each other, the charges are at a minimum distance L from one another. (They are at the state of neutral equilibrium with respect to a system of planes.) We shall draw a mark on a plane under each charge, or we shall place the observers nearby. Now we shall observe this system of charges from a relativistic missile moving at velocity $\mathbf{v}$. Let θ be the angle between vectors $\mathbf{v}$ and $\mathbf{L}$. Determining the electromagnetic forces, acting between these charges in missile's frame of reference [9], we shall be interested in tangential components of forces, i.e. in the components

of forces along the planes. The force influencing charge e_1 is

$$F_\tau = \frac{e_1 e_2 (1 - v^2/c^2)(v^2/c^2) \sin\theta \cos\theta}{L^2 (1 - v^2 \sin^2\theta/c^2)^{3/2}} \neq 0. \qquad (1)$$

Therefore, the charges will be displaced from their initial position. Let the balls be having huge charges, L be small ($L \to 0$), and v be large ($v \to c$). Let the observers to retain the balls with very thin threads. Whether they will be torn? The answer depends on the system of observation. So, who of the observers will be right? Thus, we have another inconsistency of SRT.

Now we shall make a methodical remark on confirmation of relativistic formulas. The accuracy of experiments in microscopic world's physics is low, as a rule, in a separate measurement act. However, this accuracy is artificially increased by choosing the events "needed for the theory" and by subsequent statistical processing the results (adjustment under the theory). Unlike the classical field of investigation, nobody measures directly the value of velocity (as well as the mass) of particles in relativistic ranges of velocities. Therefore, it is impossible to substitute, in the explicit form, quantities v and m into calculated (!) values of energy and momentum and verify the conservation laws of SRT. Even if one determines experimentally some nearly-kept numerical quantities, the literal expression for energy and momentum can be extracted from these figures by many various techniques. And, you see, even the numerical values of energy and momentum have been measured indirectly (again, we are dealing with theoretical interpretations). In studying collisions with particles being "at rest" the question arises: where so many resting particles have been found from? And how had this fact been verified (since this circumstance can relate to determination of collision and scattering angles, of an aiming parameter, etc.)?

SRT bears no priority relation to explaining the presence of momentum in a photon. Any particle (including a photon) is detected from its interaction with other particles, that is, actually, from the momentum transfer. The experimental basis for defining the presence of photon's momentum are Lebedev's experiments on measuring the pressure of light. The literal expression for a kinetic energy of photon can be elementary deduced from the general definition: $dE = \mathbf{v}d\mathbf{p}$ (from the general equations of motion). If we take into account that the photon moves at a speed of light $v = c$, then after integration we obtain $E = cp$ without any SRT's ideas.

Very frequently in SRT, for "simplifying" the description of collisions, the technique of transition to any "conveniently moving" frame of reference is used. Such a procedure, however, has no physical grounds, and the principle of relativity for closed identical systems is for nothing here at all. If the relativistic experiments are carried out on artificial beams of particles, then the sources (accelerators) and recording instruments are bound to the Earth, and accelerators and instruments will not fly, together with a moving observer, from our mental imagination only. If some process in Wilson's chamber is investigated, then the tracks of particles are bound to a medium (that is, to Wilson's chamber), rather than to a flying observer. For example, in the classical physics the angle between the tracks of particles will not change due to motion of an observer. At the same time, the angle between the velocities of particles, which leave mentioned tracks, can depend on observer's motion velocity. In the relativistic physics the angles between trajectories and between velocities of particles depend, also according to various laws, on observer's motion velocity. Therefore, such a seemingly probable from SRT viewpoint transition to a new frame of reference can essentially distort the interpretation of a solution. That is, any process should be considered in the frame of reference of a real observer (or recording instrument) only.

One more distortion of reality is the consideration of the process of collision of two particles (being principally point-like in SRT) as a planar motion. In fact, point-like particles should be considered as a limiting case of particles having real finite size (otherwise no frontal collisions would be observed, it would be impossible to consider collisions of atoms and molecules, the protons would not have structure, etc.). And in the present case the collision of particles is principally three-dimensional (the probability of planar motion is zero). Let, for example, two identical balls (1 and 2) to approach each other before collision over straight lines crossing in space (the minimum distance between straight lines is smaller than the ball diameter). Even from the very beginning of the experiment we cannot draw the plane through these specified straight lines. Nevertheless, we shall take the middle of a minimum distance between crossing straight lines (the trajectories before collision) and draw through it crossing straight lines parallel to the given trajectories. Now, only one plane α passes through crossing straight lines (Fig. 3). The centers of balls move parallel to this plane before collision: the first ball's center moves slightly above the plane and the second ball's center – slightly below this plane. After collision the balls will fly over other crossing straight lines. And, again, it is impossible to draw the plane through these straight lines. Again, we shall perform a similar procedure with parallel transition of straight lines, on which the lines of motion lie after collision, before crossing at the middle. We shall draw through crossing straight lines the plane β (the centers of balls will again move on different sides from this plane). However, "the plane before collision" does not coincide with "the plane after collision," but intersects it at some angle.

Second method: let us draw one plane γ through the trajectory of motion of the first particle (crossing

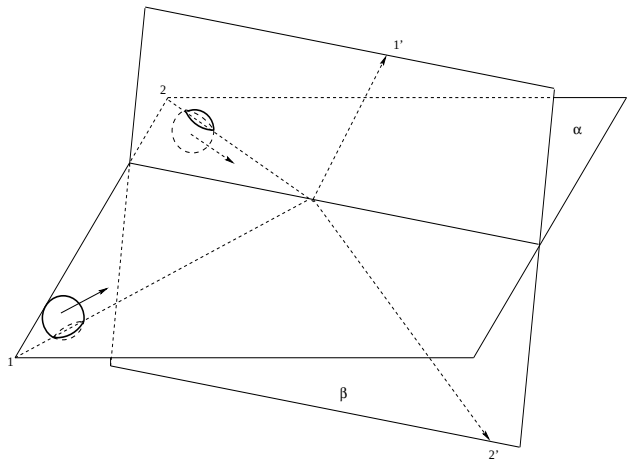

Figure 3: Nonplanar motion of two particles.

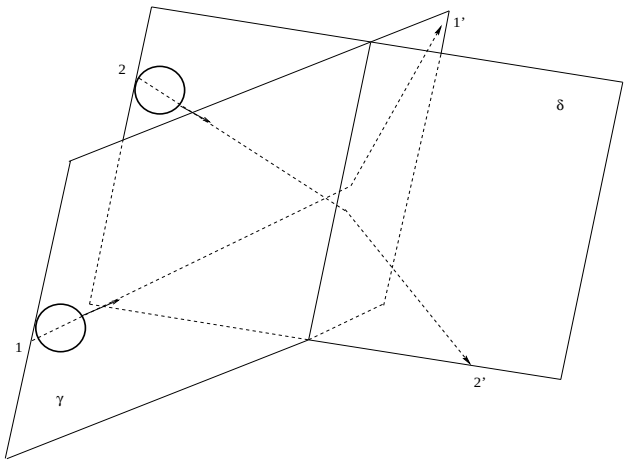

Figure 4: Three-dimensionality of collision of two particles.

straight lines of its motion before and after collision), and the second plane δ – through a similar trajectory of motion of the second particle. However, these planes are also crossed at some angle (Fig. 4). So, what follows from three-dimensionality of motion? To answer this question we shall write the classical laws of conservation of momentum (in projections) and of energy:

$$v_{1x} + v_{2x} = v'_{1x} + v'_{2x} \quad (2)$$

$$v_{1y} + v_{2y} = v'_{1y} + v'_{2y} \quad (3)$$

$$v_{1z} + v_{2z} = v'_{1z} + v'_{2z} \quad (4)$$

$$\sum_i (v_{ix}^2 + v_{iy}^2 + v_{iz}^2) = \sum_i (v'^2_{ix} + v'^2_{iy} + v'^2_{iz}). \quad (5)$$

We see, that for six unknown quantities (v'_{1x}, v'_{1y}, v'_{1z}, v'_{2x}, v'_{2y}, v'_{2z}) there are four equations only. Thus, there should remain <u>two</u> indefinite parameters in the solution. If we suppose the motion to be planar (i.e. exclude equation (4)), then for remaining four unknowns we shall have three equations. Therefore, in comparing SRT results with the classical physics the substitution of solutions is accomplished, and there remains only <u>one</u> indefinite parameter (the scattering angle is usually considered to be the latter one). Such a substitution results in improper interpretation of the experimental data, especially when the missed quantities are restored. For example, the book [10] demonstrates two tracks of fly-away of particles of identical mass and charge (more correctly, of identical e/m ratio) with dispersion angle lower than $90°$, and the conclusion on the classical mechanics invalidity is drawn from this demonstration. Let us write the expression for angle α between the trajectories of dispersed particles:

$$\cos\alpha = \frac{v'_{1x}v'_{2x} + v'_{1y}v'_{2y} + v'_{1z}v'_{2z}}{\sqrt{(v'^2_{1x} + v'^2_{1y} + v'^2_{1z})(v'^2_{2x} + v'^2_{2y} + v'^2_{2z})}}. \quad (6)$$

Choose axis Z so, that it will be $v_{1z} = v_{2z} = 0$. Now we express variable v'_{1x} from equation (2), variable v'_{1y} – from equation (3), variable v'_{1z} – from equation (4), and from equation (5) we shall express quantity v'^2_{2z} (in this case the condition $v'^2_{2z} > 0$ restricts the region of possible values of all variables). Substitute all aforementioned quantities into equation (6). As a result, we obtain the two-parametric dependence on v'_{2x} and v'_{2y}, which is not written here because of its awkwardness. Using graphical programs, we can be convinced that for the given values of $v_{1x}, v_{1y}, v_{2x}, v_{2y}$ we obtain some surface similar to the inner part of a cylinder; that is, quantity $\cos\alpha$ varies within wide limits. For example, it can easily be verified that the values

$$v_{1x} = 0,1; \quad v_{1y} = 0,1; \quad v_{2x} = 0,7; \quad v_{2y} = 0,7;$$

$$v'_{1x} = 0,6; \quad v'_{2x} = 0,2; \quad v'_{1y} = 0,4;$$

$$v'_{2y} = 0,4; \quad -v'_{2z} = v'_{1z} = \sqrt{0,14}$$

satisfy all classical conservation laws (2-5). For these values we obtain $\cos\alpha = 0.29554$, that is, $\alpha \approx 72.8°$. Note: if the velocities are assumed to be expressed in terms of the speed of light, then a lower velocity is quite real for the motion of internal electrons in atoms beginning with $z \geq 60$. And, generally, nobody saw electrons in atoms being at rest! The angle of $90°$ is unambiguously obtained in the classical physics at collision with a particle being at rest in the coordinate system of a recorder (but only where such a particle can be found?). However, the observed fly-away angle of $90°$ does not result at all in an unambiguous opposite assertion, that one of particles had been at rest (the mathematical probability of such an event is infinitesimal). Thus, the reverse problem of restoring the missed data is not an unambiguous procedure either in the classical, or in the relativistic physics (there exists an infinite number of various self-consistent solutions).

For more rigorous verification of conservation laws in collisions (from any theory) it is necessary to study

collisions of particles in vacuum for narrow monoenergetic beams of known particles for the given collision angles. In this case the complete study of the collision process should include the check of the energy balance of particles (for each scattering angle in space), the testing the balance of momenta of particles, the testing the balance of the total number of particles in beams before and after collision (the probability of scattering), the control of the balance of arising radiation in energies and directions. There are two more questions (two more uncertainties), which are not usually emphasized, namely: does the scattering depend on a mutual orientation of spins of colliding particles? And do these spins change during the collision? In the classical physics the answer to these questions is "yes" (but in the quantitative respect it strongly depends on the "structure" of balls).

The author did not meet any complete analysis of any collision process in SRT with respect to all issues set forth above. This does not imply, however, an unambiguous conclusion on invalidity (within the limits of experimental errors) of usually utilized relativistic conservation laws in any collision process (though this can quite occur to be the fact for many separate cases). The author only asserts that there are no even separate examples of absolute confirmation of relativistic collision laws (to say nothing of the global confirmation).

From a principally rigorous position, the application of relativistic conservation laws to the collision process in the elementary particle physics is rather doubtful. Whether these laws can retain their form irrespective of the charge of colliding particles, collision angles and dispersion angles? You see, the charged particles undergo acceleration during the collision. Therefore, some radiation (field) should always be observed. Is it necessary, really, to behave as the students having peeped at the answer to the problem: if the instrument has recorded a γ-quantum ("has seized our hand"), then it should be clearly taken into account "with a clever air." And should one trust in validity of SRT formulas "with a clever air" in remaining cases as well? So, where is the "predictive force" of SRT? Actually, the conservation laws should be explicitly supplemented by the terms, which take into account the energy and momentum of the field.

Generally speaking, the only case, where the discussion of relativistic conservation laws at "collisions" is lawful, is the interaction of particles with the forces of electromagnetic nature (the Lorentz force). For remaining cases the fulfillment of relativistic conservation laws is an unverified hypothesis (the light spheres of SRT bear no relation to the forces of non-electromagnetic nature). However, in the case of electromagnetic interactions no SRT ideas are required for deriving relativistic conservation laws as well. It is known that the equations of motion with the initial conditions completely determine all characteristics of motion, including the integrals of motion. Such an integral of motion can be the energy (but not always!). It follows from the equation of motion, that

$$\frac{d\mathbf{P}}{dt} = \mathbf{F} \quad \Rightarrow \quad \mathbf{v}d\mathbf{P} = \mathbf{F}d\mathbf{r}. \tag{7}$$

Introduce the definition of the potential energy

$$U = -\int_{r_0}^{r} \mathbf{F}d\mathbf{r}.$$

Knowing the form of the momentum (this is a quantity appeared in the experimental equation of motion (7); for example, in the classical case $\mathbf{P} = m\mathbf{v}$ and in the relativistic case $\mathbf{P} = m\mathbf{v}/\sqrt{1-v^2/c^2}$, one can obtain the energy conservation law from $dE = \mathbf{v}d\mathbf{P} - \mathbf{F}d\mathbf{r}$: classical $U + mv^2/2 = constant$, or relativistic $U + mc^2/\sqrt{1-v^2/c^2} = constant$, respectively. Under the condition of equality forces of action and counteraction (the third Newton's law, the hypothesis of central forces) we have: $\mathbf{F}_{12} = -\mathbf{F}_{21}$. Then from the equation of motion (7) we can obtain the momentum conservation law (this is again a quantity appeared in the experimental equation of motion (7): from $d\mathbf{P_1}/dt = \mathbf{F}_{12}, d\mathbf{P_2}/dt = \mathbf{F}_{21}$ we obtain

$$\frac{d(\mathbf{P}_1 + \mathbf{P}_2)}{dt} = 0, \quad \Rightarrow \quad \mathbf{P}_1 + \mathbf{P}_2 = constant.$$

However, in the presence of magnetic forces $\mathbf{F}_{12} \neq -\mathbf{F}_{21}$, and the relativistic law of conservation of momentum of particles can be violated in the general case. Since the majority of particles (even many electrically neutral ones) have magnetic moment, the application of the relativistic momentum conservation law in the nuclear physics and elementary particle physics without explicit considering the field momentum is completely illegitimate. Therefore, we again arrive at the necessity of explicit considering the momentum (and, hence, the energy) of the field at collisions. (Possibly, this will help to regulate the nuclear physics and elementary particle physics and to decrease the number of particles-ghosts?)

The account taken of the radiation reaction force also results in violation of energy and momentum conservation laws declared in SRT. Should we refuse from accounting this force in the process of collision of particles? But this force just should be most significant in this process (there are great fields, owing to rapprochement of high-energy particles, and great variable accelerations).

The non-conservation of generally-accepted expressions for relativistic energy and momentum at collisions of particles results, in the general case, in the non-conservation of the angular momentum in SRT as well. However, the relativistic expression of the angular momentum can be easily discredited for much simpler examples [11]. Let us recall, for example, the paradox of a lever. Let two forces, equal in magnitude,

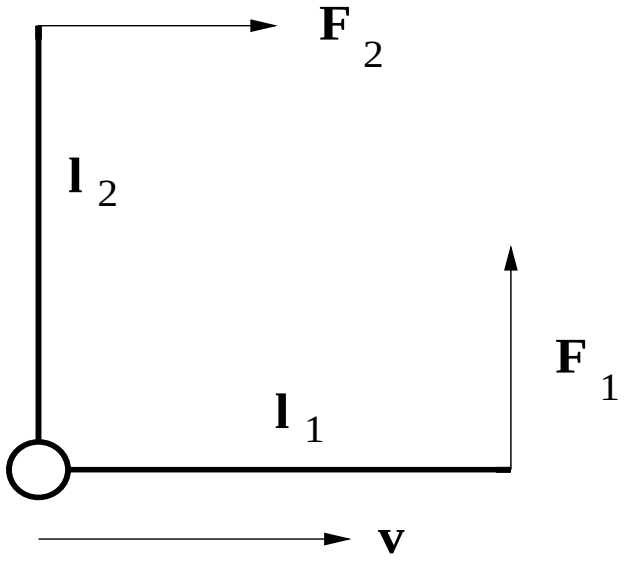

Figure 5: Paradox of a lever.

$F_1 = F_2 \equiv F$, to act on two identical arms $l_1 = l_2 \equiv l$, disposed at angle $\pi/2$ (Fig. 5). The total moment of forces equals zero. The structure remains motionless. In the classical physics the result does not depend at all on the frame of reference, and, hence, it is not necessary to invent any new physical concepts, processes, phenomena or mathematical derivations.

Different is the situation in SRT. If somebody will only look at this system from a missile moving at velocity v along one of arms, then the total moment will occur to be nonzero. Owing to contraction of lengths and transformation of forces we have: $M_{sum} = Flv^2/c^2 \neq 0$. The lever must begin to rotate. It would seem that such an inconsistency should entail refusal from SRT and returning to the classical physics, that provides an obvious and true result. However, the relativists (following Laue and Sommerfeld) have gone another way [12]. "For the sake" of pseudo-science it was necessary to sacrifice something. Since the common sense is less significant for relativists, than SRT, it was necessary for them to invent the missing pseudo-moment. Now, if you simply rest upon something (on the wall, for instance) or use a lever, then you should store some additional clothes: "something" (the energy) will begin to flow through you, and this quantity can occur huge! Besides, the fluxes (of sweat, probably?) can occur to be different simultaneously, if somebody "spies" upon you from different moving missiles. If you keep both levers with your hands with identical force, then the energy from one hand merely flows away to an axis and "settles" somewhere. Do not worry, however! This "something" can not be measured in any way, but this is just not necessary for relativists: this is not engaging in physics, you see! Simply, the literal expressions should be met with an obvious (from the common sense viewpoint) result. Thus, instead of one principally undetectable relativistic effect (otherwise the inconsistency would be detected) we would obtain two principally undetectable relativistic effects exactly balancing each other. Similar tricks have an effect on many people (the letters just converge!), in spite of the fact that "the dry remainder" of all similar "inventions" is a priory obvious classical result.

Also fully unsatisfactory is the semi-classical derivation of the Einstein formula [1]: $\Delta E = \Delta mc^2$. First, the notion of the center of masses is contradictory in SRT [7]. Second, for some reason one remembers about acoustic waves in SRT only when they are unessential (distract from apparent paradoxes). But these waves bear some relation to the given situation. Let at the ends of a homogeneous tube of length L and mass M there are bodies A and B of negligible mass [1] (we take, for example, the monomolecular layers of the same substance). Let the atoms of layer A be at exited state. The following "circular process" is considered in [1]. At first, body A emits a short light pulse in the direction of body B. It is stated that the tube will begin to move as a whole. But this is not the case. Let the length $L = 1$ cm. The emitted pulse will make body A to bend and move to the distance of about intermolecular one from tube's molecules retaining it. Then the elastic force will arise, which tends to return the lost equilibrium. As a result, the complicated system of longitudinal and transversal oscillations will propagate along a tube. During the time, for which the light will reach body B, these acoustic waves will pass the distance not greater than 10^{-5} cm (since $v_{sound} \ll c$). A similar process will be repeated with body B. Thus, the oscillating tube will extend from center O in opposite directions (to the side of body A – to a slightly greater distance), until the acoustic waves will cancel each other and the equilibrium will establish. But even this complicated real process does not matter, indeed. Further on [1] body B with absorbed energy is brought into contact with body A by internal forces; body B returns energy back to body A and returns to its place (and then the mathematical symbols are written). One moment! Third, in what manner could body B transfer electromagnetic excitation energy without transferring momentum? Besides, it could be only the light pulse (otherwise according to the second thermodynamic law not all energy could transfer to body A). But in such a case we would simply have a mutually reciprocal momentum transfer by means of light, and no global conclusions follow from this situation. The given problem is similar to the classical problem on throwing a ball in a boat from one person to another. The ball has a mass, and in flight it also possesses nonzero momentum and energy. The value of mass enters expressions for a momentum and kinetic energy, but no "all-universe" conclusions follow from this situation. The thing sought in [1] can be obtained much easier. From the general

expression $dE = \mathbf{v}d\mathbf{P}$ we have for light $\Delta E = c\Delta P$. If we introduce, in a classical manner, for a photon the mass of motion $P = mv$, then from $v = c = constant$ follows the only possibility $\Delta P = c\Delta m$. As a result, without any mental SRT ideas, we have $\Delta E = c^2\Delta m$. However, fourth, this result (irrespective of the method of its derivation) relates to the electromagnetic energy only and not to anything more (at least, there are no proofs of generality of the result).

It would seem that for electromagnetic interactions there should be the least number of reasons to doubt in the relativistic equation of motion: $\frac{d\mathbf{P}}{dt} = e\mathbf{E} + \frac{e}{c}[\mathbf{v}\times\mathbf{B}]$, and, as a consequence, in relativistic conservation laws for the process of collision. Nevertheless, we shall make some remarks on the issue of validity of relativistic description of the Compton effect. Above we have already considered some uncertainties for collision of balls – an analog of the "billiard"-type Compton model. We shall analyze the experiments described in the standard tutorials, for example, in [1,13,14]. Note that if the time of coincidence of instants of recording γ-quanta and electrons $\Delta t > 10^{-20}$ sec, then the experiments not only do not prove the simultaneity of emitting of particles, but also do not allow to attribute unambiguously the particles to any act of scattering. Such an accuracy is outside the limits of even modern possibilities (that is, this is still a matter of "faith," and no statistics will help here).

It is methodically incorrect to call the electrons, participating in scattering, as free ones, because in such a case their number should be constant in the experiment. However, one has to consider this number to be different depending on a scattering angle, and if this angle is rather small, all electrons are bound. In fact, however, all electrons participate in the momentum transfer (owing to their motion in an atom) and capture from a γ-quantum a part of energy (because they are bound in the atomic coordinate system).

Some points in the Compton effect theory are not obvious. For example, what is the role of scattering on larger particles, than electrons, – on nuclei (whether the interference and its influence from radiation, scattered on nuclei, are possible?)? Why the non-shifted line is absent in the experiment with lithium (Compton, Wu)? On the contrary, it should always be present, for example, from scattering on a nucleon. Why for all substances there exist two peaks, situated almost symmetrically with respect to the initial line, rather than one shifted peak? Besides, all tracks are not visualized (as in the ideal theory), but are only restored with the help of auxiliary means (and interpretations). That is, in verifying the conservation laws we are dealing with statistical hypotheses. In the experiments there are no estimates of the probability of double scattering from a specimen (but it can have a noticeable value), and the role of multiply scattered "background" from all parts of an experimental setup is evaluated nowhere. The accuracy of experiments, even on determination of a scattering cross-section, is low about In so doing, the most presentable (favorable to the theory) events are chosen. For example, in the experiment by Crane, Gaerttner and Turin only 300 cases from 10000 photos nave been chosen (whether this is not too little?), and the coincidence of the scattering cross-section data with the Klein-Nishina-Tamm formula is declared. In the case of large thickness of specimens (Kohlrausch, Compton, Chao) the double scattering must obviously be taken into account. Similarly, it is obvious that in Szepesi and Bay's experiment the number of double scattering events is of the same order, as that of single scattering ones. If this fact is not taken into account, the declared accuracy of 17% is rather doubtful. The declarative corrections (adjustments), made by Hofstadter in his experiment due to influence of various factors, cause bewilderment. In this case after all corrections (adjustments up to 30%!) the accuracy of 15% is declared. In reality, in all experiments not the dispersion directions are found, but the hitting into the given site of space is recorded. The experimental confirmation of a SRT interpretation occurs to be rather doubtful. For example, in the experiment by Cross and Ramsey almost a half of points, with regard to declared limits of tolerances, lie outside the theoretical curve. Of interest is the fact, that after removing a recording device from the plane of scattering the number of coincidences in scattering acts remains to be considerable: it more than three times exceeds the background value. Also rather strange is to compare Skobeltsyn's experiments with the theory with respect to the ratio of a number of particles scattered to various angles $N_{0^\circ}^{10^\circ}/N_{10^\circ}^{20^\circ}$. You see, each of these quantities (both numerator and denominator separately) represents some averaged (effective) quantity. And how is it possible, in the general form, to compare the ratio of average quantities (two experiments) with the ratio of true quantities (a theory)?

For more complete theoretical substantiation of the Compton effect not one collimator is required (for incident particles), but three collimators for separating, in addition, each type of scattered particles over narrow directions. The absorbers are also necessary for eliminating the background. Then there will remain "only" the problem of filtering all particles over energies. Thus, even such an, apparently, purely relativistic phenomenon, as the Compton effect, is not experimentally verified to a complete measure.

An incorrect procedure may occur to be also the searching for solutions in SRT to an accuracy of up to some expansion in v/c. The rejected terms can cardinally change the form of a solution. The field of applicability of the approximate solution in time can occur to be such small, that the approximate solution will not have any theoretical and practical value (but how can it be detected without knowing the behavior of a true function?). Also doubtful is to derive the averaged solu-

tion from approximate one. A trivial example: it would seem formally, that in the Lorentz force it is possible to neglect the magnetic force containing v/c. This is not the case, however: in the classical limit, instead of a real average drift of a particle at constant velocity perpendicular to both fields, we would obtain the accelerated motion along the field $\mathbf{E}$. In the relativistic limit [9] the velocities grows most rapidly also in the direction of $[\mathbf{E} \times \mathbf{B}]$. Apparently, due to this reason the approximate Lagrange functions, constructed in SRT up to some term in v/c, can cause some problems, and the construction of an accurate Lagrange function is principally problematic in SRT. The limited nature of SRT results reveals itself in self-acceleration of charges under an effect of radiation reaction. The radiation is determined in the far-field zone and should not strongly depend on the processes occurring on particle scales: only re-evaluation of SRT rigorousness compels one to consider elementary particles as point-like ones.

From author's standpoint the most consistent attitude is a principal recognition of the results of relativistic dynamics and electrodynamics as approximate ones, to an accuracy provided by the experiment. One should not overestimate the possibilities of purely theoretical techniques and to overload the physics with globalisms. It is namely this reason and insufficient substantiation of relativistic experiments, why the author does not try to offer any alternative theory. At present, the theory should analyze and generalize those experiments, which have been carried out particularly in the region of high velocities.

3. Conclusion

The inconsistency of some aspects of the relativistic kinematics and some dynamic concepts of SRT is additionally demonstrated in the present paper. The main attention is given to criticism of the relativistic dynamics. The logical inconsistencies in this, seemingly "working" and "verified"

field of investigations are presented. The complete groundlessness of a generally-accepted interpretation of the relativistic dynamics is demonstrated, and the SRT interpretation of the Compton effect is analyzed in detail.

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LARGE SCALE PERIODICITY IN REDSHIFT DISTRIBUTION

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We review the previous studies of galaxies and quasar redshifts discretisation. We present also the investigations of the large scale periodicity, detected by pencil–beam observations, which revealed 128 (1/h) Mpc period, afterwards confirmed with supercluster studies. We present the theoretical possibility of obtaining such a periodicity using a toy-model. We solved the Kepler problem, i.e. the equation of motion of a particle with null energy moving in the uniform, expanding Universe, decribed by FLRW metrics. It is possible to obtain theoretically the separation between large scale structures similar to the observed one.

1. Introduction

In the large scale Universe the search of regularities is connected with testing, if radial velocities of galaxies can admit an arbitrary values, or some regular patterns, called periodisation or quantisation of galaxy redshifts is observed. The search for possible periodicity in redshift distribution has been an important question from the point of view of selection effects in observational data, as well as the correctness of applied statistics. The possible interpretation of such effect is very important too. The lack of a known mechanism causing redshift discretisation constituted the basis for claims invoking new physics at work. Due to different methods of investigations we describe separately investigations of galaxy and quasar redshift periodisation. There are presented in sections two and three. The quasar redshift periodisation in more details is presented elsewhere (Bajan et al. 2004) Moreover, the fourth section is devoted to the large scale periodicity with a period of a 128 (1/h) Mpc. This large scale periodicity obtained originally by pencil beam observations has been confirmed by various studies. So, in reality, it is the only redshift discretisation, which is almost commonly accepted. In the last section we give the possible solution of the large scale periodicity. We obtain the exact solution of the Kepler problem in the expanding Universe. With appropriate fine tunning it is possible to obtain the distribution of structures with about 130 Mpc separation between them.

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2. The discretisation of galaxy redshifts

The discussion of redshifts quantisation started with works of Tifft. In the Coma cluster of galaxies (Tifft 1976) optically determined redshifts of member objects can be grouped into bands with the differences of 72.46 $\mathrm{km \cdot s^{-1}}$. The repetition of the analysis based on the more accurate, this is HI, data confirmed this periodicity.

The result was preceded by the study of the distribution of galaxy redshifts versus nuclear magnitudes in the Coma cluster core (Tifft 1974 and references therein), were strong redshifts periodicity of 220 $\mathrm{km \cdot s^{-1}}$ were observed. The existence of band structure on nuclear magnitude-redshift diagram was reported by Nanni et al. 1981 on the basis of better nuclear magnitude and redshift determination. However, in order to find the effect of quantisation it was necessary to apply to galaxy heliocentric redshift also the correction connected with the solar galactocentric movement, which is not precisely known.

Few years later Tifft and Cocke (1984) generalised

their claim for all galaxies. There exists global periodicity. It is equal to 36.3 km$\cdot$s^{-1} for broad-line galaxies and 24.2 km$\cdot$s^{-1} for narrow-line galaxies. The later value afterwards was not confirmed, so presently the value of about 36 (or 72) km$\cdot$s^{-1} is considered as the basic one.

Tifft (1980) shown that the redshift differences for double galaxies have a statistically significant grouping near multiples of 72 km $\cdot$ s^{-1}. Afterwards, the initial sample of galaxies has been enlarged and objects with more accurate redshift determination ($\sigma < 25$ km$\cdot$s^{-1}) considered (Tifft 1982a,b). The periodicity of 72 km $\cdot$ s^{-1} was observed only for such well determined redshifts. Greater uncertainties blurred the observed periodicity. The way, in which statistical analysis has been performed was critisied by Newman, Haynes & Terzian (1989). Cocke and Tifft (1991) re-addressed this problem, concluding that the approach was statistically correct. Schneider and Salpeter (1991) used the sample of 107 isolated binary galaxies with very reliable 21 cm redshifts. They do not find the multiplicity of 144, 216 ... km $\cdot$ s^{-1}, suggested by Tifft, but they confirm the excess in velocity differences near 72 km $\cdot$ s^{-1}.

Considering 40 members of the Local Group Rudnicki et al (2001) claimed the existance, at 95 % significance level, of redshifts periodisation in the considered sample, however without the precise value of the periodisation. They concluded, that the uncertainties in the published redshift determination do not allowed to make more precise statements. It is worthwhile to note, that the discretisation of redshift in the Local Group concern not only galaxies, but also globular clusters. The further analysis of the problem (Godlowski et al. 2003) shown that the strict quantisation is excluded, but a weak evidence of period P about 36 (or 24) km $\cdot$ s^{-1} is observed.

Guthrie and Napier (1991) from the database extracted 89 non-Virgo spirals with galactocentric redshifts ¡ 1000 km$\cdot$ s^{-1} and quoted redshift accuracy $\sigma \leq 4$ km $\cdot$ s^{-1}. An evidence of periodicity about 37.5 km $\cdot$ s^{-1} was noted. Afterwards they (1996) repeated the analysis using 247 spirals with galactocentric radial velocities ¡ 2600 km$\cdot$ s^{-1}, finding strong periodisation with P $\sim$ 37.6 km$\cdot$ s^{-1}. The paper precisely describes the procedure of Power Spectrum Analysis, the hypothesis tested, as well as the determination of the solar vector in respect to the Galaxy centre.

3. The quasar redshift quantisation

This phenomenon is probably the eldest one, because in the late sixties of the previous century first claims were published. Cowan (1968) reported an effect with a period of 0.1666 in redshift z = $\Delta\lambda/\lambda$. The result was broadly discussed and the re-analysis of existing data, with increasing number of quasars considered, was performed. The Power Spectrum Analysis was implemented for periodicity search, which allows to determine precisely the statistical significance of the effects (Lake & Roeder 1972). Some further claims were that periodicity is 0.089 in log(1+z), which corresponds to a factor 1.227 between values of two consecutive maxima in the 1+z redshift distribution. Kjaergaard (1978) carefully discussed the manner, in which quasars are found and concluded, that the strong selection effects influence the observed redshift distribution, causing the existence of several peaks. So, according to his conclusions observed peaks are due to selection effects. Quite recently the sample of 1647 quasars selected in the uniform way has been analysed. Some maxima can be observed, but according to Power Spectrum Analysis they are statistically insignificant (Hawkins et al. 2002).

4. Large scale periodisation

Broadhurst et al. (1990) found the high peaks separated by regular spacing, strongly indicating the existence of a 128 $\cdot$h^{-1} Mpc (where h^{-1} is the Hubble constant in units of 100 km $\cdot$ s^{-1}) period in the redshift distribution. This result based on narrow pencil-beam method was confirmed by other researchers, who using the distribution of Abell galaxy clusters founded a 120 Mpc periodicity (Einasto et al. 1997). Several deep galaxy redshift surveys show this periodicity the presence of 100-Mpc scale structures (Kirshner 1997). The possibility of such large scale distribution of matter was pointed out also by Gonzales et. al (2000).

The Voronoi foam being a model describing of galaxy distribution in sheets, filaments and clusters surrounding voids was applied for study the possibility of explanation this periodicity. Van de Weygaert (1991) was able to explain the effect, but he concluded that the periodicity, even in the cellular Universe, is not a common phenomena. The similar conclusion was reached by Ikeuchi and Turner (1991), who stressed that the quasi-periodicic pattern is less than only 2σ fluctuation in a Voronoi tessellation.

The other simply possibility is the existence of a coherent peculiar velocity field with the amplitude of the order of 10^{-3} and the period 128 h^{-1} Mpc (Hill, Steinhardt and Turner 1991). Such an amplitude is similar to the peculiar velocity field observed in our vicinity and connected with so-called Great Attractor. The oscillating Universe (Morikawa 1990) or the change of the values of the fundamental constants (Hill, Steinhardt and Turner (1990)) were also involved as possible explanation of this periodicity. Salgado et al. (1996), Quevedo et al. (1997) discussed the oscillation of gravitational constant.

5. The possible explanation of the large scale periodicity

We study the Newtonian motion of a particle in a gravitational field in the space–time with the Friedmann—Lemâitre—Robertson—Walker (FLRW) metrics

$$(ds^2) = (dt)^2 - \sum_i a^2(t)(dx^i)^2. \quad (1)$$

The observational coordinates X^i of the expanding Universe can be written as

$$X^i = a(t)x^i, \quad dX^i = a(t)dx^i + x^i da(t), \quad (2)$$

and instead of the differential of the Euclidean space dX^i, we use the covariant differential of the FLRW space coordinates

$$a(t)dx^i = d[a(t)x^i] - x^i da(t) = dX^i - X^i \frac{da(t)}{a(t)}. \quad (3)$$

One can check that the interval (1) in terms of these variables (2) becomes

$$(ds^2) = (dt)^2 - \sum_i \left(dX^i - H(t)X^i dt\right)^2, \quad (4)$$

where $H(t) = \dot{a}(t)/a(t)$ is the Hubble parameter. As example the classical Newton action in the space with the interval (4) and the covariant derivative $(\dot{X}^i - H(t)X^i)$ takes the following form

$$S_A = \int_{t_I}^{t_0} dt \left[\sum_i \left(P_i(\dot{X}^i - H(t)X^i) - \frac{P_i^2}{2m_I} \right) + \frac{\alpha}{\sqrt{X_i X^i}} \right], \quad (5)$$

where $\alpha = M_{\rm O} m_I G$ is a constant of a Newtonian interaction of a galaxy with a mass m_I in a gravitational field with central mass $M_{\rm O}$.

In the terms of the conformal time $d\eta = dt/a$ in effective units $r = \sqrt{x_i x^i} = R/a$, $P_r = P_R a$ the action (5) takes the form

$$S_A = \int_{\eta_I}^{\eta_0} d\eta \left[P_r \frac{dr}{d\eta} + P_\theta \frac{d\theta}{d\eta} - \frac{P_r^2 + P_\theta^2/r^2}{2m} - \frac{\alpha}{r} \right], \quad (6)$$

where $m = a(\eta)m_I$.

Now let us consider a probably particle moving in a plane in the cylindrical coordinates

$$X^1 = R\cos\Theta, \quad X^2 = R\sin\Theta \quad (7)$$

in the gravitational field with Schwarzschild's metrics

$$ds^2 = \left(1 - \frac{2\alpha}{mr}\right) dt^2 - \frac{dr^2}{1 - 2\alpha/(mr)} - r^2 \sin(\theta)^2 d\theta^2. \quad (8)$$

In this paper we consider the case of rigid state when densities of a energy and a pressure are equals. In this case $a(\eta) = \sqrt{1 + 2H_I(\eta - \eta_I)}$, where the H_I is the initial value of Hubble velocity (Behnke et. al 2002). In the terms of the conformal time $d\eta = dt/a$ in relative units $r = R/a$, $P_r = P_R a$ the action takes the form:

$$S_{\rm schw} = \int_{\eta_I}^{\eta_0} d\eta \left[P_r \frac{dr}{d\eta} + P_\theta \frac{d\theta}{d\eta} - \right.$$
$$\left. - Q_{\rm schw} \sqrt{P_r^2 Q_{\rm schw}^2 + P_\theta^2/r^2 + m^2} + m \right], \quad (9)$$

where $Q_{\rm schw} = \left(1 - \frac{r_g}{r}\frac{m_I}{m}\right)^{1/2}$, $r_g = M_{\rm O} G$, and P_r, P_θ are conjugate impulses to corresponded coordinates. The path of the probably particle is shown on the Fig. 1.

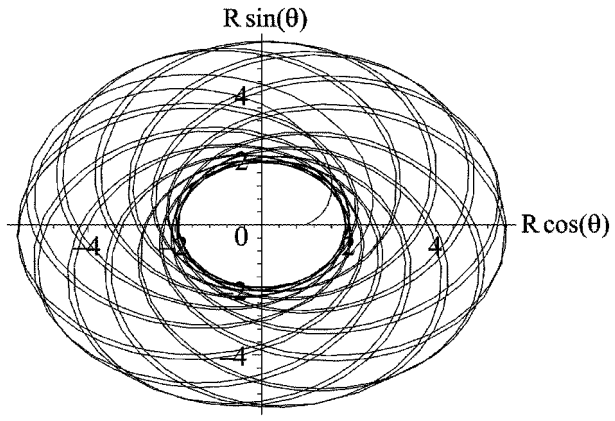

Figure 1: Solution equation of motion for the action (9) at $r(\eta_I) = 1$, $r'_\eta(\eta_I) = 0$, and $\theta(\eta_I) = 0$ for $H_I = 1$, $m_I = 1$, $R_I = 1$, $P_\theta = 1$, and $r_g = 0.5$. For these values of initial data and integrals of motion the total system energy (defined from (9)) is equal to zero at initial point $\eta = \eta_I$. This point corresponds to initial point of the structure creation.

We chose the total energy of a system defined in (9) as

$$E = Q_{\rm schw} \sqrt{P_r^2 Q_{\rm schw}^2 + P_\theta^2/r^2 + m^2} - m \quad (10)$$

at the initial point $\eta = \eta_I$ as equals zero. The trajectory begin at the point (1, 0). From Fig. ?? we see that some region are more occupied then others. In such a way we show that in the expanding FLRW metrics and assuming rigid state of matter, where density equals pressure, it is possible to obtained the formation of clusters from the uniform distribution of particles with zero gravitational distributional energy. It is possible to regard this mechanism as a main reason of cellular structures is the Universe. With the fine tunning we are able to find the distributions equals to about 130 Mpc.

6. Conclusions

There are several effects, which are called the redshifts quantisations. The scale of this effect is drastically dif-

ferent. From the almost local values to fantastically great part of the Universe. The clear interpretation is only in the case of 100–Mpc periodisation, which is probably due to the large scale structure, but such structure origin is not easily explained. The discretisation of the quasar redshifts seems to be an artifact of selection effects and smallness of the samples. On the other hand Zhuck et al. (2001) show that the quasars seems to be located in thin walls of web with the size of $50 \div 100$ Mpc. This finding is in good agreement with the size of voids, as well as not in great contradiction with the large scale distribution of galaxies revealed by optical data.

In the case of 36 (or 72) $\mathrm{km \cdot s^{-1}}$ periodisation, which is of the main interest of the adherents of redshifts quantisation, we express the opinion that the effect is not convincingly shown. It is not quite clear, why from several thousands of galaxies in the Local Supercluster only about 250 objects (i.e. less than 4%) is taken into account, which can caused a serious bias. It will be interesting to compare the real differences between various galaxy redshifts determination and not only to consider to quoted by authors formal errors. This point was stressed also by Guthrie and Napier (1996). If this alleged effect will be confirmed, this will open totally new areas of investigations, opening also doors for so-called new physics. Beforehand, however, the detailed analysis of observational errors and applied statistical methods should be performed. The papers presenting the results have obtained till now clearly shown the weak and the strong points, which will be fruitful in further work. Moreover, the investigations of the redshift distribution in other superclusters will be of great interest. Due to accumulation of precise measurements of redshifts in the last years the re-discussion of the redshift discretisation is possible and could help to solve this bizarre problem. We show that the new physics is not needed for explanation of the existence of the large scale periodicity of about 130 Mpc. Using very simple model in which a massive particle is circulating around the source of gravitational field in the expanding Universe with FLRW metrics it is possible to obtain regions with higher density. This means that particles will be with greater probability located in some regions than others. With appropriate fine tunning it is possible to obtain the separation between dense regions (structures) of the order of 130 Mpc, which is consistent with observations.

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MULTIPLICITIES OF FUNDAMENTAL PHYSICAL CONSTANTS. COSMOLOGICAL MODEL

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Regularities of fundamental physical constants (FPC) and multiplicities for masses, time (frequencies), densities, etc. are obtained as a result of the analysis of these constants. Display of multiplicities is typically for processes, phenomenon and the effects observed in the nature by virtue of universality of FPC.

1. Introduction

Such fundamental constants as velocity of light in vacuum, Plank constant determines the calculated quantity of an electron charge and a relation of these values with a gravitational constant determine the Planck mass. Numbered constants, their relations are used for the characteristic and exposition of electromagnetic, gravitational interactions, etc. P. Dirak has given a series of relations, the multiple to the quantity 10^{40}, it is: a relation $X_c \div X_g \approx 10^{40}$, where:

X_c is the constant of an electromagnetic interaction,

X_g is the constant of a gravitational interaction;

— the dimensionless age of the Universe determined as the relation of age of the universe and time of passage by a signal of the size of a nucleon: $\frac{10^{17}s}{10^{-14}m \div 3 \cdot 10^8 m/s} \cong 10^{40}$, where: 10^{17} s is the age of the Universe;

10^{-14} is the size of a nucleon;

$3 \cdot 10^8$ m/s is velocity of light in vacuum. is multiply to the quantity 10^{40} a relation of the size of the Metagalaxy and the size of a nucleon.

The number of heavy particles N in the universe is multiply 10^{80}: $N = \left(\frac{hc}{Gm^2p}\right)^2 \approx 10^{80}$, where: G is a gravitational constant;

m_p is the mass of a proton;

c is velocity of light in vacuum;

h is Plank constant.

The Heisenberg nonlinear field theory includes, the new constant offered to him, the multiply 10^{20}:

$$\lambda_{pc} = \frac{t}{m_p c} \approx 10^{20} lp.$$

One can see, a series of relations of FPC has multiplicities 10^{20}; 10^{40}; 10^{80}, which are used in physics for exposition and the characteristic of processes of a weak coupling, a field theory, definition of masses, etc.

2. Multiplicities of masses, time (frequencies), etc.

Let's make a series of multiplicities for masses (multiplicity 10^{20}), starting from quantity of mass of nucleons in the Universe 10^{52} kg aside diminutions: m (kg)

$$10^{52}\ 10^{32}\ 10^{12}\ 10^{-8}\ 10^{-28}\ 10^{-48}\ 10^{-68}\ 10^{-88}\ 10^{-108}...$$

and analyze the obtained values:

$m = 10^{52}$ is the mass of nucleons in the Universe;

...

10^{-8} is the Planck mass;

10^{-28} is the calculated mass of a proton;

...

10^{-68} is the calculated mass of a photon.

Let's make a series of multiplicities for time, starting from estimated quantity of a lifetime of a proton 10^{38} s (10^{37} s): t (s)

$$10^{38}\ 10^{18}\ 10^{-2}\ 10^{-22}\ 10^{-42}$$

or

$$10^{37}\ 10^{17}\ 10^{-3}\ 10^{-23}\ 10^{-43}$$

10^{17} is a lifetime of the Universe from the moment of the Big Bang;

10^{18} is the quantity inverse Hubble constant;

10^3 Hz is occurrence of radiation of the long-wave radiowaves;

10^{-23} is a lifetime of a nucleon resonance Δ^*;

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10^{23} is the frequency of a proton relevant to a Compton wave length of a proton;

10^{43} Hz is the Planck frequency.

Let's make a series of multiplicities for densities, starting from Planck density. We shall receive the following values: $\rho\left(\frac{kg}{m^3}\right)$ $10^{97}10^{57}10^{17}\underline{\underline{10^{-23}}}\left(10^{-26}\right)$

$\rho \approx 10^{97}$ is Planck density;

$\rho \approx 10^{57}$ is density of a nucleus of a quark;

$\rho \approx 10^{17}$ is density gluon substances;

$\rho_c \approx 10^{-26}\frac{kg}{m^3}$ is the critical density estimated from a relation, on Hubble constant.

At values of densities $\rho > \rho_c$ development of the Metagalaxy happens on model of the closed Universe. We shall approach to the analysis of this standing later when we shall view cosmological model.

...

3. Cosmological model

If to make a series of multiplicities for linear dimensions starting from the Planck size and to reduce values of multiplicities of masses, densities, frequencies (time) in the table, we shall receive the basic relations of the substances evolve, i.e. cosmological model (table 1):

Not featuring explicitly the scenario, we shall stop on separate standings which follow from cosmological model.

Such existing formations as black holes, neutron stars are the testimony of stages of evolution of the Metagalaxy under the suggested scenario of above mentioned cosmological model and are an integral part of the cosmological objects which have been given birth during evolution at the relevant stages.

Evolution of the Metagalaxy is quantum process. The level of quantization itself corresponds for each stage of development and shaping of the relevant kind of a substance (quarks, neutrons, atomic substance, etc.).

Evolution of Metagalaxy happens inside an orb to radius of SHvartsshild, but, nevertheless, process of expansion is prolonged and till today since simultaneously to magnification of mass there is also a magnification of radius of Metagalaxy.

Structurization of nucleons at a stage of shaping of nucleons has taken place, and the magnification of mass of Metagalaxy and masses of substance in it is prolonged and in the subsequent periods due to magnification of number of nucleons and shaping of macrostructures of Metagalaxy.

Process of formation of mass is prolonged and will be prolonged up to quantity 10^{72}. After terminating structurization of Metagalaxy ($t = 10^{32}$), in resonance stage, will be a quantum decay of substance such in previous stage.

Structurization of space - time - substances (vacuum - fields - **substances**) creates a uniform, quantized continuum at all levels, possessing blanket laws of the organization, and as a whole, with the mechanism of regulation of processes, forms a blanket Universum.

The given cosmological model for the scenario of the Big Bang puts some questions which have the solution.

...

4. Conclusion

As a result of the analysis of multiplicities of FPC the multiplicities of masses, time (frequencies) and structure of space are detected.

A corollary of these standings is the inference about structure as a whole of space - time - vacuum - fields - substances which form a uniform blanket continuum. The given standing has a series of the subsequent standings.

In particular, stated by a series of authors the hypothesis about the fluctuating nature of values of physical quantities [1, 2, 3, 4, 5, 6] in my opinion is not true, since change of one of values of physical quantities gives in decay of all continuum that excludes a problem of their possible limiting changes. The problem of a fluctuation of values of physical quantities could take place in preceding, "adjusting" models.

In this connection it is possible to view and a problem on a constancy of physical constants. If to starting from positions of structure of a uniform continuum of space - time - vacuum - fields - substances and the given model of evolution that the deduction and about a constancy fundamental physical constants and an invariance of them eventually is inevitable.

From these positions the deduction about structuredness and at a microlevel that gives in an opportunity of development of models of particles is inevitable. These models give an explanation of some the existing effects which are not having adequate models of processes, and existence of these effects can be considered, in turn, as one of proofs, structure of a continuum as a whole.

...

One of the standings demanding the further development is the problem of the physical content of a Hubble constant which has also other interpretations (see tab. 1 (Time (frequencies))). On numerical value it corresponds to a series of physical quantities and is not univalent in treatment. This problem is developed by a series of authors. Fundamentality of its content at a level of the main law of dynamics is uncovered in work [7].

...

Table 1: Basic relations of the substances evolve

Value of radius, m	Value of mass, kg	Density, kg/m^3	Frequencies (time), 1/s	Stages
10^{-35}	10^{-8}	10^{97}	10^{43}	Shaping quarks.
10^{-15}	10^{12}	10^{57}	10^{23}	Shaping neutrons.
10^{5}	10^{32}	10^{17}	10^{3}	Shaping stars.
10^{25}	10^{52}	10^{-23}	10^{-17}	The present stage of development.
10^{45}	10^{75}	10^{-63}	10^{-37}	
...	...	...	...	

The brief analysis of some standings of model of the Big Bang (BB) under the script of development of Metagalaxy from Planck mass (that does not exclude existence of other cosmological models under script BB with other initial parameters [8]) is carried out in this work; stages are chosen and underline quantum character of stages; problems formation of mass posed and discordances of existing model BB are marked, etc.

But the problem of a viewed problematic of cosmological model is much wider, since cosmological representations reflect a degree of understanding and adequacy of our representations about the continuum, shapes of its display and parameters.

...

To some extent, in a problem of the physical content of FPC were engaged from times of discovery of physical laws. In physics of XX century is M.Plank, P.Dirak, A.Ejnshtejn, V.Gejzenberg, etc. Among them is G.Gamov, which centenary is celebrated this year.

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AGAIN ON THE NON-EXISTENCE OF GRAVITATIONAL WAVES AND OF BLACK HOLES

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Very straightforward arguments proving the physical non-existence of GW's and of BH's. They are so simple that even the members of the Wheelerian establishment will understand them.

An obvious premise: in (the exact, i.e. non-approximate [1]) general relativity (GR) only the concepts and the results that are independent of the choice of the system of ***general*** co-ordinates have a physical meaning.

i) Let us consider any solution of the Einstein field equations of GR which has – in a given co-ordinate system – a definite undulatory character, i.e. that represents a gravitational wave (GW). Now, through a *finite* sequence of co-ordinate transformations, endowed with suitable undulating properties, the primary wave character of our solution can be fully *obliterated.* Thus, this character has no *physical* meaning, it is only a mathematical property of the original co-ordinate system. *Q.e.d.* –

i') A first proof of the physical non-existence of the GW's was given in 1917 by Tullio Levi-Civita [2]. Other proofs have been published in recent years by the present writer [3].

ii) As it was remarked by Eddington [4], the solution of the problem of the Einsteinian gravitational field generated by a point mass M (at rest) is given – if r, ϑ, φ are spherical polar co-ordinates – by the following spacetime interval:

$$\mathrm{d}s^2 = [1 - \frac{2m}{f(r)}]c^2\mathrm{d}t^2 - [1 - \frac{2m}{f(r)}]^{-1}[\mathrm{d}f(r)]^2 - \\ -[f(r)]^2[\mathrm{d}\theta^2 + \sin^2\theta\mathrm{d}\phi^2], \quad (1)$$

where $m \equiv GM/c^2$, and G is the gravitational constant; $f(r)$ is *any* regular function of r.

Now, the invention of the black holes (BH's) is due to a (mis)interpretation of that form of solution (1) for which $f(r) \equiv r$: it is the so-called *standard* solution, erroneously named "Schwarzschild solution". In reality, Karl Schwarzschild chose $f(r) \equiv [r^3+(2m)^3]^{1/3}$, see [5]; this *original* Schwarzschildean form is singular only at the spatial point $r = 0$. Thus, the notion of BH does *not* have a physical meaning, it is only a (fictive) by-product of a very particular choice of the function $f(r)$. *Q.e.d.* –

APPENDIX

All the (erroneous) *loci communes* concerning the GW's and the BH's are respectively illustrated in the review articles by Schutz [6] and by Celotti *et alii* [7].

"Truth is aristocratic".
Howleglas

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ELECTROMAGNETIC ENERGY AGAINST GRAVITATIONAL ENERGY

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It is considered the concept of space-time in the electrodynamics based on the dual particle-wave nature of the electromagnetic field. The coordinate space-time is defined by the Galilei transformation. The momentum space-time is defined by the Lorentz transformation. It is considered the dynamics of the electron in the electromagnetic field. The electromagnetic energy and the gravitational energy of the electron behave in the different way. The ratio of the electromagnetic energy and the gravitational energy for the electron follows the Lorentz transformation.

According to the Einstein theory of special relativity [1], the space-time in the electrodynamics follows the Lorentz transformation

$$x' = \frac{x - vt}{(1 - v^2/c^2)^{1/2}}; \qquad y' = y; \qquad z' = z;$$
$$t' = \frac{t - xv/c^2}{(1 - v^2/c^2)^{1/2}}, \tag{1}$$

where coordinates of space x, y, z and time t describe the rest frame, coordinates of space x', y', z' and time t' describe the moving frame, v is the speed of the moving frame, c is the speed of light. In the space-time defined by the Lorentz transformation, observers in the rest and in the moving frames describe events with the different intervals of length and time. An observer in his own frame measures the intervals of length and time as $\Delta x = x_2 - x_1$, $\Delta t = t_2 - t_1$ respectively. An observer in the other frame measures these intervals of length and time as $\Delta x' = \Delta x(1 - v^2/c^2)^{1/2}$, $\Delta t' = \Delta t/(1 - v^2/c^2)^{1/2}$ respectively. According to Einstein, an observer in his own frame measures the true (physical) intervals of length and time whereas an observer in the other frame do not. Then the sentences of an observer in some frame cannot be verified by observers in the other frames. Therefore the Einstein theory of special relativity contains non-verified sentences that is not acceptable. The theory has the physical meaning only if any event is described by observers in all inertial frames with the same intervals of length and time. Then the sentences of an observer in some frame can be verified by observers in the other frames.

In [2], the concept of space-time in the electrodynamics was proposed based on the dual particle-wave nature of the electromagnetic field. The main idea is that in the electrodynamics the coordinate space-time and the momentum space-time follow different transformations. The coordinate space-time follows the Galilei transformation. The momentum space-time follows the Lorentz transformation. The coordinate space-time defines intervals of length l and time t and hence the scales of momentum $p \propto 1/l$ and energy $E \propto 1/t$. Then any event is described by observers in all inertial frames with the same intervals of length and time as well as with the same scales of momentum and energy. All dynamic vectors in the electrodynamics decrease in the moving frame in accordance with the Lorentz transformation

$$\mathbf{f}' = \mathbf{f}(1 - v^2/c^2)^{1/2}. \tag{2}$$

Unlike the Einstein theory, $\mathbf{f}'$ is the true (physical) value of the dynamic vector in the moving frame.

Consider the dynamics of the electron with the charge e and the mass m in the electromagnetic field. In the rest frame, the electron experiences an acceleration due to the electromagnetic force

$$w = \frac{e}{m}\mathbf{E}, \tag{3}$$

where $\mathbf{E}$ is the strength of the electromagnetic field. In the frame moving with the speed v, the acceleration due to the electromagnetic force experienced by the electron is obtained with the use of the Lorentz transformation

$$w' = w(1 - v^2/c^2)^{1/2}. \tag{4}$$

Unlike the Einstein theory, the value w' is the true (physical) acceleration experienced by the electron in the moving frame.

Equation (4) along with eq. (3) may be interpreted as that the ratio of the electromagnetic energy (charge)

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and the gravitational energy (mass) for the electron in the moving frame decreases as

$$\frac{e}{m} \propto (1 - v^2/c^2)^{1/2}. \tag{5}$$

One can treat eq. (5) as an increase of the mass of the electron or as a decrease of the charge of the electron.

Thus the electromagnetic energy (charge) and the gravitational energy (mass) of the electron behave in the different way. According to the latter interpretation of eq. (5), the gravitational energy (mass) of the electron is fixed with the speed of the frame $m = const$, and the electromagnetic energy (charge) of the electron decreases with the speed of the frame as $e \propto (1 - v^2/c^2)^{1/2}$. It should be stressed once again that the decrease of the electromagnetic energy (charge) of the electron is the true (physical) effect.

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THE CONSCIOUS EXPERIENCE OF TIME AND SPACE

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In this paper the authors judgements about physical and psychological time are given.

In the universe the passing of physical time cannot be clearly perceived as matter and space; one can perceive only irreversible physical, chemical, and biological changes (hereinafter referred to as "change") in cosmic space. On the basis of elementary perception (sight) one can conclude that *physical time exists only as a stream of change* that runs through cosmic space (1). The terms "physical time" and "change" describe the same phenomenon. Physical time is irreversible. Change A transforms into change B, B transforms into C and so on. When B is in existence A does not exist anymore, when C is in existence B does not exist anymore.

The question arises: Why is it that irreversible physical time is experienced as past, present and future? The answer is obtained by analysing the scientific way of experiencing. The eyes perceive a stream of irreversible change. Once elaborated by the mind, the stream of change is experienced chronologically through psychological time that is a part of the human mind.

Let's look at the relationship between physical and psychological time by carrying out an experiment. Take a pen and move it from the left side of the table to the right. You can perceive only the movement of the pen in space, but you experience that the pen has also moved through time. How come? Perception passes first through psychological time and then the experience occurs. That's why you experience the movement of the pen in time. But on the basis of elementary perception (sight) one can only state that the pen has changed position in space.

It is not that change happens in physical time, change itself is physical time. In the cosmic space itself time run only as a stream of change and not as a physical reality. Space is a timeless phenomena. The universe is composed out two basic components: of space and of matter that is continuously changing.

We can measure with clocks the duration and speed of change. Experiments with high precision clocks confirm that change runs slower in the parts of universal space where the gravitational field is stronger. The speed of clocks near the sea in Venice is slower than on the mountain Monte Rosa, because gravity is stronger near sea level.

The special theory of relativity has put forward the famous "problem of twins" ; according to the special relativity, time runs slower in a fast moving space ship than on Earth, so if one of the twins were to travel through space on a fast space ship and return to Earth after five year's time, he would find himself younger than his brother who would have stayed home. Experiments with high precision clocks taken aboard fast planes have verified this. And this is where the question arises: Does time in fast flying planes really run slower than on Earth? To be empirically consequent, one has to admit that by means of an elementary perception (sight) it is only possible to conclude that the speed of clocks in a moving plane is smaller than on Earth. It is only by indirect reasoning that we interpret different clock speeds as meaning different time running speeds in the plane and on Earth. By observing the clocks in the plane and on Earth, it is only possible to state that the speed of change in fast moving inertial systems is lower than in slower inertial systems. Take two space ships heading towards one another on two parallel straight lines, the former moving at $v_1 = 0.5$ c, the latter at $v_2 = 0.001$ c (where c = speed of light). In the moment the two space ships meet, the clocks are set. The clocks on the former will run slower than the clocks on the latter, spacemen on the former will grow old slower than spacemen on the latter. The hypothesis that time as a physical quantity runs slower on the first ship than on the second, is only our deduction, and it cannot be empirically proven.

The understanding of physical time has changed over the ages. For ancient Greeks, Indians, and Mayans, time was considered a cyclic phenomenon; time moving in circles, with no beginning and no end. When Judaeo-Christian civilization arose in Europe, another understanding of time became prominent - time going forward in a straight line. According to this civiliza-

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tion, time has its beginning with God's creation of the universe and will have its end with the Last Judgement. In Newtonian physics, physical time is an independent quantity (absolute time), running uniformly throughout the entire cosmic space (absolute space). In the General Theory of Relativity, time is no more an independent physical quantity - it is linked with space in four-dimensional space-time.

According to this understanding time is not a consistent part of the universe. It exists only as a "by-product" of the matter that change in the cosmic space. In the universe time does not run. Universe is an eternal self-renewing system in dynamic equilibrium. Big bangs are cyclic, they have no beginning and will have no end. Researches of several scientist confirm that thesis: Kompanichenko from Russia, Turok from Cambridge and Steinhardt from Princeton.

It makes sense only for humans that morning is before the evening, that father is born before the son. From the point of the universe "change before" and "change after" makes no sense, they all happen in the timeless universal space that was never created.

By observing the continuous stream of irreversible physical change humans have developed psychological time through which we experience the universe. Psychological time is reversible. One can go back into past. This creates an idea that physical time also has a past, but this is not so.

General Relativity allows for speculation about time travel. Someone could travel through a black hole with a spaceship, go back into the past and kill his grandmother. The consequence is that he could never have been born (2). Travelling into the past through black holes is not possible because physical time is irreversible; the past exists only as psychological time through which it is not possible to travel with a spaceship.

The speed of psychological time does not always follow physical time, it depends on one's well-being. The more relaxed you are the slower the speed of psychological time is. In modern society time passes quickly, in so called primitive societies time passed slowly. In an altered state of consciousness, such as meditation, ecstatic dance, deep prayer, psychological time stops.

Already in a normal state of health there are, every now and then, aberrations of subjective time such as acceleration or deceleration of lapse of time. Under several mental disturbances (like those characterising serious mental psychoses, drug-induced states, trances, mediations, as well as other deep "altered" states of consciousness), these anomalies / peculiarities become more pronounced. The flux of time may even cease completely (the sensations usually described as "time standing still" , or "suspended" , arrested time or expand without limit (the feelings of "everlasting now, eternity") (3).

Human consciousness has the capacity to watch the human mind (4). Everybody can watch his thoughts and emotions. By watching them the speed of thought and the intensity of emotion calms down. Once the mind stops, human consciousness can watch and recognize itself When the mind stops, psychological time stops too. One experiences physical time consciously as he/she perceive it: as a stream of change.

In the conscious experience one experiences what he/she perceives. The mind does not elaborate the perception, so the gap between perceiving and experiencing is gone. Conscious experience is direct.

rational experience

universe — perceiving (senses) — elaborating (mind) — rational experience

conscious experience

universe — perceiving (senses) — conscious experience

One can imagine consciousness as his/her inner space and psychological time as a stream of thoughts running in the inner space. According to the Buddhist tradition the inner space in which stream of thoughts run and outer space in which material change run are undivided.

Allan Wallace says: The distinction between external and internal is an illusion; internal and external space are ultimately non-dual. This is the absolute space of phenomena. In Buddhist literature, this is the Great perfection out of which the entire universe originates (5).

We are living in the space and the space is inside of us. In cosmology the space is mostly described with Euclidian and Riemann geometries. Our imagine of the universal space depends on which geometry we use to describe it, for the human mind however its real nature remains unknown.

Euclidian geometry is based on the theory of numbers. Regarding the theory of numbers natural and real numbers are both infinite and at the same time real numbers are more than natural ones. Real numbers are composed of algebraic and transcendental numbers, with natural numbers we can numerate only algebraic numbers. Logicians confirm that there is no contradiction if we say that the infinity of natural numbers is smaller of real numbers and also if we say that they are equal (6).

By numerating each mille of a straight line with natural numbers we will get an infinite distance and by numbering a parallel line with real numbers we will also get an infinite distance. If we say that the infinite distance made out of natural numbers is shorter than

one made out of real numbers there is no contradiction, if we say that they are equal there is also no contradiction. So an infinite distance does not mean a real existing and measurable distance; infinite distance + 100 miles = infinite distance. That's why the application of an infinite distance in cosmology creates difficulties. In the universe we can observe and measure only finite distances between objects. When we imagine that universal space might be infinite as is Euclid space we do not know exactly what this means.
With the application of Riemann's geometry in cosmology the image of infinite three-dimensional cosmic space changes into the image of finite spherical four-dimensional space. The finite round space one can imagine only in the infinite Euclid space. By choosing spherical finite geometry as a model for cosmic space the question arises: what is beyond the borders of the universe, there must be some bigger space within which the finite universe lies?!

Scientific experience of the universal space is limited by geometrical models through which one experience it. Its real nature one can discover by watching the mind having conscious experience of it. Watching the mind is the science of the space, of the true vacuum, of consciousness. Practicing it regularly one becomes aware of the inner space and it being undivided with the outer space. One reaches the direct experience of the universe and him/her self. This experience reaches beyond the mind and time into the eternal quality of existence.

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NEW BOOKS

1. Troshenkin B.A. "Renewable Energy." In 2 parts. Part I: "Thermodynamics of the Ocean and Atmosphere. Ocean Thermal Energy Conversion Plants." National Academy of Sciences of Ukraine. A.N. Podgorny Institute for Mechanical Engineering Problems. — Kharkiv: Fort Publishers, 2003, 100 pp. (In Russian and English).

Since the moment of its emergence, the development of the Solar system, and in particular of the Earth, has been strictly governed by the laws of thermodynamics. These laws govern the behavior of ocean waters, the Earth's crust, and Nature. Based on i-thermodynamics, the monograph exposes the effect of ocean and atmospheric currents on Earth's rotational speed, gives an explanation for ancient floods and glaciation, and establishes the atmosphere's chemical composition during the period of formation of coal, oil and gas deposits. The sites of ocean thermal energy conversion plants, which would not affect Earth's climate, have been identified. The most effective methods of recovering natural energy have been substantiated. In turn, μ-thermodynamics has made it possible to assess the rate of formation of Earth's crust and associated therewith periods of volcano eruptions and earthquakes. As a rule, seismic zones correspond to geothermal heat sources. An analysis of the cycles of power plants utilizing Earth's heat has been presented.

The monograph is intended for experts in Earth-related power and physics problems as well as for those readers in geophysics who have a solid background in this area. It can also benefit students of higher education institutions.

2. Zhuck N.A. "On Einstein's Person Cult and its Negative Influence on Physics. — Kharkiv: "Infobank" Ltd, 2003, 88 pp. (In Russian).

The Albert Einstein's abilities, life and scientific creative work are given and analyzed in the work on the basis of the known and little-known items of information, the author's proper fundamental researches and original argumentation, the reasons resulting in his image idealization and relativity theory cult, comparable on a scale with medieval inquisition are observed. The Einstein's sexual constitution and his close relatives is explored and shown for the first time, that its weakness was combined not with any physicist's intellectual talents, but with his enterpreneurship mentality termed as scientific business. The Einstein's person cult connection with dramas and tragedies of modern scientists is observed, as well as with those forces, which are convenient and this cult suits them till nowadays.

This work proves useful for all persons concerning with physics and the history of physics.

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