FUNDAMENTAL RESULTS OF THE THEORY OF PHYSICAL VACUUM

Dedicated to René Descartes,

philosopher, physicist,

and mathematician



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Introduction

There have been more and more publications in recent years showing the signs of stagnation in theoretical physics. For example, an American theoretician specializing in the field of quantum gravity Lee Smolin is quite skeptical about the results obtained in string theory [1] noting the absence of "prophets" and an excess of artisans in this sphere. Despite the great PR by Brian Greene [2], String theory can be conceived of as a kind of intellectual fitness employing a whole set of modern mathematical trends to arrive at “physically significant conclusions” not to be verified earlier than 100-150 years.

It is not surprising for reasonable doubts to occur among physicists about the correctness of the chosen path, if the leading role in theoretical physics is given to mathematics, while physics is reduced to the background. Sabine Hossenfelder [3,4] gives a colorful description of the modern situation in theoretical physics in her book Lost in Math: How Beauty Leads Physics Astray [4] as opposed to earlier complimentary book by Brian Greene The Elegant Universe [2].

Constructive theories include the theories such as string theory implying the free flight of mathematical ideas but having a weak physical basis. It is convenient to divide all physical theories into three categories: fundamental, constructive, and constructive phenomenological ones. According to K. Popper, a fundamental physical theory should be falsifiable [5], or, to put it simple, have clear applicability limits, beyond which its principles and equations are not hold true. Only such a theory can constitute the basis for a further generalization of an existing fundamental theory. Neither the Standard Model nor string theory can be referred to the class of falsifiable theories as they allow for numerous possible generalizations, without having definite applicability limits.

According to the logarithmic classification of the Nobel Prize winner Lev Landau (Fig.1), the theoreticians of class 3.5-5 are involved in creating constructive theories. By this classification, the modern theory of elementary particle created by the scientists of class 1.0-3.5 is a constructive phenomenological theory. The fundamental theories of class 0.5-1.0, from Newton to Einstein, who is assigned class 0.5 by L Landau, appear to be the most valuable for science. L. Landau first attributed his own works to class 2.5, then evolved to class 1.0, in his opinion, and put himself on a par with Feynman and other scientists of class 1.0. The scientists of class >5 are considered by L. Landau, with intrinsic sarcasm, as "pathologists" making a "negative contribution" to the development of theoretical physics.

It follows from Fig. 1 that the leadership in theoretical research belongs to the scientists from the countries of the West and North America. This scientific work will reveal for this conclusion to be currently erroneous.

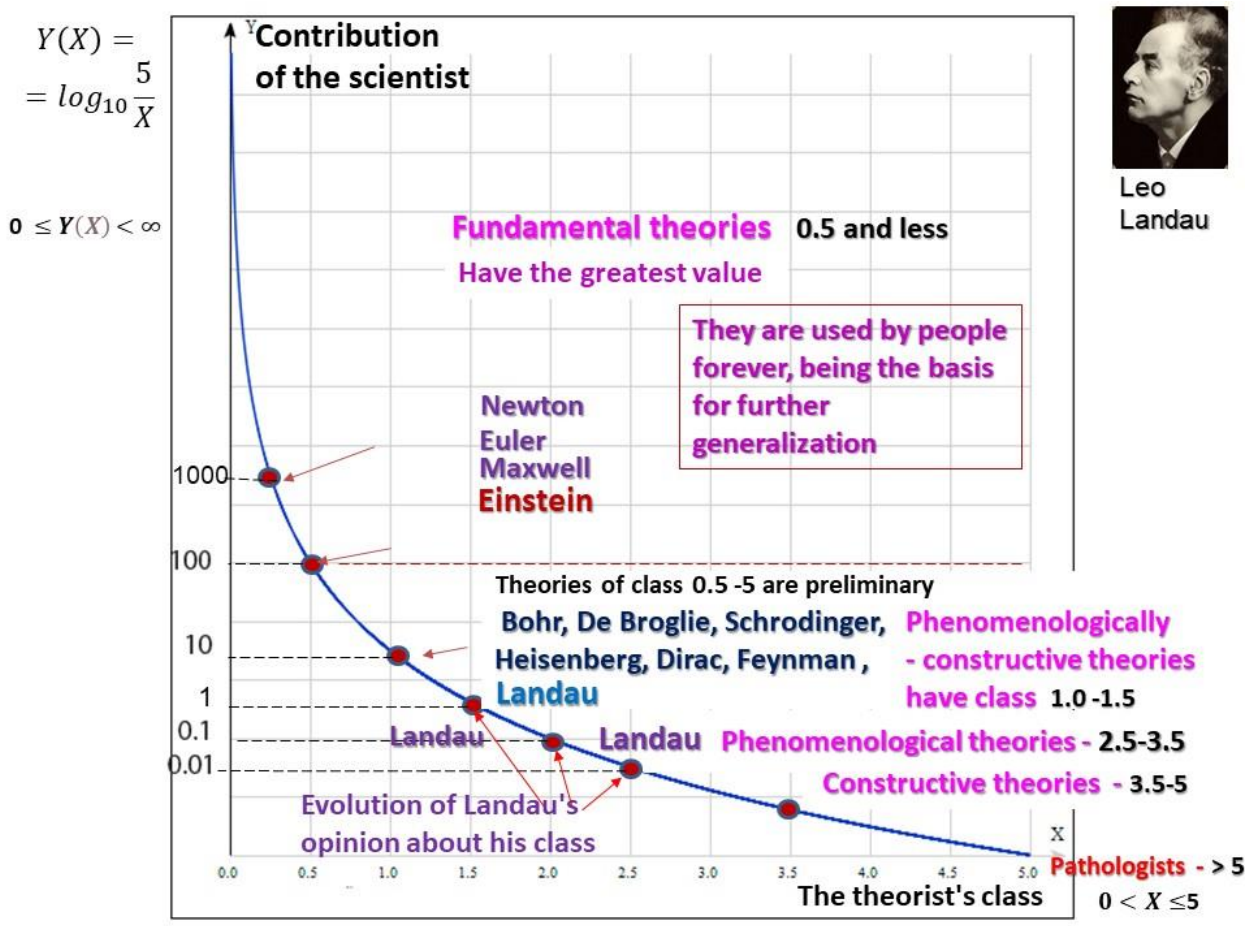


Fig.1 Classification of theoreticians according to Landau logarithmic scale

1. Shortcomings of contemporary theoretical physics

Following Lee Smolin [1], we draw attention to the fact that the departments of theoretical physics at all the leading universities in North America and Western countries are headed by well-known specialists in string theory, i.e. inherently mathematicians far from fundamental physics, who are related to classes 3.5-5 by Landau classification, the latter class flanking 'pathologists'. At the conferences on theoretical physics, ironically, string theory adherents tend to look down on other theoreticians involved, for example, in quantum gravity research, considering them second-class ones [1]. Alongside with the features of its adherents, the possibility to choose from a vast variety of 10^{100} to 10^{500} string theory versions put string theory in a range of pathological ones. Especially so as the conclusions of string theory were never connected by its founders to the experiments going beyond the framework of fundamental theories.

Another thing is the Standard Model initiated by E. Rutherford, who discovered nuclear forces in 1913 while studying the elastic scattering of charged α - particles on gold nuclei. Since there are no fundamental equations so far in official science, whose solution would lead to nuclear potentials, physicists had to handpick potentials containing arbitrary constants and set their specific values comparing theoretical and experimental dispersion curves.

The Standard Model is currently a constructive-phenomenological theory which contains from 17 to 26 fitting constants, depending on its version (Fig. 2). In view of the above properties, contemporary constructive string theory and the Standard Model turn out to be quite meaningless, since

the former is nowhere connected with fundamental experiments (e.g., has no solutions leading to nuclear interaction potentials), while the latter has to adapt continuously to newly obtained experimental data. Alas, this situation in theoretical physics cannot last indefinitely long, in the long run, fundamental theories are bound to replace constructive and phenomenological ones.

It is worth mentioning some fundamental experiments, which are usually overlooked while creating a new fundamental physical theory, such as famous N. Tesla's experiments on wireless or single-wire power transmission which led to the invention of power generators of 'zero-point' of the Physical Vacuum (or Ether energy, according to N. Tesla). Theoreticians choose to pretend being unaware of such widely known to everyone but them devices as Paul Baumann generator [6], which has already been used to light and heat several hotels in the town of Linden (Switzerland) for more than 30 years.

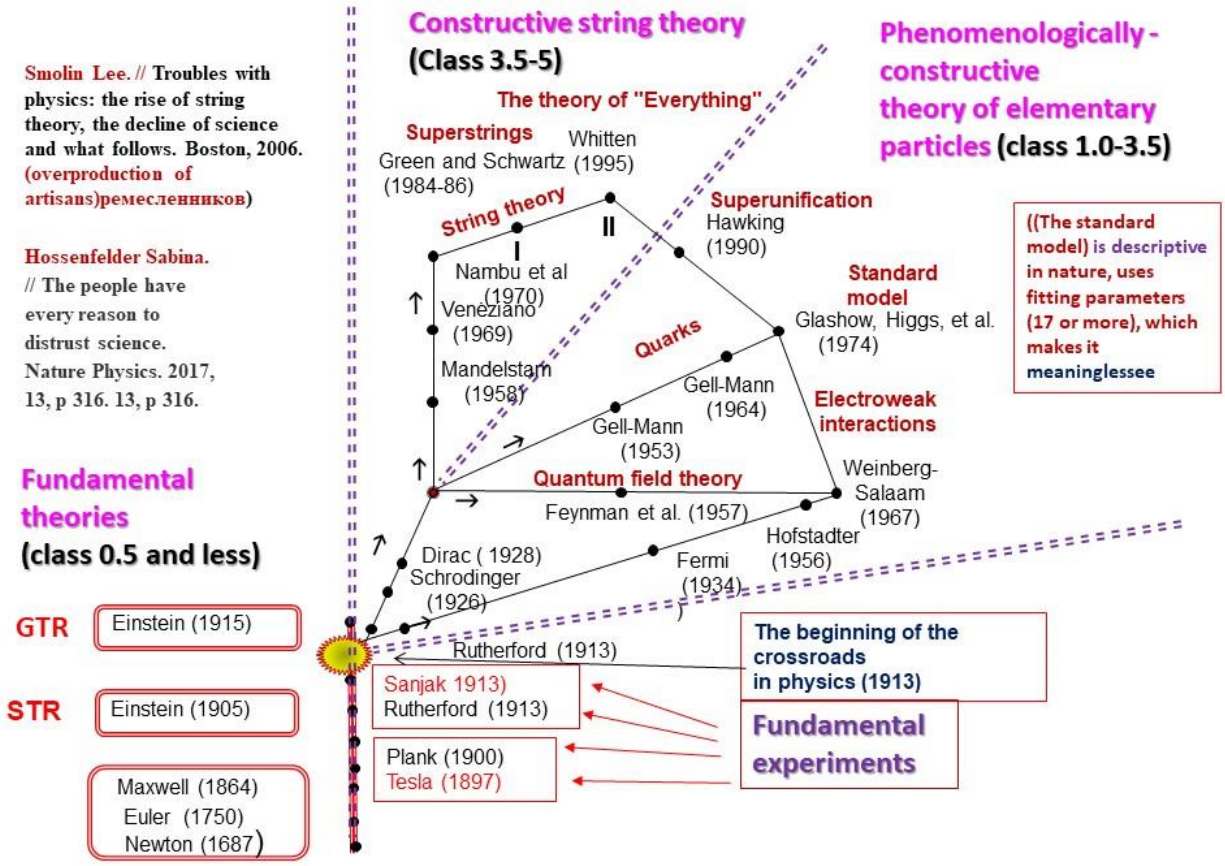


Fig.2 Physical theories and fundamental experiments

Although performed more than a century ago, simple in form but fundamental Sagnac experiment still has not been given an unambiguous physical interpretation. As we show below, this experiment indicates the absence of *rotational relativity* of the fundamental physics equations.

Generally speaking, 1913 represented a branch point in fundamental physics, with the single physical tree trunk having ramified into three branches (Fig. 2). They are as follows:1) the constructive-phenomenological microcosm physics leading to the creation of the Standard Model; 2) the constructive-phenomenological quantum theory giving birth to quantum field theory, quark theory and string theory; 3) the general relativity theory (GR) by A. Einstein generalizing fundamentally Newton's theory of gravity to the case of relativistic gravitational fields.

It is clear now why neither string theory nor the Standard Model were able to combine these three branches despite long-term intellectual efforts - the reason is that it is essentially impossible to combine a *fundamental* theory (A. Einstein's GR) with *constructive phenomenological* theories (the Standard Model and string theory). A new fundamental theory cannot originate by generalizing multiple theories by a mathematician but can be created by a physicist by extending the physical principles and equations of a limited fundamental theory recognized previously by all theoreticians.

2. On implementing the Einstein Unified Field Theory Program

String theory [7] and the Standard Model [8,9] actually represent two versions of the Unified Field Theory, being proposed to develop by A. Einstein at the beginning of the 20th century. According to A. Einstein, two problems needed to be solved to implement this program: 1) geometrizing Maxwell-Lorentz electromagnetic field equations and 2) geometrizing the equations of quantum field theory - Dirac equations, etc.

Mathematicians were the first to respond to the grand program of the Unified Field Theory. At first, H. Wehl [10,11] generalized Riemannian geometry, having been employed by A. Einstein in developing his fundamental relativistic gravity theory. A part of Weyl nonmetricity was used by H. Weyl as the vector potential of Maxwell-Lorentz electrodynamics. Then, while developing geometries different from Riemann one, A. Eddington [12] and T. Kaluza [13] tried to find a solution to Einstein's first problem, i.e. geometrize Maxwell-Lorentz electrodynamics equations. However, these formal approaches failed to lead to the desired result. After the publication of his work [11], H. Weyl was told by A. Einstein, - 'No, dear Hermann, this is not the way physical theories are created by'. Nevertheless, he himself wrote dozens of formal papers using mathematics generalizing general relativity theory equations [14-19].

2.1 Solving the first Einstein problem (1972) - geometrizing electrodynamics

According to A. Einstein, we need not only having classical Maxwell-Lorentz electrodynamics equations geometrized but also not having the charge itself regarded as a point one (the singularity problem). Indeed, in classical electrodynamics a static Coulomb field is described only by a point charge, while its density $\rho = Ze\delta(\vec{x}),\ Z = \pm 1, \pm 2, \pm 3$ ... is determined through $\delta(\vec{x})$ – Dirac delta function.

Certainly, one can choose charge density ρ for any kind of charge distribution, but then Maxwell-Lorentz equations will no longer be fundamental as one or more 'handpicked' parameters will be held in ρ. Indeed, great intellectual efforts were to be made by theoreticians to eliminate the infinite quantities caused by the point-like nature of the charge from the equations of classical and quantum electrodynamics.

Back at the beginning of the 20th century, it was proposed by Gustav Mie [20] some purely field non-linear electrodynamics with a finite proper energy of the charge. The theoretical works of G. Mie were continued by M. Born, L. Infeld [21,22], M. Abraham [23], P. Dirac [24], J. Wheeler and R. Feynman [25], A. Lande [26], D. Bohm [27], and some other well-known physicists. The analysis of these works shows that the proposed nonlinear electrodynamics models amount to the equations of linear Maxwell-Lorentz electrodynamics, with charge density ρ not being a point-like one but distributed in a certain space region using a characteristic fitting parameter.

Moreover, being skeptical about these works, A. Sommerfeld noted that 'it would be simply amazing if the main problem of elementary particles (the problem of singularity) could be solved with the help of cunning tricks' [28].

Paul Dirac, the principal creator of quantum electrodynamics, took an even more radical position on the singularity problem. He wrote in his work [29]:

'Of course, the proper inference from this work is that the basic equations are not right. There must be some drastic change introduced into them so that no infinities occur in the theory at all and so that we can carry out the solution to the equations sensibly, according to ordinary rules and without being bothered by difficulties. This requirement will necessitate some really drastic changes: simple changes will not do ...'

Such a drastic move was taken by the author in 1972 in [30]. Instead of Maxwell-Lorentz equations, it was proposed to employ the equations of general relativistic electrodynamics with the tensor electromagnetic potential and field equations of the following form

$$R_{ik} - \frac{1}{2} g_{ik} R = \frac{8\pi k}{c^4} T_{ik} \quad , \quad i,j,k \ldots = 0,1,2,3, \qquad k = e/m \, , \tag{2.1}$$

$$T_{ik} = \rho c^2 u_i u_k = e\delta(\vec{x}) c^2 u_i u_k, \qquad u^i u_i = 1 \ . \tag{2.2}$$

The field equations (2.1) lead to the following motion equations of the test charge

$$\frac{d^2 x^i}{\mathrm{ds}^2} = -\Gamma^i_{\mathrm{jk}} \frac{\mathrm{dx}^j}{\mathrm{ds}} \frac{\mathrm{dx}^k}{\mathrm{ds}} = \frac{e}{\mathrm{mc}^2} E^i_{\mathrm{jk}} \frac{\mathrm{dx}^j}{\mathrm{ds}} \frac{\mathrm{dx}^k}{\mathrm{ds}}, \tag{2.3}$$

where

$$E^i_{\mathrm{jk}} = -\frac{c^2}{2} g^{\mathrm{im}} \left(a_{\mathrm{jm},k} + a_{\mathrm{km},j} - a_{\mathrm{jk},m} \right) = -\frac{\mathrm{mc}^2}{e} \Gamma^i_{\mathrm{jk}}, \qquad k, = \frac{\partial}{\partial x^k} \tag{2.4}$$

is the intensity of a strong electromagnetic field? Respectively, e and m are the charge and mass of the test body, and c - is the speed of light. As a result of solving these equations, we obtain the metric of the parametric Riemann space

$$ds^2 = g_{ik} dx^i dx^k, \qquad i,k, \ldots = 0,1,2,3 \tag{2.5}$$

with a metric tensor

$$g_{\mathrm{ik}}(x^i, k) = \eta_{\mathrm{ik}} + \mathrm{ka}_{\mathrm{ik}}, \quad \eta_{\mathrm{ik}} = \eta^{\mathrm{ik}} = \mathrm{diag}(1 - 1 - 1 - 1), \tag{2.6}$$

on x^i coordinates, and on the specific charge of the test particle $k = \mathrm{e/m}$.

Using (2.6), we find the potential of a strong electromagnetic field given in the form of a symmetric tensor

$$a_{\mathrm{ik}} = a_{\mathrm{ki}}. \tag{2.7}$$

The simplest solution to the field equations (2.1) is the spherically symmetric metric [30]

$$\mathrm{ds}^2 = \left(1 + \frac{e}{m}\frac{2\varphi_C}{c^2}\right)c^2\mathrm{dt}^2 - \left(1 + \frac{e}{m}\frac{2\varphi_C}{c^2}\right)^{-1}\mathrm{dr}^2 - r^2(d\theta^2 + \mathrm{mathitsin}^2\theta d\varphi^2), \tag{2.8}$$

bearing resemblance to the Schwarzschild metric of Einstein gravity theory but having the Coulomb potential denoted with $\varphi_C = \pm\mathrm{Ze/r}$. This metric can be represented as

$$\mathrm{ds}^2 = \left(1 - \frac{\pm|r_e|}{r}\right)c^2\mathrm{dt}^2 - \left(1 - \frac{\pm|r_e|}{r}\right)^{-1}\mathrm{dr}^2 - r^2(d\theta^2 + \mathrm{mathitsin}^2\theta d\varphi^2). \tag{2.9}$$

Here we introduced the *electromagnetic radius*

$$r_e = \frac{2\mathrm{Ze}^2}{\mathrm{mc}^2} = \mathrm{const.} \tag{2.10}$$

In metric (2.9), sign + corresponds to attraction between $-e$ and *Ze* (or e and $-Ze$), and sign $-$orresponds to repulsion between $-e$ and $-Ze$ (or e and *Ze*).

If the two charges $-e$ and e interact on condition that mass m of the test charge is much less than mass *M* of charge e creating the field, the electromagnetic radius r_e equals twice the classical electron radius $r_e = 2\, c_{lassic} \approx 5.6 \times 10^{-13}$*cm.*

Thus, the solution to equations (2.1) with metric (2.9) describes the interaction of two charges, while one of the charge is a test one (i.e. point-like) and the second one generates the field starting on the 3D-sphere of radius (2.10). Hence, there turns out to be finite the integral field of the central charge, and there are eliminated the divergences associated with the proper energy of the charge.

Under the assumption of a weak field and in the non-relativistic approximation, there hold the following inequalities

$$\left|\frac{e}{m}a_{\mathrm{ik}}\frac{\mathrm{dx}^i}{\mathrm{ds}_0}\frac{\mathrm{dx}^k}{\mathrm{ds}_0}\right| \ll 1, \tag{2.11}$$

$$\mathrm{ds} \approx \mathrm{ds}_0 \approx \mathrm{cdt}, \qquad \frac{\mathrm{dx}^0}{\mathrm{ds}_0} \approx 1, \qquad \frac{\mathrm{dx}^\alpha}{\mathrm{ds}_0} \approx \frac{1}{c}\frac{\mathrm{dx}^\alpha}{\mathrm{dt}}, \qquad \frac{\mathrm{dx}^i}{\mathrm{ds}_0}\frac{\mathrm{dx}^k}{\mathrm{ds}_0} \approx \frac{v^2}{c^2} \ll 1 \tag{2.12}$$

and field equations (2.1) transform into Maxwell equations

$$\left(\Delta - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right)A_i = -\frac{4\pi}{c}j_i, \quad j^i = (\rho c, \rho u^\alpha), \qquad i = 0,1,2,3, \tag{2.13}$$

with the vector potential components A_i being defined through the components of the tensor potential (2.7) as

$$A_0 = \frac{c^2}{2}a_{00}\frac{\mathrm{dx}^0}{\mathrm{ds}_0}, \quad A_\alpha = a_{\alpha 0}c^2\frac{\mathrm{dx}^0}{\mathrm{ds}_0}, \qquad \alpha, \beta = 1,2,3. \tag{2.14}$$

Appropriately, under conditions (2.12), (2.13), motion equations (2.3) are transformed into the Lorentz equations

$$\frac{\mathrm{du}^i}{\mathrm{ds}_0} = \frac{e}{\mathrm{mc}^2}F^{\mathrm{ki}}u_k, \qquad F_{\mathrm{ik}} = \frac{\partial A_k}{\partial x_i} - \frac{\partial A_i}{\partial x_k}. \tag{2.15}$$

Equations (2.13) and (2.15) fail to be invariant relativistically, which was noticed long ago by the classics of science. It was shown in the pioneering works by A. Einstein [31], A. Poincaré, G. Lorentz [32] and W. Pauli [33] that the invariancy of equations (2.13), (2.15) with respect to Lorentz transformations holds merely *approximately at small particle accelerations (in weak fields* $\vec{E}$ *and* $\vec{H}$*) and at non-ultrarelativistic velocities.* This conclusion also fully applies to quantum electrodynamics. Here is what is said by P. Dirac on the applicability limits of quantum electrodynamics:

'*Our present quantum theory is very good, provided we do not try to push it too far - we do not try to apply it to particles with very high energies and we do not try to apply it to very small distances'.* [29].

A remarkable feature of field equations (2.1) happen to be the solutions having short-range additions to Coulomb potential [34]. Indeed, any solution to equations (2.1) makes it possible to determine the interaction potential energy by the formula

$$U = L_\infty - L = -\mathrm{mc}\left[\left(\eta_{\mathrm{ik}}\frac{\mathrm{dx}^i}{\mathrm{dt}}\frac{\mathrm{dx}^k}{\mathrm{dt}}\right)^{\frac{1}{2}} - \left(g_{\mathrm{ik}}\frac{\mathrm{dx}^i}{\mathrm{dt}}\frac{\mathrm{dx}^k}{\mathrm{dt}}\right)^{\frac{1}{2}}\right] \tag{2.16}$$

and, respectively potential *V*.

In the non-relativistic approximation, (2.16) leads to the simple relation $U = \mathrm{mc}^2(g_{00} - 1)/2$. Having used this formula and metric (2.9), we obtain the Coulomb potential energy $U = \mathrm{mc}^2 r_e/\mathrm{r}$.

Starting from the solution to equations (2.1), we obtain a metric with a short-range addition to the Coulomb potential energy of the form [34]

$$ds^2 = -\Phi\left(cdt + 4r_N\, sin^2(\frac{\theta}{2})d\varphi\right)^2 + \frac{dr^2}{\Phi} - (r^2 + r_N^2)(d\theta^2 + sin^2\,\theta\, d\varphi^2). \tag{2.17}$$

where

$$\Phi = -1 + \frac{\mathrm{r}r_e + 2r_N^2}{r^2 + r_N^2}$$

and $r_N = \mathrm{const}$, being of linear dimension and named by 'nuclear' radius, since the attraction of particles is ensured at nuclear distances even in the absence of electromagnetic interaction between them ($r_e = 0$).

The interaction potential energy of solution (2.17) has the following form

$$U = -\frac{\mathrm{mc}^2}{2}\frac{\mathrm{r}r_e + 2r_N^2}{r^2 + r_N^2}, r_e = \pm\frac{2\mathrm{Zze}^2}{\mathrm{mc}^2} = \mathrm{const}, r_N = \mathrm{const}. \qquad (2.18)$$

For a particular elastic scattering of charged particles (protons, α – particles, etc.), radius r_e is calculated using the middle formula in (2.18), and the nuclear radius is defined as $r_N \sim \mathrm{A}^{1/3}$, where A is the atomic number of the nucleus in the scattering center.

In Fig. 3, the theoretical curve represents theoretical calculations obtained using potential energy (2.18) [35-39]. The calculations were carried out for the differential cross section of the elastic scattering of protons, having a rest energy of 938.5MeV and a kinetic energy of 17MeV, on copper nuclei.

The radii sizes are $r_n = 3{,}15\times10^{-15}$ cm and $|r_e| = 8{,}9\times10^{-15}$ cm, with the latter being calculated by the middle formula (2.18). The experimental points represent the differential cross section for elastic scattering of 17 MeV protons on copper nuclei [40]. The almost perfect agreement between the theoretical and experimental curves in Fig. 3 justifies the assertion that the resulting from the solution of equations (2.1) potential energy (2.18) represents the first step towards creating a fundamental (rather than phenomenological) *theory of nuclear and electro-nuclear interactions*.

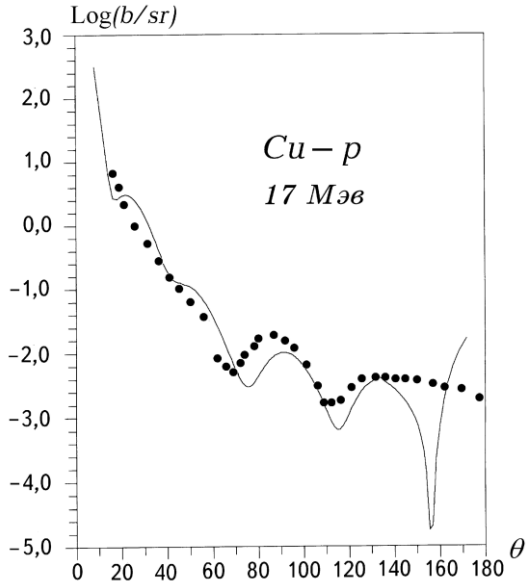
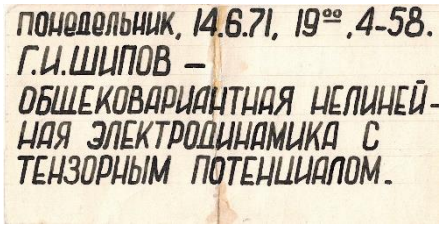


Fig.3 Elastic scattering 17 MeV protons on copper nuclei


Dmitry Ivanenko

It will be shown below that developing further the results obtained leads to creating a fundamental theory of elementary particles. Prior to publishing [30], I had given a report at the Department of Theoretical Physics of the Physics Department of Moscow State University at a seminar led by Professor, Doctor of Physical and Mathematical Sciences Dmitry Dmitrievich Ivanenko, a world-famous scientist dealing the problem of the Unified Field Theory. You can see the poster announcing



my report on the right. The work was highly appreciated by the theoreticians at the seminar, while after the seminar I was accompanied by D.D. Ivanenko who suggested during our conversation that more references should be included in my paper and wished me further success. In 1972 I prepared my thesis on general relativistic electrodynamics as a graduate student at the Russian University of Peoples' Friendship but failed to defend it because of a negative review by Doctor of Physical and Mathematical Sciences N.V. Mitskevich, a mentee of D.D. Ivanenko.

2.2. Solving the second Einstein problem (1976-77) - geometrizing the energy-momentum tensor of matter

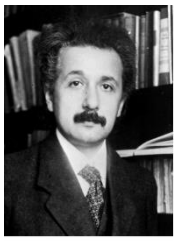
Being passionate about finding a solution to the problem of Unified Field Theory, I preferred looking for a way to solve the second Einstein problem rather than wasting energy to defend my position and thesis.

While studying the works by A. Einstein I got a hint which path to move on. As a matter of fact, A. Einstein considered his equations with a non-zero right side describing relativistic gravitational fields

$$R_{\mathrm{ik}} - \frac{1}{2} g_{\mathrm{ik}} R = \frac{8\pi G}{\mathrm{c}^4} T_{\mathrm{ik}}, i, j, k \ldots = 0,1,2,3, \tag{2.19}$$

to be imperfect in the sense that the energy-momentum tensor T_{ik} on the right side of (2.19) turns out as a nongeometrized and handpicked object.

Here what is written about this by A. Einstein:


Albert Einstein

'*The right part includes what cannot be united yet in a unified field theory. Of course, not for a minute did I doubt that such a formulation was only a temporary way out of the situation taken to give the general principle of relativity some kind of finished view. Essentially, this formulation was nothing more than a gravitational field theory, broken in some artificial way free from a theory of a unified field of as yet unknown nature.* [41]'

In what follows, Einstein relates the field of 'as yet unknown nature' to quantum theory:

'*One more final remark - my efforts to top up the general relativity by generalizing the equations of gravity were related partly to the assumption that a reasonable general relativistic field theory seemed being able to provide the key to a better quantum theory.* [42]'

Being ignored by his contemporaries, these prophetic words by A. Einstein impressed me profoundly and made me search a physical 'field of unknown nature.' As a result, in about 4 years, three papers [43-45] were written by me and recommended for publication by D.D. Ivanenko. It was indicated for the first time in science there the existence of a new fundamental physical field, A. Einstein spoke about. This field of 'unknown nature' turned out to be *the field of inertia* [45].

While general principle of relativity requires the covariance of physics equations with respect to accelerated reference frames, the motion equations of mass m in an accelerated reference frame are known from classical mechanics as [46]

$$m\frac{d\vec{v}'}{dt} = -\frac{\partial U}{\partial \vec{r}} - m\overrightarrow{W} - 2m[\vec{\omega}\vec{v}'] - m[\vec{\omega}[\vec{\omega}\vec{r}'] - m\left[\dot{\vec{\omega}}\vec{r}'\right]. \tag{2.20}$$

If mass m is falling free in a gravitational field with potential energy U created by mass $M \gg m$ then equations (2.20) take the form of d'Alembert principle

$$m\frac{d\vec{v}'}{dt} = -\frac{\partial U}{\partial \vec{r}} - m\overrightarrow{W} = m\vec{g} - m\overrightarrow{W} = 0, \tag{2.21}$$

describing, particularly, the weightlessness state of mass m in a free-falling Einstein elevator. The gravitational force $F_{\text{гр}} = -\partial U/\partial \vec{r} = m\vec{g}$ is compensated in this case by the inertia force $F_{\text{инер}} = -m\overrightarrow{W}$, with the strong equivalence principle $\vec{g} = \vec{W}$ being locally satisfied in the elevator.

Indeed, within the accepted analytics, Einstein strong equivalence principle $\vec{g} = \vec{W}$signifies that mass m being uniformly accelerated in the Einstein elevator is locally affected by a uniform inertia field $\vec{W}$ equivalent to the action of a uniform gravitational field $\vec{g}$. In a free-falling elevator, fields $\vec{g}$ and $\vec{W}$ have opposite directions and cancel each other out causing a state of weightlessness.

On the other hand, if mass m is rotating around the central mass $M \gg m$ with an angular velocity $\vec{\omega}$, equations (2.20) lead us to the equations

$$m\frac{d\vec{v}'}{dt} = -\frac{\partial U}{\partial \vec{r}} - 2m[\vec{\omega}\vec{v}'] - m[\vec{\omega}[\vec{\omega}\vec{r}'] - m\left[\dot{\vec{\omega}}\vec{r}'\right]. \tag{2.22}$$

In case of angular velocity $\vec{\omega} \approx \text{const}$ and linear velocity $\vec{v}' \approx 0$, as follows from experience, equations (2.22) take the form of d'Alembert principle

$$m\frac{d\vec{v}'}{dt} = -\frac{\partial U}{\partial \vec{r}} - m[\vec{\omega}[\vec{\omega}\vec{r}'] = 0, \tag{2.23}$$

when locally Newton gravitational force $F_{grav} = -\partial U/\partial \vec{r} = m\vec{g}$is compensated by centrifugal inertia force $F_{iner} = -m[\vec{\omega}[\vec{\omega}\vec{r}']$, while there is created the state of weightlessness inside the Satellite flying above the Earth in a stationary orbit.

By writing down the motion equations of the test mass (geodesic equations) and taking into account the equivalence of inertial m_{in} and gravitational m_g masses in Einstein's theory of gravity (weak equivalence principle), we come to the following

$$m_{\text{in}}\frac{d^2x^i}{\text{ds}^2} + m_g\Gamma^i_{\text{jk}}\frac{\text{dx}^j}{\text{ds}}\frac{\text{dx}^k}{\text{ds}} = 0, \qquad m = m_{\text{in}} = m_g, \tag{2.24}$$

where Γ^i_{jk}- is the strength of the gravitational field.

Employing the spherically symmetric solution of Einstein equations - the Schwarzschild metric [47]

$$\text{ds}^2 = \left(1 + \frac{2\varphi_N}{c^2}\right)c^2\text{dt}^2 - \left(1 - \frac{2\varphi_N}{c^2}\right)^{-1}\text{dr}^2 - r^2(d\theta^2 + \sin^2\theta d\varphi^2), \tag{2.25}$$

where $\varphi_N = -\mathrm{MG/r}$ - is Newton potential, from (2.24) in the non-relativistic weak field approximation we arrive at the motion equations of Newton gravity theory

$$m\frac{d\vec{v}}{dt} = m\vec{g}\,, \tag{2.26}$$

which differ from equations (2.21) as they do not contain inertia field $\vec{W}$. which differ from equations (2.21) as they do not contain inertia field $\vec{W}$. It means for the strong equivalence principle $\vec{g} = \vec{W}$ not to be held for equations (2.24)!

To eliminate this shortcoming of Einstein gravity theory, as it was done in [43–45], one can use the geometry of absolute parallelism A_4 instead of Riemann geometry.

This geometry was first used by A. Eddington [12] while searching for the equations of the Unified Field Theory. Then E. Cartan, in correspondence with A. Einstein, drew his attention to the existence of a geometry 'with zero curvature and non-zero torsion of space [48]', calling this geometry as 'tele-parallelism' (which stands for 'far parallelism'). Later, this geometry was called as 'absolute parallelism'.

While searching for the equations of the Unified Field Theory, A. Einstein published the most works (12 articles in total), which employed the geometry of absolute parallelism $\mathrm{A_4}$. At the same time, the torsion of the geometry of absolute parallelism $-\Omega^{\cdot\cdot\mathrm{i}}_{\mathrm{jk}}$ was used in one of the versions of the new theory for writing Lagrangian in the following form [49]

$$\mathcal{L} = Ag^{ik}\,\Omega^{\cdot\cdot n}{}_{ij}\,\Omega^{\cdot\cdot j}{}_{kn} + Bg^{ik}\Omega^{\cdot\cdot n}{}_{in}\,\Omega^{\cdot\cdot n}{}_{kn} + Cg^{is}g^{kd}g_{mp}\Omega^{\cdot\cdot m}{}_{ik}\,\Omega^{\cdot\cdot p}{}_{sd}\,.$$

In our case, geometry $\mathrm{A_4}$ was used due to the need for modifying the motion equations (2.24) of Einstein gravity theory so that they included inertial forces while holding true the strong equivalence principle $\vec{g} = \vec{W}$ observed experimentally.

Indeed, the geodesic equations of the space $\mathrm{A_4}$ have the following form [34, 43-45]

$$m\frac{\mathrm{du}^i}{\mathrm{ds}} + m\Gamma^i_{\mathrm{jk}}u^j u^k + \mathrm{mT}^i_{\mathrm{jk}}u^j u^k = 0, \tag{2.27}$$

where the term added to the Einstein equations of motion (2.24) contains the force of inertia $\mathrm{mT}^i_{\mathrm{jk}}u^j u^k$, while the field of inertia T^i_{jk} (or the Ricci rotation coefficients [34])

$$T^i_{\mathrm{jk}} = -\Omega^{\cdot\cdot\mathrm{i}}_{\mathrm{jk}} + g^{\mathrm{im}}\left(g_{\mathrm{js}}\Omega^{\cdot\cdot\mathrm{s}}_{\mathrm{mk}} + g_{\mathrm{ks}}\Omega^{\cdot\cdot\mathrm{s}}_{\mathrm{mj}}\right) \tag{2.28}$$

is defined through the torsion $\Omega^{\cdot\cdot\mathrm{i}}_{\mathrm{jk}}$ of space $\mathrm{A_4}$ as follows

$$\Omega^{\cdot\cdot\mathrm{i}}_{\mathrm{jk}} = e^i_a e^a_{[k,j]} = -\frac{1}{2}e^i_a\left(e^a_{j,k} - e^a_{k,j}\right) = -T^i_{[\mathrm{jk}]} \neq 0, \qquad {}_{,k} = \frac{\partial}{\partial x^k}. \tag{2.29}$$

Here e^a_k is a nonholonomic basis, and the notation $e^a_{[k,j]}$ is understood as a four-dimensional curl, so the vectors of the nonholonomic basis e^a_k rotate, as we see from (2.29). In mathematics, torsion (2.29) is sometimes called an object of anholonomity [50].

An infinitesimal rotation of a nonholonomic tetrad e^a_k is given on a six-dimensional manifold of nonholonomic coordinates $\varphi_1, \varphi_2, \varphi_3, \theta_1, \theta_2, \theta_3$, while their differentials $d\chi^a_b$ are related to the differentials of spatial coordinates $x^i = x^i(x, y, z, \mathrm{ct})$ in the following way

$$d\chi_b^a = T_{\rm bk}^a {\rm dx}^k, d\chi_{\rm ab} = -d\chi_{\rm ba}, a, b, c \ldots = 0,1,2,3 \tag{2.30}$$

and form a rotational metric

$$d\tau^2 = d\chi_b^a d\chi_a^b = T_{\rm bk}^a T_{\rm an}^b {\rm dx}^k {\rm dx}^n. \tag{2.31}$$

In turn, the nonholonomic tetrad e_k^a forms the translation metric

$${\rm ds}^2 = g_{\rm ik}{\rm dx}^i{\rm dx}^k, \quad g_{\rm ik} = \eta_{\rm ab}e_i^a e_k^b, \quad \eta_{\rm ab} = \eta^{\rm ab} = {\rm diag}(-1,1,1,1), \tag{2.32}$$

which defines the Christoffel symbols [34]

$$\Gamma^i{}_{jk} = g^{im}\left(g_{jm,k} + g_{km,j} - g_{jk,m}\right)/2\ . \tag{2.33}$$

It should be noted that formulas (2.27), (2.30), and (2.31) were overlooked by A. Einstein as he and his followers might have missed the connection between tensor $T_{\rm jk}^i$ and the field of inertia. According to E. Cartan [51], the connection of torsion $\Omega_{\rm jk}^{\cdot\cdot\rm i}$ with the rotation of material objects remained unnoticed. It is formulas (2.27), (2.30), and (2.31) that made it possible to prove E. Cartan hypothesis that the rotation of matter generates the torsion (2.29) of the space of absolute parallelism [51].

Indeed, dividing the right and left sides of the infinitesimal rotation equation (2.30) by ds, we obtain the angular rotation velocity of the non-holonomic tetrad e_k^a linked rigidly with the material object

$$\Omega_j^i = \frac{d\chi_j^i}{ds} = T_{jk}^i \frac{dx^k}{ds} = \frac{De_a^i}{ds} e_j^a. \tag{2.34}$$

Formulas (2.27), (2.30), (2.31), and (2.34) explicitly indicate that we have a ten-dimensional event space formed by four holonomic coordinates $x^i = x^i(x, y, z, {\rm ct})$ of a linear dimension and six non-holonomic non-dimensional angular coordinates $\varphi_1, \varphi_2, \varphi_3, \theta_1, \theta_2, \theta_3$.To distinguish this space of absolute parallelism from the space A_4 used by A. Einstein and other theoreticians, we denote our ten-dimensional space as $A_4(6)$.

Using the connectivity of geometry $A_4(6)$ [34]

$$\Delta_{\rm jk}^i = \Gamma_{\rm jk}^i + T_{\rm jk}^i = e_a^i e_{j,k}^a, \tag{2.35}$$

we find the curvature tensor of space $A_4(6)$

$$S^i{}_{jkm} = R^i{}_{jkm} + 2\nabla_{[k}T^i{}_{|j|m]} + 2T^i{}_{s[k}T^s{}_{|j|m]} = R^i{}_{jkm} + P^i{}_{jkm} = 0, \tag{2.36}$$

where

$$R^i{}_{jkm} = 2\partial_{[k}\Gamma^i{}_{|j|m]} + 2\Gamma^i{}_{s[k}\Gamma^s{}_{|j|m]} \tag{2.37}$$

is the Riemann tensor defined in terms of Christoffel symbols (2.33), and

$$P^i{}_{jkm} = 2\nabla_{[k}T^i{}_{|j|m]} + 2T^i{}_{s[k}T^s{}_{|j|m]} \tag{2.38}$$

is the Ricci curvature tensor defined in terms of inertia field (2.28) (or Ricci rotation coefficients)?

By forming Einstein tensor $G_{\text{ik}} = R_{\text{ik}} - \frac{1}{2} g_{\text{ik}} R$with (2.36), we obtain ten fully geometrized Einstein equations

$$R_{\text{jm}} - \frac{1}{2} g_{\text{jm}} R = \nu T_{\text{jm}}, \tag{2.39}$$

where geometrized matter energy-momentum tensor T_{jm} is formed by inertial field T^{i}_{jk} and has the following form [43]

$$T_{jm} = -\frac{2}{\nu}\left\{\left(\nabla_{[i} T^{i}_{|j|m]} + T^{i}_{s[i} T^{s}_{|j|m]}\right) - \frac{1}{2} g_{jm} g^{pn}\left(\nabla_{[i} T^{i}_{|p|n]} + T^{i}_{s[i} T^{s}_{|p|n]}\right)\right\} . \tag{2.40}$$

Hence the density of matter ρ is defined as

$$\rho = \frac{T}{c^2} = \frac{g^{jm} T_{jm}}{c^2} = \frac{2 g^{jm}}{\nu c^2}\left\{\nabla_{[i} T^{i}_{|j|m]} + T^{i}_{s[i} T^{s}_{|j|m]}\right\}. \tag{2.41}$$

If we decompose Riemann tensor (2.37) into irreducible parts, then it will be additionally obtained for Weyl tensor C^{i}_{jkm} ten fully geometrized Yang-Mills equations [34]

$$C^{i}_{jkm} + 2\nabla_{[k} T^{i}_{|j|m]} + 2 T^{i}_{s[k} T^{s}_{|j|m]} = -\nu J^{i}_{jkm}, \tag{2.42}$$

where current tensor J_{ijkm} is defined through energy-momentum tensor (2.40) as

$$J_{ijkm} = 2 g_{[k(i} T_{j)m]} - \frac{1}{3} T g_{i[m} g_{k]j} , \tag{2.43}$$

i.e. it is also defined in terms of inertia field T^{i}_{jk}.

Thus, it was proposed in [43] for the first time completely geometrized Einstein equations (2.39) with the matter energy-momentum tensor (2.40), which made it possible to construct a purely field theory of gravity passing into Einstein theory in the limit when the source of gravitational field is a stationary and point-like [45].

Following the works by R. Penrose [52], field equations (2.39) were written in the spinor basis [44], while the matter density (2.41) in the quasi-inertial spinor reference frame being defined as

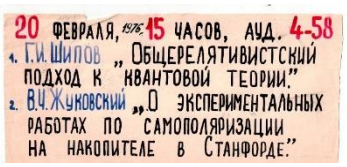
$$\rho = -\frac{1}{2\nu c^2} \mu_{\dot{P}\dot{Q}} \mu^{\dot{P}\dot{Q}} = \frac{1}{2\nu c^2} \overline{\mu}_{\dot{Q}P} \mu^{\dot{P}\dot{Q}}, \tag{2.44}$$

where $\mu_{P\dot{Q}}$ is the spinor representation of the pseudovector part of inertial field T^{i}_{jk}.

Later it was shown [34] that field $\mu_{P\dot{Q}}$ being normalized to unity (assuming the field to be weak) is comparable to the de Broglie wave and satisfies the Schrödinger equation.

Works [43-45] were reported at the Department of Theoretical Physics of the Physics Department of Moscow State University in 1974-1976. The announcements of the reports have been saved in my archive.







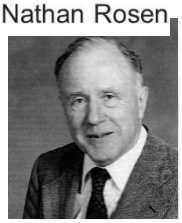

Peter Bergmann

The reports were highly appreciated and were recommended by Professor of Moscow State University D.D. Ivanenko for publication. Article [44] was appreciated especially and noted as promising by the International Commission headed by N. Rosen, a mentee of A. Einstein, in the journal General Relativity and Gravitation, 1983, Vol. 15, No. 1, p. 98. Bull No. 41.

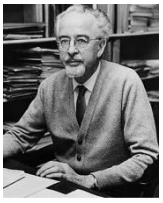

Nathan Rosen


George Ellis

I believe, it was of utmost importance for my further work on developing the Unified Field Theory the opinion of this authoritative commission, in which in various years took part or lead mentees and co-authors of A. Einstein, namely, Nathan Rosen, Peter Bergman, John Wheeler, as well as world-famous specialists in the general theory of relativity and quantum gravity, such as Christian Möller (personally acquainted), George Ellis, McCallum (personally acquainted), Roger Penrose and other highly respected theoreticians.


John Wheeler


Malcolm Mac Callum


Christian Møller

It is shown in [44] that the relation established by A. Fock and D. Ivanenko [54] between Pauli spinors and Dirac matrices and the geometry of the Minkowski event space can be generalized to the geometry of absolute parallelism by introducing generalized Pauli matrices or Infeld-van der Waerden symbols [55]. Thus, works [43-45] complete the part of the program for developing the Unified Field Theory that was put forward by A. Einstein. Further development of this program led to the discovery of a new fundamental physical field - the field of inertia. The task was to find the dynamic equations the inertia field satisfies (2.28) and learn how to solve them.

3. Dynamic equations of the inertia field (1979) and the consequence for the problem of motion of matter

The fully geometrized Einstein equations (2.39) and Yang-Mills equations (2.42) follow from the definition of the curvature tensor (2.36) of space $A_4(6)$. If translational metric (2.32) defined in terms of nonholonomic tetrad e_k^a is searched for as a solution to equations (2.39) and (2.42), then it follows that relation (2.36) is an identity for any tetrad e_k^a. The situation is different when we search for both translational metric (2.32), and rotational metric (2.31) defined in terms of inertia field T^i_{jk},while considering e_k^a and T^i_{jk} as independent variables. In this case, it follows from the definition of torsion (2.29) of space $A_4(6)$ the equations of the following form

$$\nabla_{[k} e^a_{j]} + T^i_{[k\ j]} e^a_i = 0, \qquad (A)$$

where ∇_k is the covariant derivative with respect to the Christoffel symbols (2.33)?

It is proved in the mathematical part of book [34] that equations (A) are the first structural Cartan equations of geometry $A_4(6)$. For obtaining the second structural equations of this geometry inertia field T^i_{jk} and Riemann curvature R^i_{jkm} should be considered as independent variables in relation (2.36). As a result, we get

$$R^i{}_{jkm} + 2\nabla_{[k}T^i{}_{|j|m]} + 2T^i{}_{s[k}T^s{}_{|j|m]} = 0. \qquad (B)$$

For the first time, equations *(A), (B)* were presented as dynamic equations for the inertia field in the monograph [56] published at Moscow State University in 1979. There were also introduced the Lagrangian to derive equations *(B)* and the most significant solutions to equations *(A), (B)*, generalizing the Newton-Coulomb potential. To found these solutions, we employed a well-known Newman-Penrose spin coefficient method [57], which is based on the use of the system of equations *(A), (B)*, as it was proved in book [34].

By decomposing Riemann tensor into the irreducible parts – Weyl tensor C_{ijkm} (ten components), Ricci tensor R_{jm} (nine components), and scalar curvature R, we come to the following relation [58]

$$R_{ijkm} = C_{ijkm} + g_{i[k}R_{m]j} + g_{j[k}R_{m]i} + Rg_{i[m}g_{k]j}/3 \qquad (3.1)$$

Finally, after the appropriate transformations considering relation (3.1), we obtain the fully geometrized Einstein equations (2.39) and the fully geometrized Yang-Mills equations (2.42) [34].

Referring to the motion of matter in equations (2.39), it is described by equations following from the Bianchi identities of geometry $A_4(6)$

$$\nabla_{[p}R^i{}_{jk]m} = 0 \quad \text{or} \quad \nabla^*{}_{[p}P^i{}_{jk]m} = 0, \qquad (3.2)$$

r

where ∇^*_p is the covariant derivative with respect to the connection (2.35) of geometry $A_4(6)$, while P^i_{jkm} is defined by (2.38)?

As relation (2.36) implies $R^i_{\text{jkm}} = -P^i_{\text{jkm}}$, Bianchi identities (3.2) are allowed to be written as $\nabla^*{}_{[p}R^i{}_{jk]m} = 0$, while obtaining the conservation law of matter energy-momentum tensor (2.40) in the following form

$$\nabla^*_i\left(R^{\text{ik}} - \frac{1}{2}g^{\text{ik}}R\right) = \nu\nabla^*_i T^{\text{ik}} = 0, \qquad (3.3)$$

or

$$\nabla^*_i T^{\text{ik}} = 0. \qquad (3.4)$$

By substituting here energy-momentum tensor $T^{\text{ik}} = \rho c^2 u^i u^k, \quad u^k u_k = 1$, we obtain

$$\nabla^*_i T^{\text{ik}} = \nabla^*_i\left(\rho c^2 u^i u^k\right) = 0. \qquad (3.5)$$

There holds $\nabla^*_i g^{\text{ik}} = 0$ [34] in geometry $\text{A}_4(6)$.

On condition of incompressibility of the ideal fluid $\nabla_i^*\rho = 0$ equations (3.5) are found to decompose into:

1) the geometrized continuity equation

$$\nabla_i^*(\rho u^i) = \partial_i(\rho u^i) + \rho u^n \Gamma^j_{\mathrm{nj}} + \rho u^n T^j_{\mathrm{nj}} = 0; \tag{3.6}$$

2) the geometrized equations similar to Euler hydrodynamic equations

$$\rho \frac{D^* u^k}{\mathrm{ds}} = \rho \frac{\mathrm{du}^k}{\mathrm{ds}} + \rho \Gamma^k_{\mathrm{mn}} u^m u^n + \rho T^k_{\mathrm{mn}} u^m u^n = 0; \tag{3.7}$$

3) he geometrized equation for the incompressible "ideal fluid"

$$\nabla_i^*\rho = \partial_i\rho = 0. \tag{3.8}$$

For a point source of density $\rho = m\delta\left(\vec{r}\right)$ equations (3.7) go over into equations of motion (2.27), with mass m being generally defined in terms of density (2.41) as

$$m = \frac{2}{vc^2}\int(-g)^{1/2}\left\{g^{jm}\left(\nabla_{[i}T^i_{|j|m]} + T^i_{s[i}T^s_{|j|m]}\right)\right\}dV. \tag{3.9}$$

It follows from relations (2.41) and (3.9) that inertia field T^i_{jm} determines density ρ of mass m, while mass m itself is *a measure of the inertia field.* It is also determined in a similar way the charge of a purely field formation which was called an “inertion” in [56]. The motion of such an object as a whole unit is conveniently described by Liouville equation

$$\frac{\partial\rho}{\partial t} + [\rho, H] = 0\,, \tag{3.10}$$

where ρ is the density of an extended object, H is a Hamilton function, and?

$$[\rho, H] = \left(\frac{\partial\rho}{\partial x_i}\,\frac{\partial H}{\partial p_i} - \frac{\partial\rho}{\partial p_i}\frac{\partial H}{\partial x_i}\right) \tag{3.11}$$

is a Poisson bracket [46].

There are associated with each point of such an extended object coordinate x_i and momentum p_i, with the momentum of a small volume being given as $p_i = \Delta\mathrm{mv}_i$. There is proved in Liouville mechanics a theorem, in which the phase volume of an extended object is stated to be conserved

$$\Delta\mathrm{x}_i\Delta\mathrm{p}_i = \mathrm{const}, \tag{3.12}$$

while the coordinates of the mass center and the momentum of an extended object - inertion - are determined by the formulas

$$\bar{x}_i = \frac{1}{m}\int(-g)^{1/2}\rho x_i dV\ , \qquad \bar{p}_i = \frac{1}{m}\int(-g)^{\frac{1}{2}}\rho p_i dV\,. \tag{3.13}$$

If density ρ is normalized to unity, we get the quantity

$$\rho_W = \frac{(-g)^{1/2}\rho}{m}, \tag{3.14}$$

which can be interpreted as the probability density to find the coordinate and momentum of the mass center of the inertion, according to the formula

$$\bar{x}_i = \int \rho_W x_i dV \ , \qquad \bar{p}_i = \int \rho_W p_i dV \ . \tag{3.15}$$

For a constant mass of the inertion and in weak fields ($(-g)^{\frac{1}{2}} = 1$) probability density ρ_W complies with the equation

$$\frac{\partial \rho_W}{\partial t} + [\rho_W, H] = 0 \ . \tag{3.16}$$

It is now sufficient to find a solution to equations *(A), (B)* that describes in the limiting case a stationary particle, and for a quasi-inertial reference frame we obtain right away the relation for density ρ of the same type as the wave-particle duality of quantum mechanics

$$\rho = m\delta\left(\vec{r}\right) = m\psi^*\psi \ or \ \ \rho = e\delta\left(\vec{r}\right) = e\psi^*\psi, \tag{3.17}$$

where ψ is the inertia field normalized to unity, $\delta\left(\vec{r}\right)$is a Dirac delta function [56]?

On the assumption that the wave function ψ in relations (3.17) coincides with de Broglie wave there can be obtained instead of (3.12) and (3.16) the quantum Heisenberg uncertainty relation and the quantum von Neumann equation

$$\Delta x_i \Delta p_i = \pi\hbar, \tag{3.18}$$

$$i\hbar\frac{\partial \rho_W}{\partial t} + [\rho_W, H] = 0 \ . \tag{3.19}$$

By using (3.17), the Schrödinger equations for ψ and ψ^* can be shown to follow from (3.19). This leads us to conclusion that quantum mechanics is a purely classical theory of the unity-normalized inertia field, while its probabilistic interpretation, as was supposed by A. Einstein, though useful in some cases is not necessary.

We remark, in conclusion, that almost 350 years ago a fundamental question was posed by Isaac Newton, why the surface of water in a rotating bucket curves as it rotates? Now we can reasonably respond that the surface curvature of the rotating water is caused by the inertia field generating inertia forces inside the rotating water. This true answer is proved by numerous experiments, which demonstrate the geometry of the water surface to be dependable on the angular velocity ω of water rotation. In short, being related to the physics of the rotational motion of matter, formula (2.34) and Cartan hypothesis are physically exhibited through the effects of the inertia field on matter.

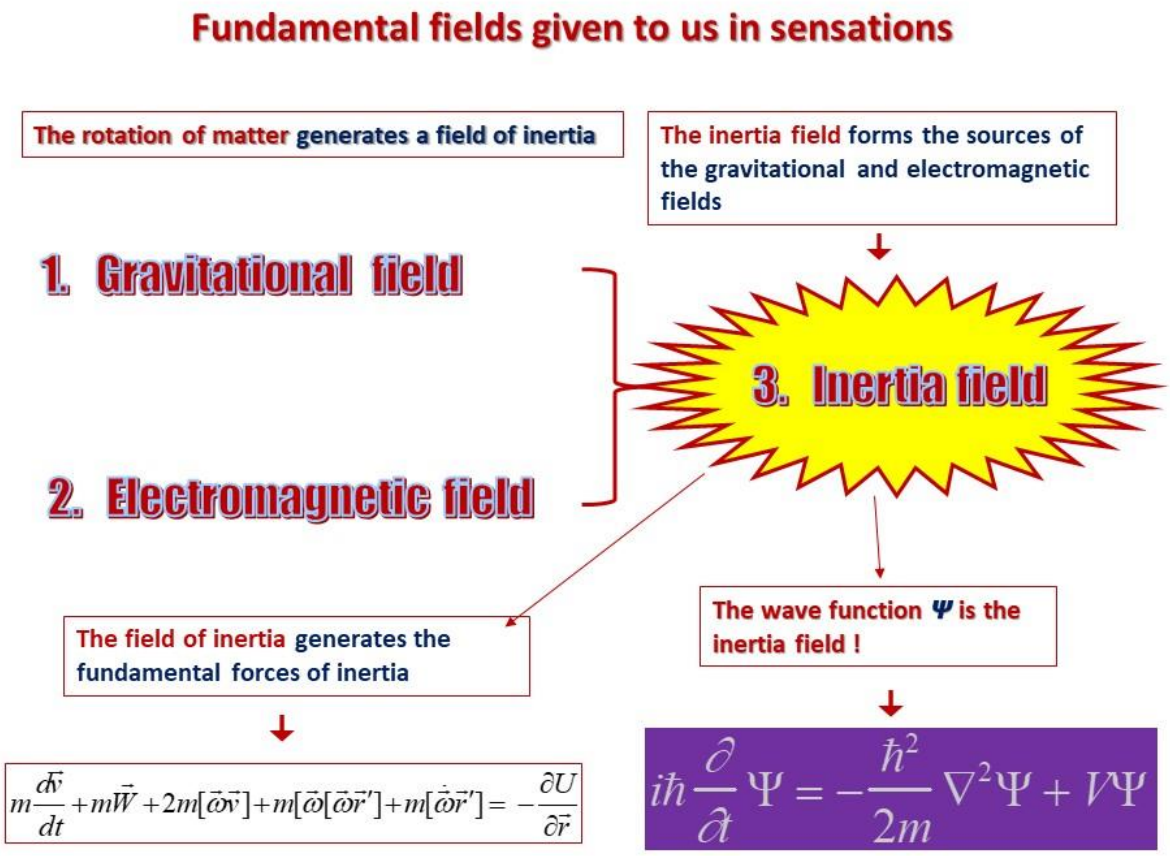


Fig.4 Three fundamental fields

In his excellent review of the state of the art in theoretical physics [59], Roger Penrose concludes that "we all missed something, something very important". He is right and it follows from equations *(A), (B)* that we 'missed' the third fundamental physical field - the field of inertia (Fig. 4). Every person, whether he realizes it or not, constantly feels the manifestations of this field in his daily life through the forces of inertia, just as we constantly feel the effects of the gravitational and electromagnetic fields through the gravitational and electromagnetic forces.

After the solutions of equations *(A), (B)* are found, field equation (2.39) lead, under certain limitations, to the Einstein equations (2.19) and the equations of general relativistic electrodynamics (2.1), with inertia field T^i_{jk}.determining the sources of field. As noted above, the inertia field determines wave function ψ in Schrödinger equation and the density of matter (3.17), with fundamental inertia field T^i_{jk}.being considered as an 'internal' field and a source of "external" gravitational and electromagnetic fields (Fig. 4).

It should be noted that besides ten equations for Ricci tensor (2.1) and (2.19), we have also ten Yang-Mills equations (2.42) being absent in Einstein theory. We have yet to study new properties of gravitational and electromagnetic fields which are described by these equations. Intuition prompts that numerous constructive fields are introduced in modern physics to imitate the fundamental field of inertia without its existence being appreciated.

4. Theory of Physical Vacuum (1988)

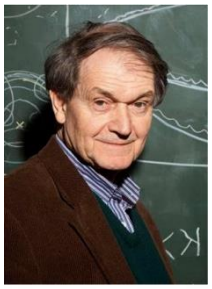
Generally, it is possible for equations (2.39) to go accurately into the equations of Einstein gravity theory (2.19) only if the right side of (2.19) vanishes

$$R_{\text{jm}} = R^{i}_{\text{jim}} = 0 \tag{4.1}$$

A. Einstein believed that only equations for empty space (Einstein vacuum equations) (4.1) could rightly be called the "perfect" equations of general relativistic gravity theory as "they represent the only rationally substantiated case of field theory that can claim to rigor... [60]". Introducing the handpicked energy-momentum tensor of matter T_{ik} into equations (2.19) was considered by him as a temporary way out. On the other hand, vacuum was considered to be the ground state of elementary particles, which constitute the foundation of matter in quantum field theory, being of a constructive-phenomenological nature.

There are the following ideas about Physical Vacuum (ether) in modern theoretical physics (both relativistic relativity theory and quantum theory):

- Physical Vacuum is a constantly developing object of theoretical and experimental research;
- Physical Vacuum is represented in relativistic physics as a space with elastic properties;
- Physical Vacuum features a non-zero energy density, constituting ~95% of the energy of the Universe;
- Physical Vacuum manifests itself in quantum physics as a seething sea of virtual particles and has the energy of a "zero point";
- Spontaneous breaking the symmetry of Physical Vacuum leads to the birth of real particles and their mutual transformations.


Rodger Penrose

Thus, studying the properties of Physical Vacuum should currently be considered as the hottest (top) problem of theoretical physics. The author considers the theory of Physical Vacuum to be in essence the Unified Field Theory in the modern sense, based on the results obtained in [30,43-45, 56] in the late 80s of the last century. It was the further development of Einstein theory of relativity rather than the quantum theory of matter that became the starting point of the new theory.


Moshe Carmeli


Gennady Shipov (1988)

Being based on the works by R. Penrose [52,53,57] and M. Carmeli [61-65], professor of the Department of Theoretical Physics at Ben Gurion University (Israel), the equations of the Theory of Physical Vacuum were first proposed in 1984 in the spinor basis as [66]

$$\nabla_{[k}\sigma^{i]} - T_{[k}\sigma^{i]} - \sigma^{[i}T^{+}{}_{k]} = 0, \qquad (A^{s})$$

$$R_{kn} + 2\nabla_{[k}T_{n]} - [T_{k}, T_{n}] = 0, \qquad (B^{s+})$$

$$R^{+}{}_{kn} + 2\nabla_{[k}T^{+}{}_{n]} - [T^{+}{}_{k}, T^{+}{}_{n}] = 0, \qquad (B^{s-})$$

$$i, k, n \ldots = 0,1,2,3.$$

In this notation, the equations contain spinor Penrose matrices $\sigma^{i}_{A\dot{B}}$ (spinor indices $A = 0,1, \dot{B} = \dot{0}, \dot{1}$ are omitted in equations (*A)* and *(B)*), which generalize the Pauli matrices to the case of a curved and twisted space $A_4(6)$, while$R_{\mathrm{ACkn}}, R^{+}_{\dot{B}\dot{D}\mathrm{kn}}$ are the spinor matrices of the Riemann curvature (sign + means Hermitian conjugation) and $T_{\mathrm{kCE}}, T^{+}_{k\dot{B}\dot{D}}$ are the spinor matrices of Carmeli inertia field (the contortion tensor of the space of absolute parallelism $A_4(6)$). Mathematically, equations *(A)* and *(B)* are respectively the first (equations *(A)*) and the second (equations *(B)*) Cartan structure equations of the geometry of absolute parallelism $A_4(6)$.

Finally, there were published two monographs [67, 68] in 1987-1988, which presented the physical principles [67] and the mathematical apparatus [68] of the theory of Physical Vacuum based on Universal Relativity principle. This principle is a unification of Einstein general principle of relativity with the rotational principle of relativity requiring physics equations to be invariant under dimensionless, nonholonomic rotational coordinates $\varphi_1, \varphi_2, \varphi_3, \theta_1, \theta_2, \theta_3$.

4.1. Equations of Physical Vacuum in a spinor reference frame

If given in a spinor basis, the system of Cartan structure equations (A^s), $\left(B^{s+}\right)$, (B^{s-}) turns into the system of complex equations. There are three major types of spinor bases [34]:
1) Γ is a basis formed by Infeld-van der Waerden symbols $\sigma^{i}_{\alpha\,\dot{\beta}}$ $\left(\alpha, \beta \ldots = 0,1, \dot{\alpha}, \dot{\beta} \ldots = \dot{0}, \dot{1}\right)$;
2) Δ is a delta basis formed by Newman-Penrose symbols
$\sigma^{i}_{A\dot{B}}$ $(\mathrm{A}, B \ldots = 0,1, \quad \dot{B}, \dot{D} \ldots = \dot{0}, \dot{1})$;
3) a spinor dyadic basis ξ^{α}_{A} linking bases $\sigma^{i}_{\alpha\dot{\beta}}$ and $\sigma^{i}_{A\dot{B}}$ [34]

$$\sigma^{i}_{A\dot{B}} = \sigma^{i}_{\alpha\,\dot{\beta}} \xi^{\alpha}_{A} \bar{\xi}^{\dot{\beta}}_{\dot{B}}\,. \tag{4.2}$$

There are associated with the components of the spinor dyad two-component spinors o^{α} and ι^{α}

$$\xi^{\alpha}_{0} = o^{\alpha}, \;\; \xi^{\alpha}_{1} = \iota^{\alpha}\,, \;\; \bar{\xi}^{\dot{\alpha}}_{\dot{0}} = \bar{o}^{\dot{\alpha}}\,, \quad \bar{\xi}^{\dot{\alpha}}_{\dot{1}} = \bar{\iota}^{\dot{\alpha}}\,, \tag{4.3}$$

$$\alpha, \beta \ldots = 0,1, \;\; \dot{\alpha}, \dot{\beta} \ldots = \dot{0}, \dot{1}\,.$$

While spinors o^{α} and ι^{α} are Dirac spinors in traditional quantum electrodynamics, in our case, spinors (4.3) are related to the non-holonomic tetrad e^{a}_{i} as

$$e^{k}{}_{0} = \frac{1}{\sqrt{2}}(l^k + n^k) = \frac{1}{\sqrt{2}}\sigma^{i}_{\alpha\dot{\beta}}\left(o^{\alpha}\bar{o}^{\dot{\beta}} + \iota^{\alpha}\bar{\iota}^{\dot{\beta}}\right), \tag{4.4}$$

$$e^{k}{}_{1} = \tfrac{1}{\sqrt{2}}(m^k + \bar{m}^k) = \tfrac{1}{\sqrt{2}}\sigma^{i}_{\alpha\dot{\beta}}\left(o^{\alpha}\bar{\iota}^{\dot{\beta}} + \iota^{\alpha}\bar{o}^{\dot{\beta}}\right), \tag{4.5}$$

$$e^{k}{}_{2} = \tfrac{1}{\sqrt{2}}(m^k - \bar{m}^k) = \tfrac{1}{\sqrt{2}}\sigma^{i}_{\alpha\dot{\beta}}\left(o^{\alpha}\bar{\iota}^{\dot{\beta}} - \iota^{\alpha}\bar{o}^{\dot{\beta}}\right), \tag{4.6}$$

$$e^{k}{}_{3} = \tfrac{1}{\sqrt{2}}(l^k - n^k) = \tfrac{1}{\sqrt{2}}\sigma^{i}_{\alpha\dot{\beta}}\left(o^{\alpha}\bar{o}^{\dot{\beta}} - \iota^{\alpha}\bar{\iota}^{\dot{\beta}}\right), \tag{4.7}$$

$$i, j, k \ldots = 0,1,2,3, \quad \alpha, \gamma, \ldots = 0,1, \quad \dot{\beta}, \dot{\mu}, \ldots = \dot{0}, \dot{1},$$

where $z^{i}_{a} = (l_a, n_a, m_a, \overline{m}_a)$ is a complex (non-holonomic) light tetrad, with its two components l_a and n_a being real isotropic vectors, and two components m_a and $\overline{m}_a$ being complex vectors, while holding $\overline{m}_a = \overline{m_a}$ [57].

By using spinor bases, the equations of Physical Vacuum *(A), (B)* can be written down in the spinor form, which was first done by E. Newman and R. Penrose in 1962 [57]. The system of Newman-Penrose nonlinear spinor equations turned out to be very effective in finding new solutions to Einstein equations.

As it was proved by the author in [34], Cartan structure equations (A^S), $\left(B^{S+}\right)$, (B^{S-}) of geometry $A_4(6)$ coincide with the equations of Newman-Penrose formalism, when written in spinor Δ −basis, and have the following form

$$\partial_{A\dot{B}}\sigma^i{}_{C\dot{D}} - \partial_{C\dot{D}}\sigma^i{}_{A\dot{B}} = \varepsilon^{PQ}\left(T_{PAC\dot{D}}\sigma^i{}_{Q\dot{B}} - T_{PCA\dot{B}}\sigma^i{}_{Q\dot{D}}\right) + \varepsilon^{\dot{R}\dot{S}}\left(\bar{T}_{\dot{R}\dot{B}\dot{D}C}\sigma^i{}_{A\dot{S}} - \bar{T}_{\dot{R}\dot{D}\dot{B}A}\sigma^i{}_{C\dot{S}}\right), \qquad (4.7)$$

$$\Psi_{ACDF}\varepsilon_{\dot{E}\dot{B}} + \Phi_{AC\dot{B}\dot{E}}\varepsilon_{FD} + \Lambda\varepsilon_{\dot{E}\dot{B}}(\varepsilon_{CD}\varepsilon_{AF} + \varepsilon_{AD}\varepsilon_{CF}) - \partial_{D\dot{B}}T_{ACF\dot{E}} + \partial_{F\dot{E}}T_{ACD\dot{B}} +$$
$$+\varepsilon^{PQ}\left(T_{APD\dot{B}}T_{QCF\dot{E}} + T_{ACP\dot{B}}T_{QDF\dot{E}} - T_{APF\dot{E}}T_{QCD\dot{B}} - T_{ACP\dot{E}}T_{QFD\dot{B}}\right)$$
$$+\varepsilon^{\dot{R}\dot{S}}(T_{ACD\dot{R}}\bar{T}_{\dot{S}\dot{B}\dot{E}F} - T_{ACF\dot{R}}\bar{T}_{\dot{S}\dot{E}\dot{B}D}) = 0, \qquad (4.8)$$

where $\partial_{A\dot{B}} -$ is a spinor derivative and has the following notation for its components?

Further, the components of the spinor Δ −basis are denoted as

$$\partial_{A\dot{B}} = A\binom{0}{1}\overbrace{\begin{bmatrix} D & \delta \\ \bar{\delta} & \Delta \end{bmatrix}}^{\overbrace{\dot{0}\quad \dot{1}}^{\dot{B}}}. \qquad (4.9)$$

$$\sigma^i{}_{A\dot{B}} = A\binom{0}{1}\overbrace{\begin{bmatrix} l^i = (Y^0, V, Y^2, Y^3) & m^i = (\xi^0, \omega, \xi^2, \xi^3) \\ \bar{m}^i = (\bar{\xi}^0, \bar{\omega}, \bar{\xi}^2, \bar{\xi}^3) & n^i = (X^0, U, X^2, X^3) \end{bmatrix}}^{\overbrace{\dot{0}\quad \dot{1}}^{\dot{B}}}, \qquad (4.10)$$

and spin-tensor $T_{APD\dot{B}}$ ((of Penrose matrix) of the inertia field has the following notations for its components

$$T_{ABC\dot{D}} = AB\begin{pmatrix} 00 \\ (01) \\ 11 \end{pmatrix}\overbrace{\begin{bmatrix} \kappa & \sigma & \rho & \tau \\ \varepsilon & \beta & \alpha & \gamma \\ \pi & \mu & \lambda & \upsilon \end{bmatrix}}^{\overbrace{0\dot{0}\quad 0\dot{1}\quad 1\dot{0}\quad \dot{1}\dot{1}}^{C\dot{D}}}. \qquad (4.11)$$

The irreducible parts of Riemann tensor (3.1) in equations (4.8) are represented by spin-tensors Ψ_{ACDF}, $\Phi_{\mathrm{ACB}\dot{E}}$ и скаляром Λ and scalar Λ and have the following notations for their components [57]

$$\Psi_{ABCE} = AB\begin{pmatrix} 00 \\ 01 \\ 11 \end{pmatrix}\overbrace{\begin{bmatrix} \Psi_O & \Psi_1 & \Psi_2 \\ - & - & \Psi_3 \\ - & - & \Psi_4 \end{bmatrix}}^{\overbrace{00\quad 01\quad 11}^{CE}}, \qquad (4.12)$$

$$\Phi_{AB\dot{C}\dot{E}} = AB\begin{pmatrix}00\\01\\11\end{pmatrix}\overbrace{\begin{bmatrix}\Phi_{00} & \Phi_{01} & \Phi_{02}\\ \Phi_{10} & \Phi_{11} & \Phi_{12}\\ \Phi_{20} & \Phi_{21} & \Phi_{22}\end{bmatrix}}^{\substack{\dot{C}\dot{E}\\ \dot{0}\dot{0} \quad \dot{0}\dot{1} \quad \dot{1}\dot{1}}}, \tag{4.13}$$

$$\Lambda = \bar{\Lambda}. \tag{4.14}$$

From (4.7), it is obtained by using notations (4.9) -(4.14) a component-wise representation of the first Cartan structure equations $(A^s)$of geometry $A_4(6)$

$$\delta V - D\omega = (\bar{\alpha} + \beta - \bar{\pi})V + \kappa U - \sigma\bar{\omega} - (\bar{\rho} + \varepsilon - \bar{\varepsilon})\omega, \qquad (A^s.1)$$
$$\delta Y^\alpha - D\xi^\alpha = (\bar{\alpha} + \beta - \bar{\pi})Y^\alpha + \kappa X^\alpha - \alpha\bar{\xi}^\alpha - (\bar{\rho} + \varepsilon - \bar{\varepsilon})\xi^\alpha, \qquad (A^s.2)$$
$$\Delta Y^\alpha - DX^\alpha = (\gamma + \bar{\gamma})Y^\alpha + (\varepsilon + \bar{\varepsilon})X^\alpha - (\tau + \bar{\pi})\xi^\alpha - (\bar{\tau} + \pi)\bar{\xi}^\alpha, \qquad (A^s.3)$$
$$\Delta C - DU = (\gamma + \bar{\gamma})V + (\varepsilon + \bar{\varepsilon})U - (\tau + \bar{\pi})\bar{\omega} - (\bar{\tau} + \pi)\omega, \qquad (A^s.4)$$
$$\delta U - \Delta\omega = -\bar{\nu}V + (\tau - \bar{\alpha} - \beta)U + \bar{\lambda}\bar{\omega} + (\mu - \gamma + \bar{\gamma})\omega, \qquad (A^s.5)$$
$$\delta X^\alpha - \Delta\xi^\alpha = -\bar{\nu}Y^\alpha + (\tau - \bar{\alpha} - \beta)X^\alpha + \bar{\lambda}^\alpha\bar{\xi}^\alpha + (\mu - \gamma + \bar{\gamma})\xi^\alpha, \qquad (A^s.6)$$
$$\bar{\delta}\omega - \Delta\bar{\omega} = (\bar{\mu} - \mu)V + (\bar{\rho} - \rho)U - (\bar{\alpha} - \beta)\bar{\omega} - \left(\bar{\beta} - \alpha\right)\omega, \qquad (A^s.7)$$
$$\bar{\delta}\xi^\alpha - \delta\bar{\xi}^\alpha = (\bar{\mu} - \mu)Y^\alpha + (\bar{\rho} - \rho)X^\alpha - (\bar{\alpha} - \beta)\bar{\xi}^\alpha - \left(\bar{\beta} - \alpha\right)\xi^\alpha, \qquad (A^s.8)$$

$$\alpha = 0,2,3$$

while (4.8) leads to a component-wise representation of the second Cartan structure equations $\left(B^{s+}\right)$ of geometry $A_4(6)$

$$(D - \rho - \varepsilon - \bar{\varepsilon})\rho - \left(\bar{\delta} - 3\alpha - \bar{\beta} + \pi\right)\kappa - \sigma\bar{\sigma} + \tau\bar{\kappa} - \Phi_{00} = 0, \qquad (B^{s+}.1)$$
$$(D - \rho - \bar{\rho} - 3\varepsilon + \bar{\varepsilon})\sigma - (\delta - \tau + \bar{\pi} - \bar{\alpha} - 3\beta)\kappa - \Psi_0 = 0, \qquad (B^{s+}.2)$$
$$(D - \bar{\rho} - \varepsilon + \bar{\varepsilon})\tau - (\Delta - 3\gamma - \bar{\gamma})\kappa - \rho\bar{\pi} - \sigma\bar{\tau} - \pi\sigma - \Psi_1 - \Phi_{10} = 0, \qquad (B^{s+}.3)$$
$$(D - \rho - \bar{\varepsilon} + 2\varepsilon)\alpha - \left(\bar{\delta} - \bar{\beta} + \pi\right)\varepsilon - \beta\bar{\sigma} + \kappa\lambda + \kappa\bar{\gamma} - \pi\rho - \Phi_{10} = 0, \qquad (B^{s+}.4)$$
$$(D + \varepsilon + \bar{\varepsilon})\gamma - (\Delta - \gamma - \bar{\gamma})\varepsilon - (\tau + \bar{\pi})\alpha - (\pi + \bar{\tau})\beta - \pi\tau + \nu\kappa + \Lambda - \Psi_2 - \Phi_{11} = 0, \qquad (B^{s+}.5)$$
$$(D - \rho + 2\varepsilon - \bar{\varepsilon})\lambda - \left(\bar{\delta} + \pi + \alpha - \bar{\beta}\right)\pi - \mu\bar{\sigma} + \nu\bar{\kappa} - \Phi_{20} = 0, \qquad (B^{s+}.6)$$
$$(D - \bar{\rho} + \bar{\varepsilon})\beta - (\delta - \bar{\alpha} + \bar{\pi})\varepsilon - (\alpha + \pi)\sigma + (\mu + \gamma)\kappa - \Psi_1 = 0, \qquad (B^{s+}.7)$$
$$(D - \bar{\rho} + \varepsilon + \bar{\varepsilon})\mu - (\delta + \bar{\pi} - \bar{\alpha} + \beta)\pi - \sigma\lambda + \nu\kappa - 2\Lambda - \Psi_2 = 0, \qquad (B^{s+}.8)$$
$$(D + 3\varepsilon + \bar{\varepsilon})\nu - (\Delta + \mu + \gamma - \bar{\gamma})\pi - \mu\bar{\tau} - (\bar{\pi} + \tau)\lambda - \Psi_3 - \Phi_{21} = 0, \qquad (B^{s+}.9)$$
$$(\Delta + \mu + \bar{\mu} + 3\gamma - \bar{\gamma})\lambda - \left(\bar{\delta} + 3\alpha + \bar{\beta} + \pi - \bar{\tau}\right)\nu + \Psi_4 = 0, \qquad (B^{s+}.10)$$
$$(\delta - \bar{\alpha} - \beta - \tau)\rho - \left(\delta - 3\alpha + \bar{\beta}\right)\sigma + \tau\bar{\rho} - (\mu - \bar{\mu})\kappa + \Psi_1 - \Phi_{01} = 0, \qquad (B^{s+}.11)$$
$$(\delta - \bar{\alpha} + 2\beta)\alpha - \left(\bar{\delta} + \bar{\beta}\right)\beta - \mu\rho + \sigma\lambda - (\rho - \bar{\rho})\gamma - (\mu - \bar{\mu})\varepsilon - \Lambda + \Psi_2 - \Phi_{11}, \qquad (B^{s+}.12)$$
$$(\delta - \bar{\alpha} + 3\beta)\lambda - \left(\bar{\delta} + \pi + \alpha + \bar{\beta}\right)\mu - (\rho - \bar{\rho})\nu + \pi\bar{\mu} + \Psi_3 - \Phi_{21} = 0, \qquad (B^{s+}.13)$$
$$(\delta - \tau + \bar{\alpha} + \beta)\gamma - (\Delta - \gamma + \bar{\gamma} + \mu)\beta - \mu\tau + \sigma\nu + \varepsilon\bar{\nu} - \alpha\bar{\lambda} - \Phi_{12} = 0, \qquad (B^{s+}.14)$$
$$(\delta - \tau + 3\beta + \bar{\alpha})\nu - (\Delta + \gamma + \bar{\gamma} + \mu)\mu - \lambda\bar{\lambda} + \pi\bar{\nu} - \Phi_{22} = 0, \qquad (B^{s+}.15)$$
$$(\delta - \tau - \beta + \bar{\alpha})\tau - (\Delta + \mu - 3\gamma + \bar{\gamma})\sigma - \bar{\lambda}\rho + \kappa\bar{\nu} - \Phi_{02} = 0, \qquad (B^{s+}.16)$$
$$(\Delta + \bar{\mu} - \gamma - \bar{\gamma})\rho - \left(\bar{\delta} + \bar{\beta} - \alpha - \bar{\tau}\right)\tau + \sigma\lambda - \nu\kappa + 2\Lambda + \Psi_2 = 0, \qquad (B^{s+}.17)$$
$$(\Delta + \bar{\mu} - \bar{\gamma})\sigma - \left(\bar{\delta} + \bar{\beta} - \bar{\tau}\right)\gamma - (\rho + \varepsilon)\nu + (\tau + \beta)\lambda + \Psi_3 = 0. \qquad (B^{s+}.18)$$

The second Bianchi identities in the notation of Newman-Penrose [57] are written as:

1. The symmetric part by indices C and B

$$\partial^{P}{}_{\dot{D}}\Psi_{ABPC} - \partial_{(C}{}^{\dot{X}}\Phi_{AB)\dot{D}\dot{X}} - 3\Psi_{RP(AB}T_{C)}{}^{RP}{}_{\dot{D}} - \Psi_{ABCR}T^{R}{}_{F}{}^{F}{}_{\dot{D}} + 2T^{P}{}_{(AB}{}^{\dot{X}}\Phi_{C)P\dot{X}\dot{D}} - \\ -\bar{T}_{\dot{X}\dot{D}\dot{V}(A}\Phi_{BC)}{}^{\dot{X}\dot{V}} - \bar{T}_{\dot{X}}{}^{\dot{V}}{}_{(\dot{V}}{}_{A}\Phi_{BC)}{}^{\dot{X}}{}_{\dot{D}} = 0; \qquad (4.15)$$

2. The antisymmetric part by indices C and B

$$3\partial_{A\dot{B}}\Lambda + \partial^{P\dot{X}}\Phi_{AP\dot{B}\dot{X}} - \varepsilon^{\dot{V}\dot{W}}\left(\Phi_{AP}{}^{\dot{X}}{}_{\dot{W}}\bar{T}_{\dot{B}\dot{X}\dot{V}}{}^{P} + \Phi_{AP\dot{B}}{}^{\dot{X}}\bar{T}_{\dot{X}\dot{W}\dot{V}}{}^{P}\right) + \\ +\Phi_{PR\dot{B}}{}^{\dot{X}}T_{A}{}^{PR}{}_{\dot{X}} + \Phi_{AP\dot{B}}{}^{\dot{X}}T^{P}{}_{R}{}^{R}{}_{\dot{X}} = 0. \qquad (4.16)$$

4.2. Solving the equations of the theory of Physical Vacuum

It is readily observed for both Physical Vacuum equations (A), (B) and Einstein vacuum equations (4.1) to contain no physically significant constants, which fail to appear until after the solutions to equations (4.1) and *(A), (B)* are found [34]. While solving the equations of Physical Vacuum, there is usually used the physical constraints and symmetry properties of the object to reduce the number of independent variables. For example, the quasi-inertial geodesic motion of complex-valued light tetrad z_a^i in geometry $A_4(6)$ is described by the following equations [56]

$$z^{k}{}_{a}\nabla_{k}z_{m}^{a} = T_{bc}^{c}z_{m}^{b} = 0. \qquad (4.17)$$

This physical constraint on z_a^i requires for the components of the spinor matrix of the inertia field (4.11) in equations $(A^s.1) - (A^s.8)$ to satisfy the following equalities [56]

$$\kappa = \upsilon = \sigma = \lambda = \pi = \tau = 0\,, \quad \alpha = -\bar{\beta}, \gamma + \bar{\gamma} = 0, \rho = \bar{\rho},\ \mu = \bar{\mu}, \qquad \varepsilon + \bar{\varepsilon} = 0\ . \qquad (4.18)$$

By using appropriate tetrad transformations, the latter equality can be put down as [69]

$$\varepsilon = \bar{\varepsilon} = 0\,. \qquad (4.19)$$

According to Goldberg-Sachs theorem [70] and its generalization [71], for the spinor components of Weyl tensor (4.12) under condition $\kappa = \upsilon = \sigma = \lambda = 0$ it holds

$$\Psi_0 = \Psi_1 = \Psi_3 = \Psi_4 = 0. \qquad (4.20)$$

If solutions to Einstein vacuum equations $R_{\mathrm{jm}} = R^{i}_{\mathrm{jim}} = 0$ are sought for, it is necessary to observe the following restrictions on the spinor components of Ricci tensor (4.13), (4.14)

$$\Phi_{00} = \Phi_{22} = \Phi_{20} = \Phi_{11} = \Phi_{01} = \Phi_{12} = \Phi_{10} = \Phi_{21} = \Lambda = 0. \qquad (4.21)$$

By using constraints (4.18)-(4.21) in equations $(A^s.1) - (A^s.8)$, $(B^{s+}.1) - (B^{s+}.18)$ and in Bianchi identities (4.15), (4.16), which are considered to be the connection equations between spinors (4.11)-(4.14), E. Newman and R. Penrose managed for the first time to integrate Cartan

structure equations $(A^s.1)-(A^s.8)$, $(B^{s+}.1)-(B^{s+}.18)$ and find their solution with the translation metric similar to Schwarzschild metric [57]

$$\mathrm{ds}^2=\left(1-\frac{2\Psi^0}{r}\right)\mathrm{c}^2\mathrm{dt}^2-\left(1-\frac{2\Psi^0}{r}\right)^{-1}\mathrm{dr}-r^2(d\theta^2+\sin^2\theta d\varphi^2). \qquad (4.22)$$

Here is denoted by $\Psi^0=\mathrm{const}$ an arbitrary integration constant taking the part of the source of fields.

Omitting details and following the notation of Newman-Penrose formalism [57], we give her a static spherically symmetric solution to equations *(A), (B.1), (B.2)* in coordinates $x^0=u, x^1=r, x^2=\theta, x^3=\varphi$ [34]:

1. For the spinor components of generalized Pauli matrices

$$\sigma^i{}_{0\dot{0}}=(0,1,0,0),\ \ \sigma^i{}_{1\dot{1}}=(1,U,0,0),\quad \sigma^i{}_{0\dot{1}}=\rho(0,0,P,iP),$$
$$\sigma_i{}^{0\dot{0}}=(1,0,0,0),\quad \sigma_i{}^{1\dot{1}}=(-U,0,0,0),\ \ \sigma_i{}^{0\dot{1}}=-\frac{1}{2\rho P}(0,0,1,i), \qquad (4.23)$$

where $U=-1/2+\Psi^0/r$, $P=(2)^{-\frac{1}{2}}(1+\zeta\bar{\zeta}/4)$, $\zeta=x^2+ix^3$,

and $\Psi^0=\mathrm{const}$ is the source function.

2. For the spinor components of the inertia field $T^i{}_{jk}$:

$$\rho=-1/r,\quad \alpha=-\bar{\beta}=\alpha^0/r,\quad \gamma=\Psi^0/2r^2, \qquad (4.24)$$
$$\mu=-1/2r+\Psi^0/r^2,\quad \alpha^0=\zeta/4 \qquad .$$

3. For the spinor components of Weyl tensor (4.12)

$$C_{0011}\leftrightarrow\Psi_{0011}=\Psi_2=\Psi=-\Psi^0/r^3. \qquad (4.25)$$

In (quasi)spherical translational coordinates

$$ct=x^0-\int\frac{dr}{2U},r=x^1,\qquad \sin\theta=\frac{(\zeta\bar{\zeta})^{\frac{1}{2}}}{\left(1+\frac{1}{4\zeta\bar{\zeta}}\right)},\ \ tg\phi=\frac{x^3}{x^4}\quad ,$$

the translational space metric

$$ds^2=g_{ik}=\ \varepsilon_{AC}\ \varepsilon_{\dot{B}\dot{D}}\sigma_i{}^{A\dot{B}}\sigma_k{}^{C\dot{D}}dx^i dx^k,\quad \varepsilon_{AC}=\varepsilon^{AC}=\varepsilon_{\dot{B}\dot{D}}=\varepsilon^{\dot{B}\dot{D}}=\begin{pmatrix}0 & 1\\ -1 & 0\end{pmatrix}, \qquad (4.26)$$

takes the form (4.22) considering relations (4.23).

Moreover, the inertia field (4.24) forms the rotational metric of the solution

$$d\tau^2=-\frac{(\Psi^0)^2}{2r^4}c^2dt^2-\frac{2(\Psi^0-r)}{r}d\theta^2-\frac{2(\Psi^0-r)\sin^2\theta}{r}d\varphi^2\ . \qquad (4.27)$$

In contrast to translational metric (4.22), rotational metric (4.26) is dimensionless since rotational coordinates $\varphi_1,\varphi_2,\varphi_3,\theta_1,\theta_2,\theta_3$ are dimensionless.

Requiring for metric (4.22) to be consistent with Schwarzschild metric (2.25), we find

$$\Psi^0=\frac{\mathrm{MG}}{c^2}=\frac{r_g}{2}=-\frac{\varphi_N r}{c^2},\ \ \varphi_N=-\frac{\mathrm{MG}}{\mathrm{r}}. \qquad (4.28)$$

where $M = const$ is the mass of the central body, G is the gravitational constant, c is the speed of light, r_g is the gravitational radius?

Note that solution (4.22) -(4.27) contains relation (4.25) representing the solution of Yang-Mills equations (2.42), which are known to be absent in Einstein theory. With the constant (4.28) being determined, the solution (4.22) -(4.27) to Physical Vacuum equations describes the gravitational field and the inertia field created by mass M. Furthermore, the same solution describes the electromagnetic field of vacuum equations (4.1).

To prove this, it is sufficient to require that metric (4.22) be in line with metrics (2.8), (2.9), i.e. there be used in metric (4.22) the following relations

$$\Psi^0 = \frac{r_e}{2} = -\frac{e}{m}\frac{\varphi_C r}{c^2}, \qquad r_e = \frac{2\mathrm{Ze}^2}{\mathrm{mc}^2} = \text{const.} \tag{4.29}$$

This is how simple and natural it is to unite gravitational and electromagnetic fields with inertia fields by using the equations of Physical Vacuum.

4.3. Relation between the stability of a field particle and the singularity

As the solution $(4.23) - (4.25)$ of vacuum equations (4.1) describes gravitational and electromagnetic fields outside the source, the energy-momentum tensor of matter (2.40) in the fully geometrized Einstein equations (2.39) should satisfy the equation $T_{\mathrm{ik}} = 0$. Considering the solution to Einstein equations (2.39), with the energy-momentum tensor having the form of a singular source (point-like particle)

$$T_{ik} = \rho c^2 l_i l_k = m\delta(\vec{x})c^2 l_i l_k, \qquad l^i l_i = 0\,, \tag{4.30}$$

where $l_i$is one of the vectors of complex light tetrad z_m^a , we note that it imposes further restriction on Weyl tensor

$$\Phi \quad = \Phi_{22} = \frac{1}{2}\nu\rho c^2, \tag{4.31}$$

in addition to restriction (4.21),

and come to the following relation

$$\Psi = \Psi_2 \neq 0. \tag{4.32}$$

From the solution obtained, with detailed calculations omitted, we find a completely geometrized energy-momentum tensor of the form (4.30), where the matter density (2.41) is as follows

$$\rho = -\dot{r}_g(t)/2\nu c^2 r^2\,, \quad \dot{r}_g(t) = \partial r_g/\partial t < 0. \tag{4.33}$$

Here $r_g(t) = 2M(t)\mathrm{G}/\mathrm{c}^2$stands for the variable gravitational radius of the source of mass $M(t)$. The solution to the system of equations *(A) (B.1), (B.2)* with the energy-momentum tensor (4.30) leads to the Vaidya-type metric [69]

$$\mathrm{ds}^2 = \left(1 + \frac{2\varphi_N(t)}{c^2}\right)c^2\mathrm{dt}^2 - \left(1 + \frac{2\varphi_N(t)}{c^2}\right)^{-1}\mathrm{dr}^2 - r^2(d\theta^2 + \mathrm{tsin}^2\theta d\varphi^2). \tag{4.34}$$

While it describes the gravitational field of variable mass $M(t)$. in the theory of gravity, metric (4.34) transforms into Schwarzschild metric (2.25) in case of $M = \mathrm{const}$, with matter density (4.33) vanishing.

Passing to the limit $M(t) \to M = \text{const}$., we introduce parameter ς of linear dimension

$$\varsigma = \frac{\pi r^2}{2r_g}\left|\dot{r}_g(t)\right| \tag{4.35}$$

and use it to represent density (4.33) as

$$\rho = \frac{4\pi r_g}{\nu c^2}\frac{1}{2\pi r^2}\frac{\varsigma}{r^2} = \frac{4\pi r_g}{\nu c^2}\frac{1}{2\pi r^2}\frac{\varsigma}{(r^2+\varsigma^2)}\left(1+\frac{\varsigma^2}{r^2}\right). \tag{4.36}$$

As $M(t) \to M = \text{const}$. it holds that $\varsigma \to 0$.

By using the well-known formula

$$\frac{1}{2\pi r^2}\frac{1}{\pi}\lim_{\varsigma\to 0}\frac{\varsigma}{(r^2+\varsigma^2)} = \frac{1}{2\pi r^2}\delta(r) = \delta(\vec{r}),$$

where $\delta(\vec{r})$ is a three-dimensional Dirac function, we write (4.36) for $\nu > 0$ as follows?

$$\rho = \lim_{M(t)\to M}\frac{2\left|\dot{r}_g(t)\right|}{\nu c^2 r^2} = \frac{4\pi r_g}{\nu c^2}\lim_{\substack{\frac{1}{2\pi r^2}\\ \varsigma\to 0}}\frac{\varsigma}{(r^2+\varsigma^2)} =$$

$$= \frac{4\pi r_g}{\nu c^2}\frac{1}{2\pi r^2}\delta(r) = \frac{4\pi r_g}{\nu c^2}\delta(\vec{r}). \tag{4.37}$$

This relation includes an uncertain quantity ν. On the other hand, (4.37) coincides with the point mass density M, if

$$M = \frac{4\pi r_g}{\nu c^2}. \tag{4.38}$$

Taking into account relations $r_g = 2MG/c^2$ and (4.38), we find the value of factor ν in the following form

$$\nu = \frac{8\pi G}{c^4}. \tag{4.39}$$

This factor coincides with the factor in Einstein equations (2.19), while *the density of matter* (4.37) *represents the density of a point particle*. Thus, in the theory of Physical Vacuum a point particle appears to be *the limiting case of a stationary state of a spherically symmetric extended purely field object.*

Proceeding in a similar way and using metric (2.9) which describes variable charge $\pm Ze(t)$

$$ds^2 = \left(1-\frac{\pm|r_e(t)}{r}\right)c^2dt^2 - \left(1-\frac{\pm|r_e(t)}{r}\right)^{-1}dr^2 - r^2(d\theta^2+\sin^2\theta d\varphi^2), \tag{4.40}$$

we find in the limit $\pm Ze(t) \to \text{const}$, that factor ν in fully geometrized equations (2.39) appears to be equal to

$$\nu = \frac{8\pi k}{c^4}, \qquad k = \frac{e}{m}. \tag{4.41}$$

As is proved above, only a stable point particle is considered to be a fundamental source in the modern theory of gravitational and electromagnetic fields. It is sometimes handpicked the source density, which differs from a point-like one (not matching Dirac delta function $\delta(\vec{r})$), then there appears in the theory a 'free' parameter (or several ones) breaking its fundamental nature, as an element of constructibility.

4.4. On some geometrized energy-momentum tensors in field equations (2.39)

Soon after Schwarzschild solution (2.25), there is appeared in Einstein gravity theory the solution to the equations

$$R_{\rm ik} - \frac{g_{\rm ik}R}{2} = -\Lambda g_{\rm ik}, \Lambda = \text{const}\,, \tag{4.42}$$

obtained by a Dutch mathematician W. de Sitter [72]. The metric of the solution has the following form

$$\mathrm{ds}^2 = \left(1 - \frac{r_g}{r} - \frac{\Lambda r^2}{3}\right)c^2\mathrm{dt}^2 - \left(1 - \frac{r_g}{r} - \frac{\Lambda r^2}{3}\right)^{-1}\mathrm{dr}^2 - r^2(d\theta^2 + \sin^2\theta d\varphi^2). \tag{4.43}$$

With the energy-momentum tensor $T_{\rm ik} = -\Lambda g_{\rm ik}$ having a geometric (vacuum) nature in equations (4.42), they are considered to be a vacuum generalization of Einstein equations (4.1).

By using formula (2.16) and metric (4.43), we find a centrally symmetric potential generalizing Newton potential in the following form

$$V = -\frac{c^2}{2}\left(\frac{r_g}{r} + \frac{\Lambda r^2}{3}\right). \tag{4..44}$$

For the matter density which generates potential (4.44) to be positive, $\Lambda < 0$ should be chosen. If it holds $\Lambda = 0$, then equations (B.1) lead to Einstein vacuum equations $R_{\rm ik} = 0$, while metric (4.43) turns into Schwarzschild metric. In this case, we have $r_g = \frac{2\mathrm{MG}}{c^2}$, where M is the source mass.

Making observations of space objects in a (quasi)inertial reference frame, an observer registers their motions as being produced by test masses in the external gravitational field, corresponding to solution (4.46), under the impact of the gravitational potential of central body M (the Newton part) and that of the 'mega-quark' potential

$$V = -\frac{c^2}{2}\frac{\Lambda r^2}{3}, \Lambda < 0, \tag{4.45}$$

increasing with the distance r from the central body.

There is presented in Fig. 5 a qualitative analysis of the impact of the 'mega-quark' additive $-\Lambda c^2 r^2/6$, to Newton potential leading to the effects being named in science as 'dark matter' and 'dark energy'. For better perceiving the curves in Fig. 5, their scales are deliberately distorted since the distances in zones 1, 2 and 3 being given in real scales may differ by several orders of magnitude.

In observation zone 1 'mega-quark' potential $-\Lambda c^2 r^2/6$ appears to be negligible, as there is satisfied $\Lambda \approx 1/\mathrm{R}_0^2 \approx 10^{-56}(m)^{-2}$, where $R_0 \approx 10^{26\div 30}m$ is the radius of the Universe. Therefore,

the motion of massive formations in zone one is described by Newton potential with great accuracy.

As 'mega-quark' potential $-\Lambda c^2 r^2/6$ comes into effect in zone 2, Newton trajectories change in such a way that one can observe no significant changes in linear velocities of massive bodies with increasing distances to the central mass.

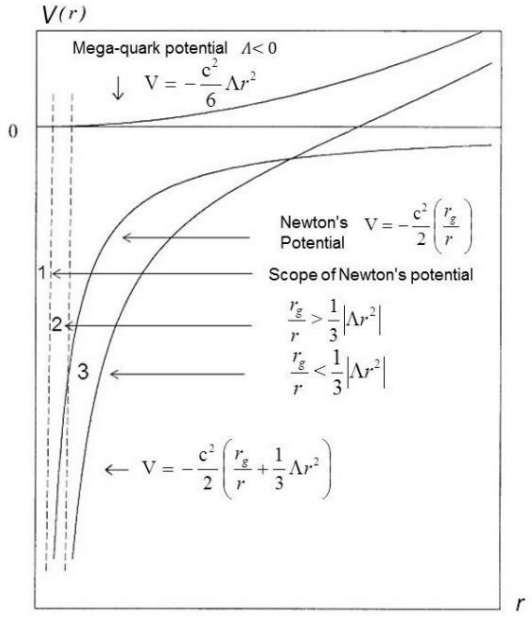


Fig.5 Plots for the gravitational potential of interaction for solution (4.43)

Finally, the impact of the 'mega-quark' potential $-\Lambda c^2 r^2/6$ becomes so significant in zone 3 that there are generated repulsive forces overcoming Newtonian attraction, and massive systems start accelerating to scatter from the center, which is confirmed by cosmological observations.

There is a particular interest for physicists in the solution of the equations of Physical Vacuum *(A), (B),* which describes the motion of variable masses and charges having their own rotation. This solution was obtained by mathematicians through the formalism of external differential forms by Debney-Kerr-Schild [73]. With the notation adopted in NP-formalism and in coordinates $x^0 = u$, $x^1 = r$, $x^2 = \theta$, $x^3 = \varphi$, this solution takes the following form:

1. For the components of generalized Pauli matrices $\sigma_i^{A\dot{B}}$

$$\sigma_i{}^{0\dot{0}} = l_i = \delta_i{}^0 - a\sin^2 x\,\delta_i{}^3, \qquad \sigma_i{}^{1\dot{1}} = n_i = \rho\bar{\rho}\left[\Upsilon\delta_i{}^0 + (\rho\bar{\rho})^{-1}\delta_i{}^1 - a\sin^2 x\,\Upsilon\delta_i{}^3\right],$$
$$\sigma_i{}^{0\dot{1}} = m_i = -\frac{\bar{\rho}}{\sqrt{2}}\left[ia\sin x\,\delta_i{}^0 - (\rho\bar{\rho})^{-1}\delta_i{}^2 - i\Omega\sin x\,\delta_i{}^3\right], \tag{4.46}$$
$$\Omega = r^2 + a^2, \qquad \Upsilon = \frac{r^2 + a^2 - \Psi^0(u)r}{2}.$$

3. For the spinor components of the inertia field $T^i{}_{jk}$:

$$\rho = -\frac{1}{r - ia\cos x}, \beta = -ctgx\frac{\bar{\rho}}{2\sqrt{2}}, \pi = ia\sin x\frac{\rho^2}{2\sqrt{2}}, \alpha = \pi - \bar{\beta}, \tag{4.47}$$

$$\mu = \Upsilon\rho^2\bar{\rho},\ \nu = -i\frac{\Psi^0}{2}ra\sin x\frac{\rho^2\bar{\rho}}{\sqrt{2}},\ \gamma = \mu + \left[r - \frac{\Psi^0}{2}\right]\frac{\rho\bar{\rho}}{2},\ \tau = -ia\sin x\frac{\rho\bar{\rho}}{\sqrt{2}}.$$

3. For the spinor components of Riemann tensor

$$\Phi_{12} = -i\frac{\ddot{\Psi}^0}{2}a\sin x\frac{\rho^2\bar{\rho}}{2\sqrt{2}},\ \Phi_{22} = -\frac{\dot{\Psi}^0}{2}ra^2\sin^2 x\frac{\rho^2\bar{\rho}^2}{2} - \frac{\dot{\Psi}^0}{2}r^2\rho^2\bar{\rho}^2,$$
$$\Psi_2 = \frac{\Psi^0}{2}\rho^3,\ \Psi_3 = -i\frac{\dot{\Psi}^0}{2}a\sin x\frac{\rho^2\bar{\rho}}{2\sqrt{2}} - i\dot{\Psi}^0 ra\sin x\frac{\rho^3\bar{\rho}}{\sqrt{2}}, \qquad (4.48)$$
$$\Psi_4 = \frac{\ddot{\Psi}^0}{2}ra^2\sin^2 x\frac{\rho^3\bar{\rho}}{2} + \frac{\dot{\Psi}^0}{2}ra^2\sin^2 x\,\rho^4\bar{\rho}.$$

where $\Psi^0(u)$ is the source function depending on the time parameter u, and $a = \text{const}$ is Kerr parameter describing the source rotation?

The metric of solution (4.46) -(4.48) is as follows:

$$ds^2 = (1 - \Psi^0(u)r\rho\bar{\rho})du^2 + 2dudr + 2\Psi^0(u)ra\sin^2 x\,\rho\bar{\rho}dudy - 2a\sin^2 x\,drdy - (\rho\bar{\rho})^{-1}dx^2 -$$
$$-(\Psi^0(u)ra^2\sin^2 x\,\rho\bar{\rho} + r^2 + a^2)\sin^2 x\,dy^2. \qquad (4.48)$$

By using metric (4.48) and substituting corresponding quantities from solution (4.46) -(4.48), we find the explicit form of the energy-momentum tensor (2.40) in field equations (2.39)

$$T_{ik} = \frac{1}{\nu}\left(\left[-\frac{\ddot{\Psi}^0}{2}ra^2\sin^2 x\,(\rho\bar{\rho})^2 - \dot{\Psi}^0 r^2(\rho\bar{\rho})^2\right]l_i l_k - \sqrt{2}\dot{\Psi}^0 a\sin \rightleftarrows x\rho\bar{\rho}\,Im(\,l_{(i}\bar{m}_{k)}\rho)\right). \qquad (4.49)$$

After the variable source function

$$\Psi^0(u) = \frac{M(u)G}{c^2} = \frac{r_g(u)}{2}, \qquad (4.50)$$

is substituted here, we obtain Vaidya-Kerr metric from (4.48) and the energy-momentum tensor which creates Vaidya-Kerr gravitational field [34].

The spin parameter $a = \text{const}$ will be denoted as

$$a = r_s = \text{const}, \qquad (4.51)$$

where r_s is the spin radius?

By assuming the source function (4.50) (mass or charge) in solution (4.46) -(4.48) to be equal to zero, we obtain a solution describing the spin field which does not transfer energy but is capable of transferring information. Such an object transferring only spin in vacuum was phenomenologically called as phyton by A.A. Akimov based on the analysis of a large number of experiments studying spin interactions of various types of matter [74]. Phytons can be considered as the primary excitations of Physical Vacuum (primary vortices) which, once emerging, cover in no time the entire Universe and represent a perfect apparatus for controlling all the processes in it.

5. Nonholonomic mechanics of Physical Vacuum (Descartes mechanics)

Mechanics has always been the basis for the entire theoretical physics, with any new fundamental theory entailing a fundamental generalization of mechanics. However, it is important to distinguish a fundamental generalization from modification. For example, while Lagrange mechanics is a modification of Newton mechanics, Euler mechanics of solids is its fundamental generalization based on new principles [75], namely, there are considered non-holonomic rotational coordinates $\varphi_1, \varphi_2, \varphi_3$ - Euler angles, in addition to translational holonomic coordinates x, y, z, which is absent in Newton mechanics. As per non-holonomic mechanics of the theory of Physical Vacuum, its special virtue comes from combining traditional classical mechanics with the field theory due to the discovery of the inertia field and the equations describing its dynamics (Fig.6). Thus, Planck-Einstein-de Broglie-Schrödinger deterministic quantum mechanics turns out under certain limitations to be a consequence of the equations of non-holonomic mechanics of Physical Vacuum and a part of field theory, rather than a constructive theory of modern physics.

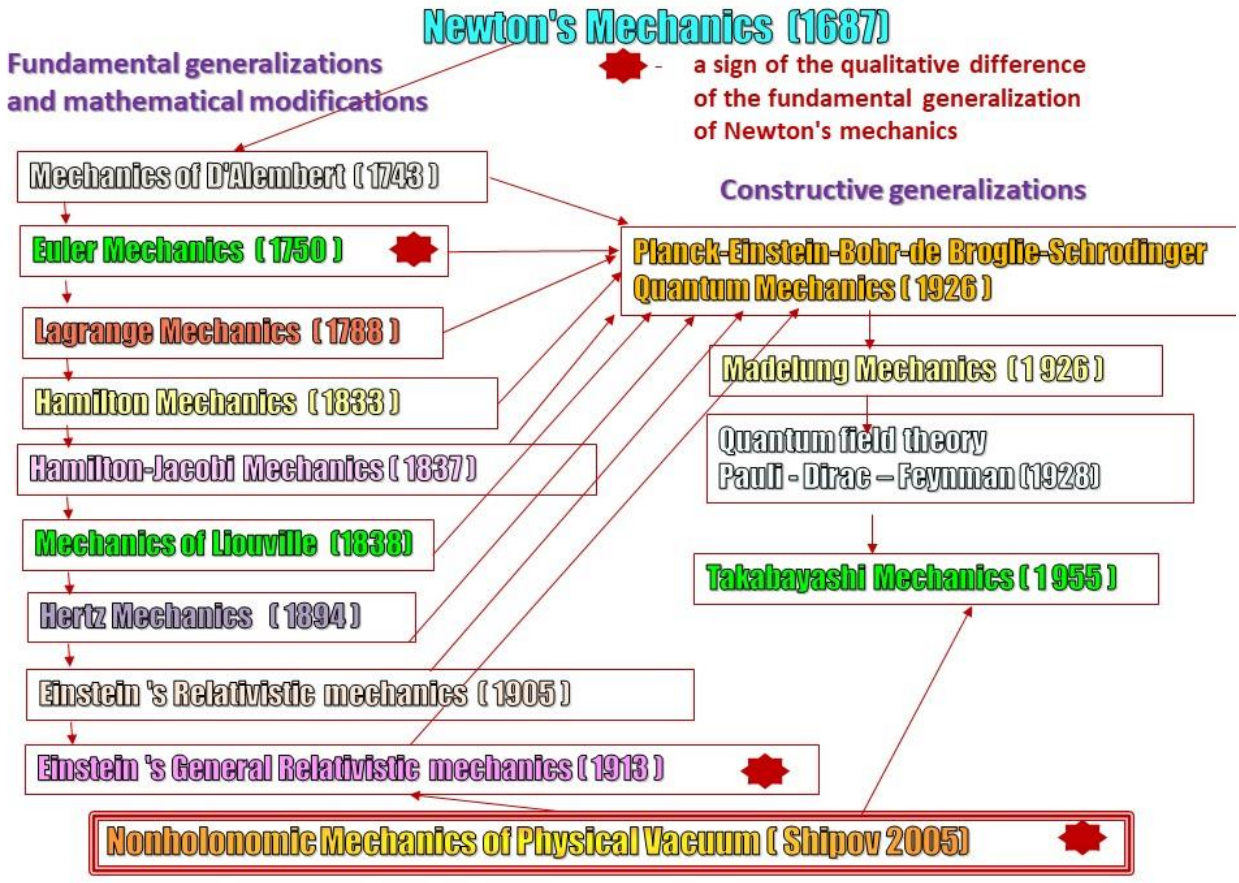


Fig.6 Generalizations and modifications of Newton mechanics

One of the basics of mechanics of Physical Vacuum is rejecting an abstract notion of the inertial reference frame. As every motion in this world is accelerated, we went on to use the accelerated quasi-inertial reference frame with a negligibly small acceleration instead of the inertial reference frame of Newton mechanics. Furthermore, in the new mechanics any accelerated motion is

considered to be a rotation, which is generated by the rotation of matter (Cartan hypothesis), as shown in formula (2.34). In non-relativistic approximation, matrix (2.34) has the following form [34]

$$\Omega_{\mathrm{ij}} = -\Omega_{\mathrm{ji}} = \frac{1}{c^2}\begin{pmatrix} 0 & -W_1 & -W_2 & -W_3 \\ W_1 & 0 & -c\omega_3 & c\omega_2 \\ W_2 & c\omega_3 & 0 & -c\omega_1 \\ W_3 & -c\omega_2 & c\omega_1 & 0 \end{pmatrix}, \tag{5.1}$$

where $\vec{\omega} = (\omega_1, \omega_2, \omega_3)$ – is an angular velocity of spatial rotation (rotation in spatial angles $\varphi_1, \varphi_2, \varphi_3$), $\vec{W} = (W_1, W_2, W_3)$ is a translational acceleration or angular velocity of spacetime rotation (rotation in spacetime angles $\theta_1, \theta_2, \theta_3$) and c is the speed of light.

Thus, the new mechanics considers rotation as the main type of motion in nature, which was yet stated by Rene Descartes. In this connection, I made a presentation entitled as "Descartes mechanics as the fourth generalization of Newton mechanics" [76] at an international conference dedicated to the centenary of the creation of the special relativity theory in the city of Liege, Belgium, 2005.

The most salient conclusion of Descartes non-holonomic mechanics is that it is possible to control fields and inertial forces the same way we have learned to control electromagnetic fields. For practical analysis of mechanical systems in Descartes mechanics, it is convenient to use field equations *(A)*, *(B)*, written in 1 + 3 splitting formalism [77-80].

In this formalism, the equations of non-holonomic mechanics take the following form

$$\nabla_{[b}u_{a]} + T^{c}{}_{[ab]}u_c = \nabla_{[b}u_{a]} - A_{[a}u_{b]} + \omega_{[ab]} = 0, \tag{A^{1+3}}$$

$$R^{d}{}_{abc} - 2A_a\left(\omega_{bc} - A_{[b}u_{c]}\right)u^d - 2\nabla_{[c}A_{|a|}u_{b]}u^d + 2\nabla_{[c}\omega_{|a|b]}u^d + +2\nabla_{[c}\sigma_{|a|b]}u^d + \\ + \frac{2}{3}\Theta_{,[c}\,h_{b]a}u^d - \frac{2\Theta}{3}\left(u_a\omega_{bc} - u_aA_{[b}u_{c]} + \omega_{a[c}u_{b]} + \sigma_{a[c}u_{b]} + \frac{\Theta}{3}h_{a[c}u_{b]}\right)u^d = 0, \tag{B^{1+3}}$$

where a, b, c ... = 0,1,2,3,

and inertia field T^{c}_{ab} is expressed through local time-like unit vector $u_b = \frac{\mathrm{dx}_b}{\mathrm{d}\tau}$, $u_b u^b = -1, d\tau^2 = h_{ab}dx^a dx^b$, h_{ab}a metric tensor of a three- dimensional surface orthogonal to vector u_b, in the following way

$$T^{c}_{\mathrm{ab}} = e^c_i \nabla_a e^i_b = e^c_0 \nabla_a e^0_b = u^c \nabla_a u_b = -A_a u_b u^c + \omega_{\mathrm{ab}}u^c + \sigma_{\mathrm{ab}}u^c + \frac{1}{3}\theta h_{\mathrm{ab}}u^c. \tag{5.2}$$

Here we use four parameters - acceleration A_a, rotation ω_{ab}, shear σ_{ab} , and expansion θ - to describe different types of accelerated motion of local reference frame e^0_b.

Equations $\left(B^{1+3}\right)$ lead us to the known in general relativity Raichauduri equation [50]

$$R_{\mathrm{ab}}u^a u_b = \omega_{\mathrm{ab}}\omega^{\mathrm{ab}} - \sigma_{\mathrm{ab}}\sigma^{\mathrm{ab}} + \frac{1}{3}\theta^2 - \frac{d\theta}{d\tau}, \tag{5.3}$$

which shows that *it is possible to control the local curvature of space* R_{ab}, if we can change independent parameters ω_{ab}, σ_{ab} and θ, i.e. *change artificially created local inertia fields*.

Using equation (5.3), an English physicist M. Alcubierre [81] proposed a *space craft* that moves in space using an engine controlling space expansion θ. Works of Russian researchers [82-84] showed the use of rotation parameter $\omega_{\rm ab}$ to be *more promising*, as there is a relation between acceleration parameter A_a and rotation parameter $\omega_{\rm ab}$ [77]

$$\nabla_a \omega^a - A_a \omega^a = 0, \omega^a = \varepsilon^{abc}\omega_{bc}/2, \qquad a,b,c \ldots = 0,1,2,3, \tag{5.4}$$

following from Ricci identity $2\nabla_{[a}\nabla_{b]}u^a = R_{ab}{}^{c}{}_{d}u^d$.

Since relation (5.4) is a new, yet unknown conservation law in mechanics, this cannot help leading to the rejection of the inventions in which it is experimentally observed. For example, it follows from conservation law (5.4) that *uneven rotations* ω^a of engine elements inside the spacecraft hull should generate acceleration A_a of its center of mass.

This conclusion repeals the part of Provision 1.6 *on scientific discoveries, scientific ideas, scientific hypotheses which claims 'the motion due to internal forces to be impossible.*'. In this case, the motion of the mechanical system mass center occurs under the impact of internal inertia forces, which are known to disobey Newton third law of mechanics [46]. It is this property of the inertia forces that takes them beyond the framework of Newton theorem of mechanics asserting that it is impossible for an isolated system to move under the impact of internal forces which must satisfy Newton third law (according to the theorem conditions).

We express matter density (2.41) and mass (2.40) through acceleration A_a, rotation $\omega_{\rm ab}$, shear $\sigma_{\rm ab}$, and expansion θ parameters in the following form

$$\rho = \frac{1}{c^2}\left(\nabla_a A^a + 2\omega^2 - 2\sigma^2 - \frac{d\theta}{d\tau} - \frac{1}{3}\theta^2\right) \ , \tag{5.5}$$

$$m = \int \rho \sqrt{-g}\mathrm{dV} = \frac{1}{vc^2}\int \left\{\nabla_a A^a + 2\omega^2 - 2\sigma^2 - \frac{d\theta}{d\tau} - \frac{1}{3}\theta^2\right\} \sqrt{-g}\mathrm{dV}, \tag{5.6}$$

where $\omega^2 = \omega_{\rm ab}\omega^{\rm ab}$, $\sigma^2 = \sigma_{\rm ab}\sigma^{\rm ab}$.

It follows from (5.6) that the mass of a mechanical system can be changed by changing locally parameters $\omega_{\rm ab}$, $\sigma_{\rm ab}$, and θ, while conservation law (5.4) is satisfied. Taking into account (5.4), we come to conclusion that using rotation parameter $\omega_{\rm ab}$ is most convenient for practical purposes.

Changing the speed of a mass center under the impact of controlled inertia forces was first demonstrated in Russia by engineer N.V. Tolchin [82], employing as a deformable body a symmetrical vibrator with an installed control element named a motor-brake. The purpose of the motor-brake was in changing the angular velocities of the rotating weights m of the symmetrical vibrator for various angular sectors https://www.youtube.com/watch?v=bsXFBbqLn_0. Having named his invention by inertoid, N.V. Tolchin developed several versions of such devices, including inertoids mounted on torsion balances [82].

We apply the method of geometric description of the system of bodies [83-86] forming a symmetric vibrator for describing analytically the symmetric vibrator (Fig. 7 on the right), being the basis

for Tolchin inertoid. There is a servomotor installed on the symmetrical vibrator, helping to control the inertia forces inside the system.

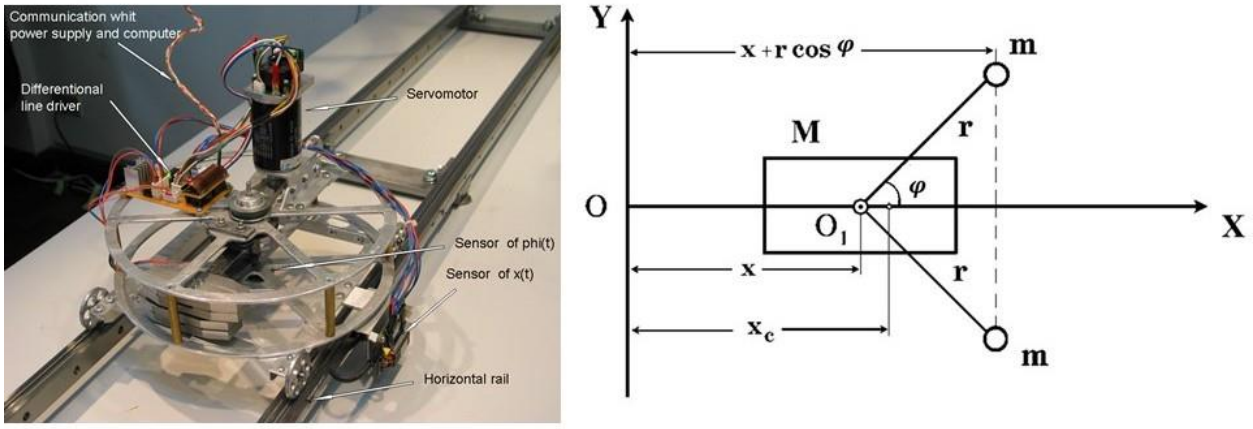


Fig.7 On the right, it is a diagram of a symmetrical vibrator; on the left, it is a 4D gyroscope model on a test bench

The symmetrical vibrator equipped with the control system of inertia forces was called a 4D gyroscope, as there occur in this device the rotations both along spatial angle φ and space-time angle θ [83-86].

The geodesic equations of the two-dimensional space, being considered as the event space of a moving 4D gyroscope, take the form of equations (2.27) leading to the system of equations

$$\frac{dv_c}{dt} = \frac{dv}{dt} - B\frac{d}{dt}(\omega \sin\varphi) = B\Phi\omega, \tag{5.7}$$

$$r\frac{d\omega}{dt} - \frac{dv}{dt}\sin\varphi = \frac{L}{2mr} - \Phi v \quad , \tag{5.8}$$

where it holds relation $B = k^2 r = 2mr/(M + 2m)$, M is the mass of the case, m is the mass of each rotating weight, $v_c -$ is the mass center velocity, v is the case velocity, ω is the angular velocity of a rotating weight, r is the rotation radius of weight m, L is the momentum created by the servomotor on the rotation axis of the weights, Φ is the inertia field due to momentum L.

A 4D gyroscope having its main control element for inertia forces, the motor-brake, replaced by a servomotor (Fig. 7) was experimentally and theoretically studied by a group of Russian scientists in Thailand in 2000. While a computer program specially designed to control the servomotor slowed down and accelerated the rotation of the weights in certain angular sectors, the 4D gyroscope did move forward only [84]. This result refutes the objections of the opponents claiming the friction forces between the wheels of the supporting cart and the underlying surface to be the cause of the movement.

As an illustration, Fig.8 shows the plots of theoretical numerical calculations of equations (5.7), (5.8) carried out in Matlab compared to classical calculations and experimental data.

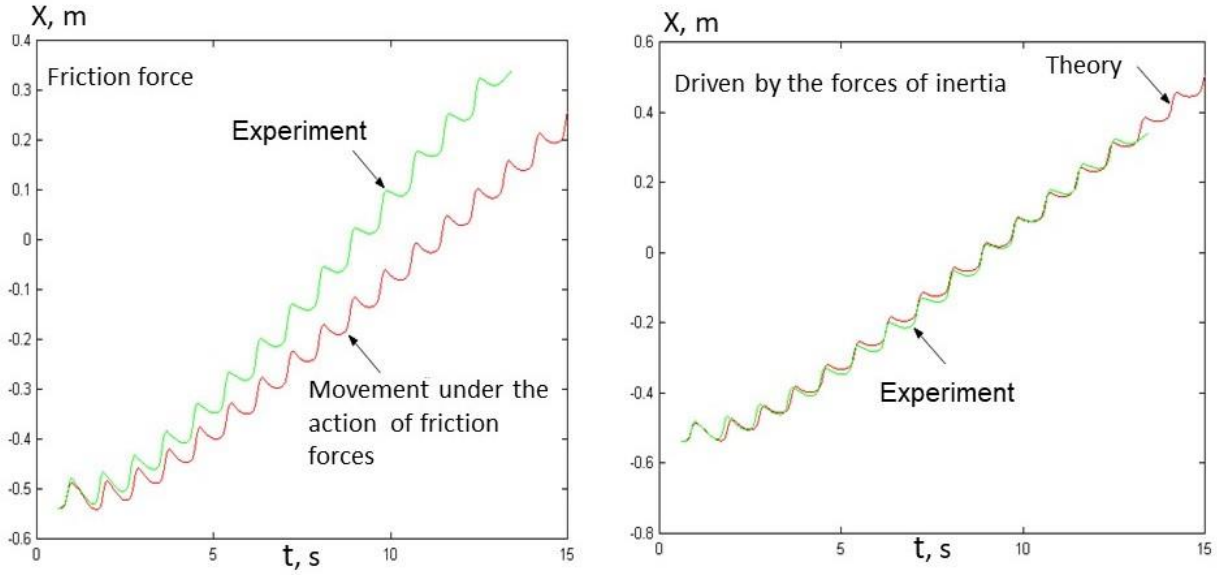


Fig.8 Comparison between the theoretical and experimental plots:
on the left, the calculations taking into account friction forces under Newton theory as compared to the experiment; on the right, the calculations under the theory of non-holonomic mechanics using Matlab as compared to the experiment.

To this end, there was built the motion theory of a 4D gyroscope due to nonlinear friction forces within the framework of Newton mechanics, and then the resulting theoretical curve is compared to the experimental one (Fig. 8 on the left). In Fig.8 on the right, there is compared the theoretical curve obtained from equations (5.7), (5.8) of Descartes non-holonomic mechanics to the experimental one. The comparison shows that the motion of a 4D gyroscope is caused by the internal inertia forces acting on its mass center rather than by friction forces.

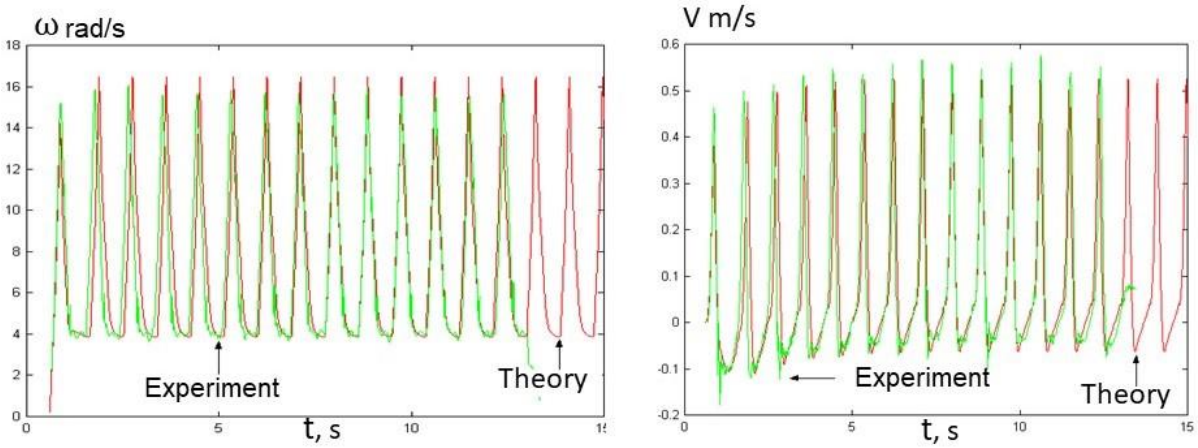


Fig.9 Comparison of the theoretical curves with the experimental data

There are compared in Fig.9 the theoretical (calculated according to the equations of Descartes mechanics) and experimental graphs: for the angular velocity ω of the rotating weights m, on the

left; for the velocity of the 4D gyroscope case$v(t) = v_c + k^2 r\omega \sin\sin\varphi(t)$, on the right. As follows from the graphs in Fig.8 and Fig.9, formulas (5.7), (5.8) describe quite accurately the motion of the mass center, the case and the angular velocity of the rotating weights of the 4D gyroscope, giving hope for the successful usage of the new motion principle in outer space.

6. Field of Consciousness, a psychophysical observer and an indirect evidence of the existence of God

The amount of repeated experimental facts is growing recently that go beyond the materialistic ideas about the surrounding world [87]. These facts continue to cast doubts to the materialistic assertion that matter is primary, while consciousness is secondary and comes as a product of a highly developed matter. Moreover, there are observed some phenomena demonstrating physical processes able to be controlled by consciousness, which challenges not only modern philosophy but also theoretical physics. As a response, there is appeared a new branch of physics called psychophysics [87]. Unfortunately, even being widely known, psychophysical experiments are completely ignored by leading theoretical physicists involved in the development of the "theory of everything" (Unified Field Theory), i.e. string theory and the Standard Model, being limited to material world.

The sole exception is an American theoretician John Hagelin, a specialist in the theory of elementary particles and a leaner of an Indian philosopher and physicist Maharish Mahesh Yogi, who tried to develop a Unified Field Theory based on the existence of the Field of Consciousness (or Superconsciousness), which carries all the laws of the universe [88]. Thus, the consciousness of a person in a meditative state is given an opportunity to "connect" to the Field of Consciousness to get knowledge on the arrangement of the World directly, bypassing ordinary physical experiments. Based on ancient Indian teachings, J. Hagelin writes out a rather complex expression for Lagrangian of the Field of Consciousness in a similar way as it is done in the Standard Model.

An interesting idea about the entire Universe being a huge Superconsciousness was also expressed by M. Pitkanen [89] in his concept of Topological Geometrodynamic (TGD-model) [90]. From the standpoint of theoretical physics, however, there still remains the question, what it is the physical carrier of the field of Consciousness. If not complete, then at least partial answer to this question can be found in the equations of the theory of Physical Vacuum.

The Theory of Physical Vacuum takes us beyond the material world as it includes, in addition to four material levels of reality (Fig.10) studied by modern materialistic physics, three more levels related to the World of Higher Reality.

The first level of reality is described by an identity of the form $0 \equiv 0$. From the viewpoint of modern science (within the framework of the binary 'yes'/ 'no' logic) this identity seems to be meaningless, failing to state anything concrete about Absolute 'Nothing'. Nevertheless, it is this level of reality that generates level II of primary Inertia Fields and level III of Physical Vacuum. Thus, the level of Absolute 'Nothing' having *maximum stability* is synonymous to God.

Indeed, the level of Physical Vacuum is described by system of equations *(A), (B),* which turn into the equations of the primary Inertia Fields provided Riemann curvature R_{ijkm} vanishes. Such an object is described by solution (4.46) -(4.48) provided the source function Ψ^0 equals to zero, and

$r_s \neq 0$, while the object energy equals to zero, and information is transferred by spin and differs from zero.

Level II is represented by some primary matrix determining the emergence of the primary Inertia Field, which differs in its properties from an ordinary matter in that it does not curve space, i.e. does not participate in force interactions.

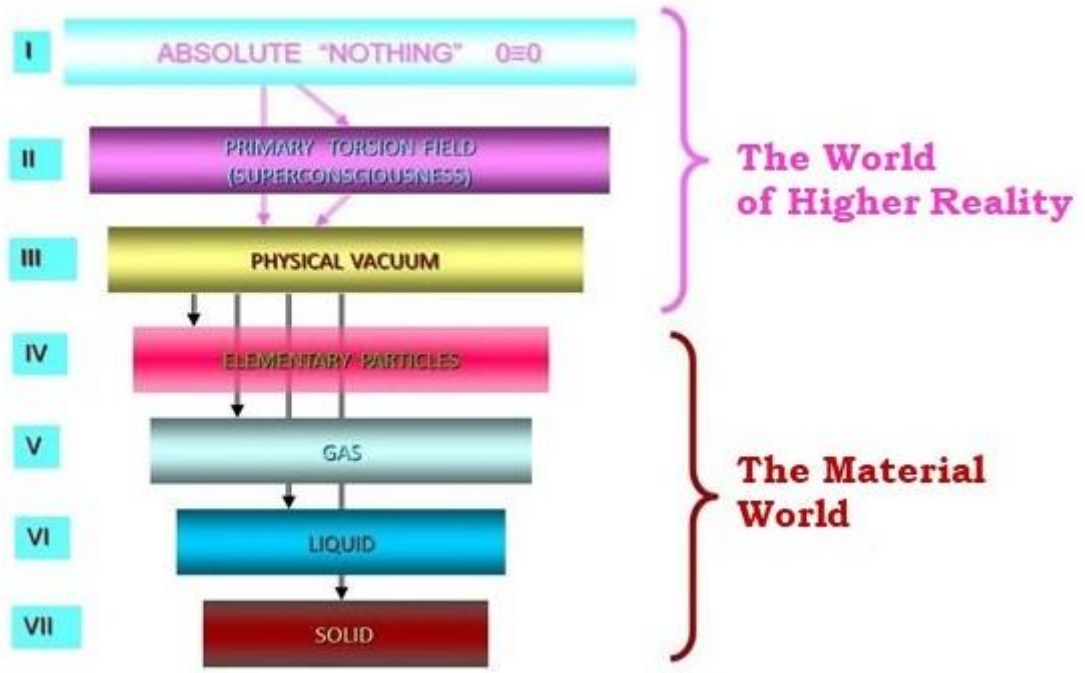


Fig.10 Levels of reality in the theory of Physical Vacuum

The equations of levels II and III satisfying generally any set of required variables are identities in nature. After having Levels II and III emerged from Absolute 'Nothing', there is a 'subtle matter' born at level II, manifesting as the primary Inertia Fields.

The analysis of the equations of the primary Inertia Fields shows that t*he energy-momentum tensor of these fields equals to zero,* although the fields themselves differ from zero. Hence, representing fields with a zero energy-momentum tensor, primary Inertia Fields do not curve space, nor have any energy, while carrying information about the rotational properties of matter. So, there can be generally changed the magnitude and direction of rotation of the proper angular momentum of a material object with the 'rotational' information, while having its energy unchanged.

The solutions to the equations of primary Inertia Fields show that there are objects in nature having neither mass nor charge but featuring spin only. By their lacking the potential energy of interaction, the penetrating power of these objects turns out to be significant. In modern physics, it is experimentally established a high penetrating power of neutrino, an elementary particle having only spin likewise (theoretically) the primary Inertia Field.

With the primary Inertia Field having zero energy and momentum from the very beginning, there is generally no sense in speaking about its propagation speed. As soon as it appears, such a field *covers* the entire space all at once, as if it were there all the time and everywhere. This exceptional property can be defined as *hypercausality*, since it enables the primary Inertia Field to be an excellent tool for controlling the processes occurring in the Universe.

Level II can be defined as the field of Superconsciousness or as a database of the all events that have happened, are happening and will happen in the future, containing all the laws of the universe, known already and yet to be known to the mankind.

Level III is analytically described by the complete system of equations of the Physical Vacuum, with its solutions describing both objects with zero energy (zero mass, as the primary Inertia Field) and objects with positive, negative, and imaginary masses. Objects with a negative rest mass are known to move backwards in time [91-93], while the classical principle of causality is violated for them, as the effect precedes the cause in this case (*supercausality*). A particle called tachyon is known to always move at superluminal speed and features an imaginary mass [92]. As the existence of tachyons leads, according to Terletsky theorem [92], to the existence of negative masses, then supercausality should combine the superluminal speed of motion with the motion backwards in time.

Supercausality was first predicted theoretically in the work by A. Einstein, B. Podolsky and N. Rosen [94] almost a hundred years ago, which brought up an issue now known in science as the EPR paradox of quantum mechanics. It claims for two quantum particles, say, two photons, emitted by the same source, after flying apart over a sufficiently large distance to remain seemingly interconnected by a 'spooky action at a distance' [94], while the information connecting them transmits at superluminal speeds. Being the intermedium of superluminal transmission, the wave function ψ carries information about the spin of the photon, i.e. its polarization, with field ψ behaving here like a real physical field, as we know now, the Inertia Field.

It would have come as a surprise for Einstein to know for his conjecture of superluminal interactions due to the entanglement of wave functions to be experimentally confirmed at the beginning of the 21st century [95-99]. The recognition of superluminal information transfer conjectured in the EPR paradox is secured by the nomination of three experimenters Alain Aspect (France), John Clauser (USA) and Anton Zeilinger (Austria) for the Nobel Prize in Physics in 2022 "for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science".

So, the theory of Physical Vacuum studies both the Material World and the Worlds of Higher Reality (Fig. 10), with all these worlds being associated with any object, including a person. Possessing a physical body with five sense organs, a person studies the Material World, while the Worlds of Higher Reality are connected with a person, forming an aura around their physical body. The aura is most likely to be a multi-level psycho-physical body of a person, capable of cognizing the Worlds of Higher Reality through 'psycho-physical' organs such as spirit, soul, mental and astral bodies, etc. While in the Material World a physical observer can study objects moving with the speed of light or less, a psychophysical observer in the Worlds of Higher reality is capable of studying instantaneous and superluminal events subject to hypercausality and supercausality (Fig. 11).

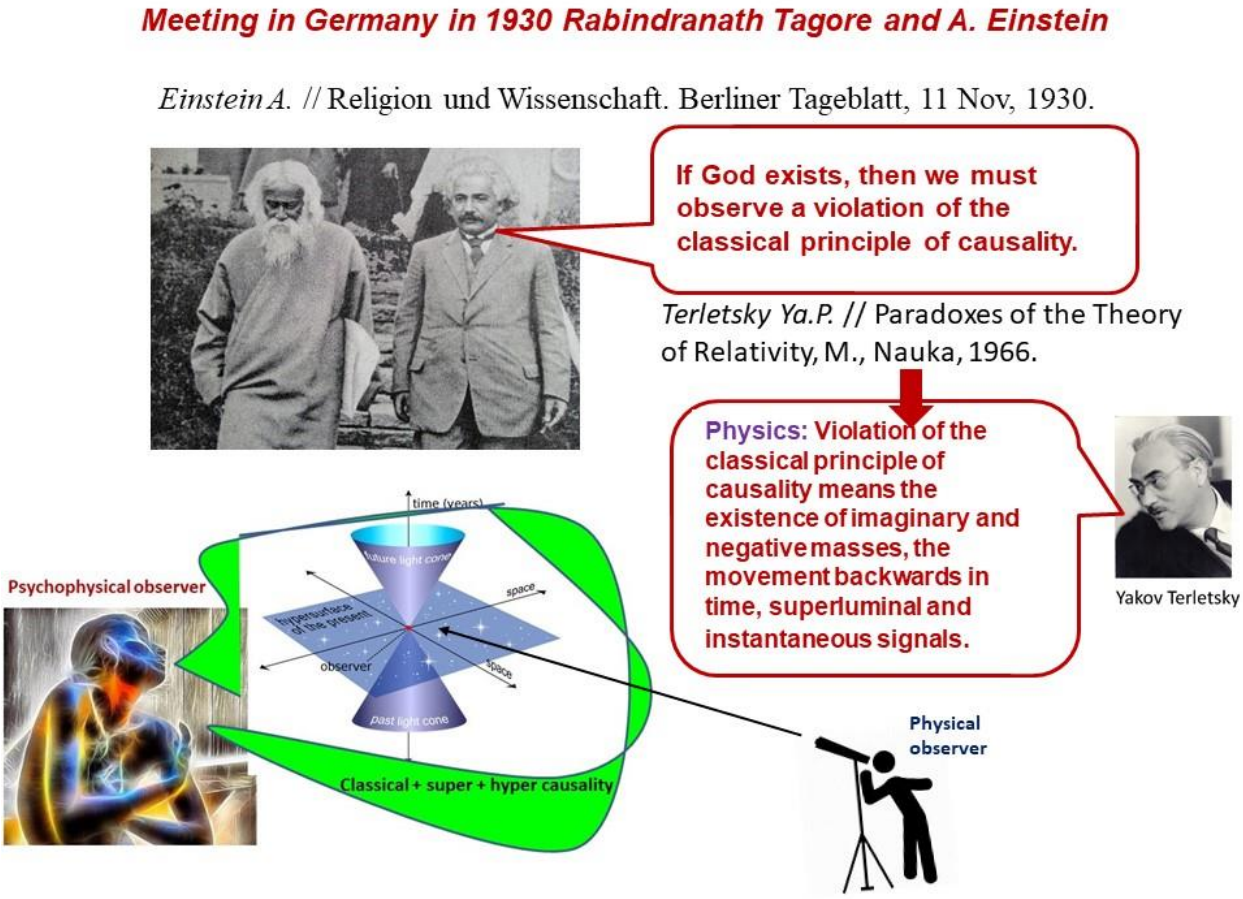


Fig. 11 The psychophysical observer is capable of cognizing the Reality in a broader way than the physical one

There was a meeting in 1930, in Germany between Rabindranath Tagore and Albert Einstein, at which it was discussed by the two great minds the basic question of science - what comes first, matter or consciousness. Being a materialistic scientist, A. Einstein argued in favor of matter, with R. Tagore stating the primacy of consciousness. Following the meeting, A. Einstein published an article Religion and Science reading that "if God exists, then we must observe a violation of the classical causality principle [100]". In fact, to this end it is sufficient to observe superluminal signals. Since there was awarded the Nobel Prize in Physics in 2022 for such observations, this fact can be considered as *the first indirect scientific proof of the existence of God*.

The existence of a physical observer capable of studying instantaneous and superluminal events, which lead to indirect proof of the existence of God, is the most important consequence of the theory of Physical Vacuum leading to a major transformation of human consciousness.

Conclusion

It was at 16 as a cadet of the Baku Naval School that I encountered the works of A. Einstein on the special theory of relativity while reading the book by V.I. Lenin *Materialism and Empirio-Criticism, Critical Notes on a Reactionary Philosophy* which treated the dependence of a body mass on its speed of movement. Back then, I decided to understand this phenomenon by studying physics at a prestigious university as it turned out to be later at the Physics Department of Moscow State University. During final years of my university studies, my supervisor was, first,

Academician of Russian Academy of Sciences Rem Viktorovich Khokhlov, Rector of Moscow State University in 1973-1977, and then, Academician of Russian Academy of Sciences Leonid Veniaminovich Keldysh, Director of Lebedev Physical Institute in 1989-1994. Thanks to the scientific guidance of these outstanding scientists, I got the opportunity to work in science, being focused on a high scientific result rather than on titles and positions. After my graduation from the university, L.V. Keldysh suggested that I join him as a postgraduate student but by that time I had already been fully focused on the development of A. Einstein's ideas aimed at building the Unified Field Theory. At one of the meetings, I confessed it to L.V. Keldysh, who remarked looking thoughtfully at me: "*A discovery can be made here, but I doubt if anybody will listen to you*". Being naive, I perceived it as a joke, but as events showed later, the very title of the scientific research direction I had chosen - Unified Field Theory - sounds to some colleagues either as a personal insult or as a claim to their place on a career ladder.

The less the creator's subjective factor there is in a creative scientific work the more valuable it is. That is why I suggest looking at my work from an outside observer's point of view but with the author's eyes as, I hope, so far nobody can see its goals and results deeper than the author himself. Top physical theories - the String Theory and the Standard Model - are criticized on the grounds of their temporary nature, as the first is a constructive theory, and the second is a constructive-phenomenological one. Replacing them with a fundamental theory is the main task of theoretical physics.

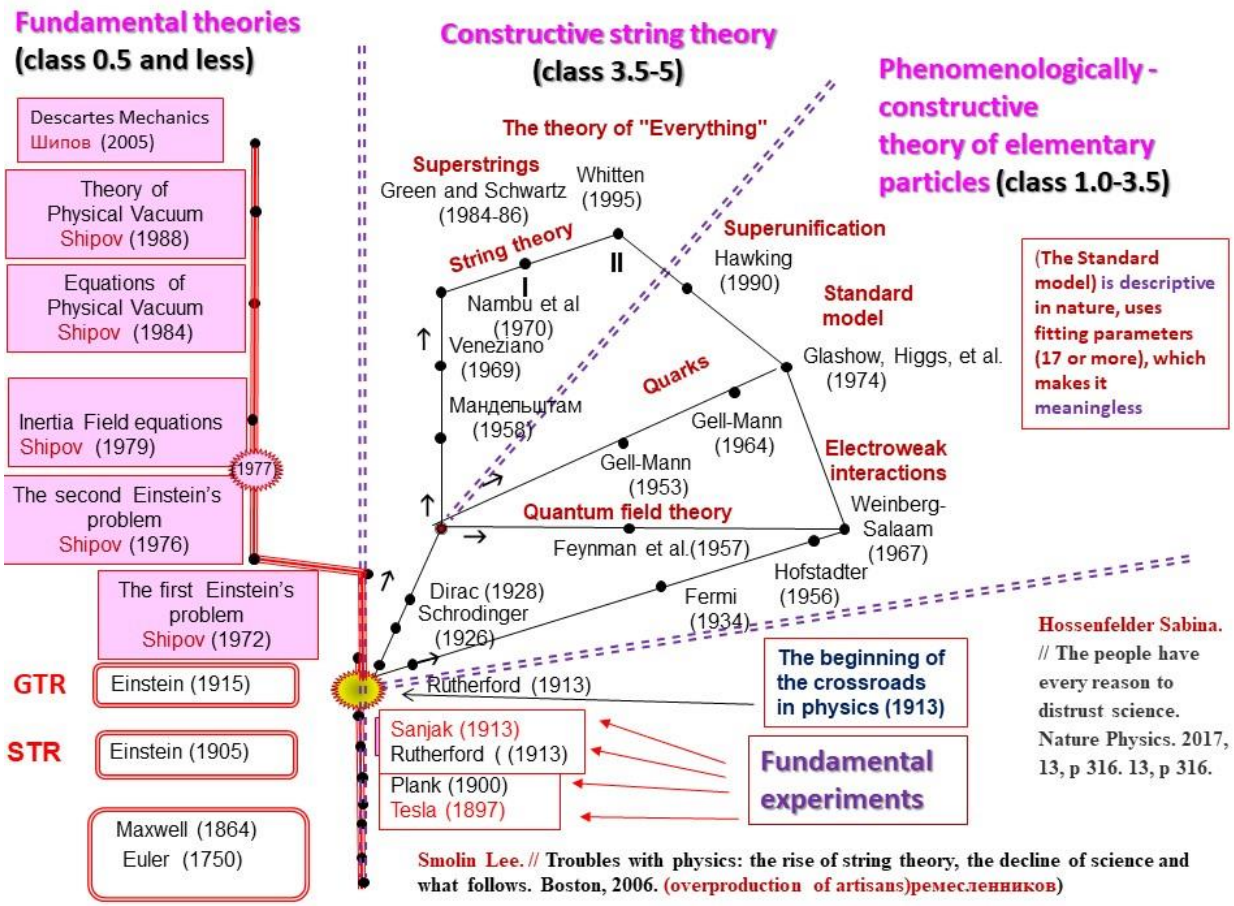


Fig.12 Comparison of three types of Unified Field Theory

Fig.12 represents the state of contemporary theoretical physics taking into account the theory of Physical Vacuum. On the left there is the development path of fundamental theories passed by the author from 1967 to 2005. Certainly, this state is not recognized by the world scientific community since the major intellectual resource is concentrated on string theory and the Standard Model. While most theoreticians are focusing their attention on developing constructive or constructive-phenomenological theories, there are limited communication opportunities with the world scientific community available to me, and few influential theoreticians are aware of my work. Perhaps, it is appropriate to mention here the admission of a Nobel Prize winner Roger Penrose that "we all missed something, something very important [57]."

On the other hand, the remarkable logarithmic curve by L. Landau shown in fig. 13 allows every theoretical physicist to look at a "mirror image" of his work and himself, evaluating his contribution to the theoretical physics development more or less objectively.

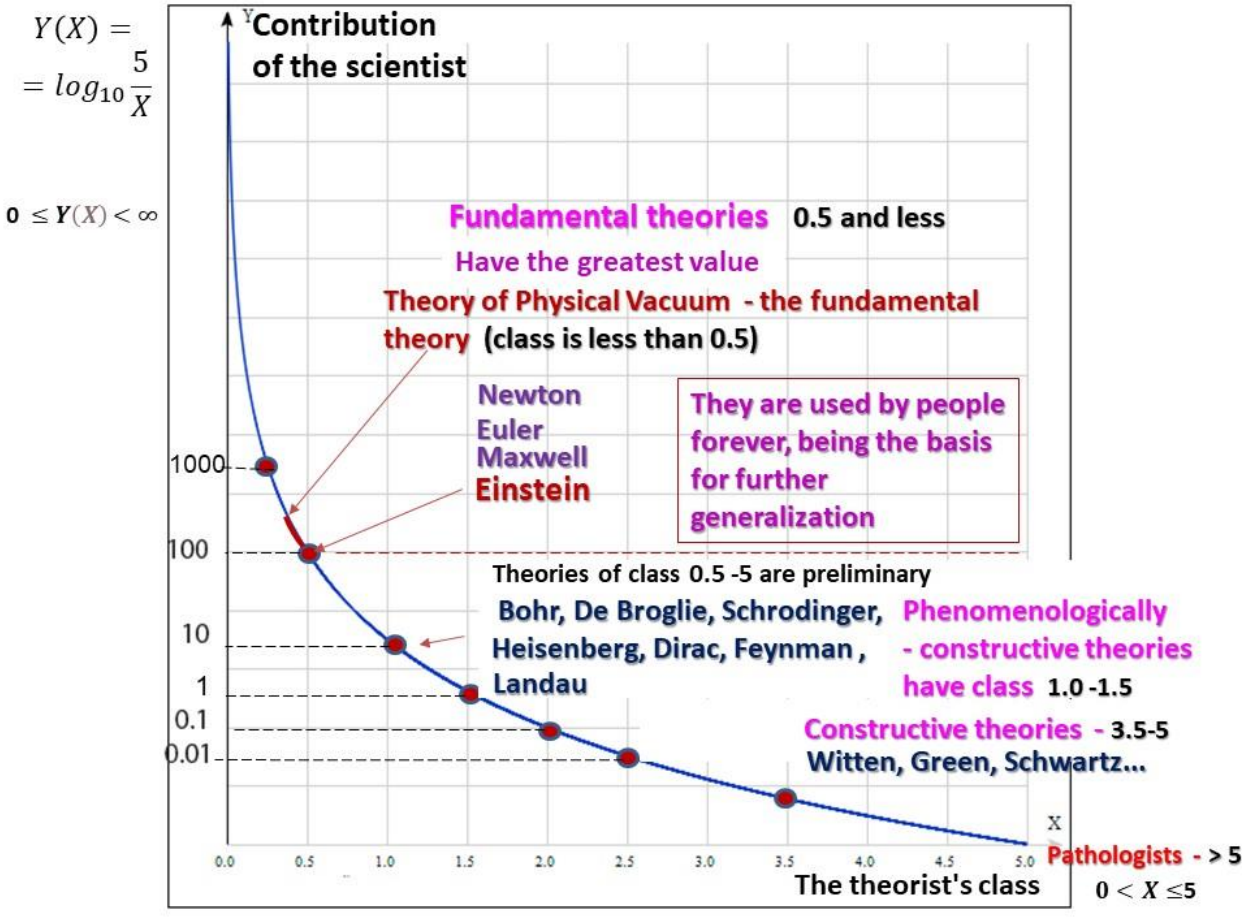


Fig.13 Theory of Physical Vacuum on Landau Curve

In Fig. 13, the class equaled or less than that of Einstein level 0.5 is given to fundamental works. The scientists of class 3.5 - 5 on Landau scale work out constructive theories, such as string theory, with class 5 being at the border to pathologists (see Fig.1). The theoreticians of class 1.0-3.5 are engaged with The Standard Model.

It should be mentioned that these theoreticians comprise the most Nobel Prize winners, while the only laureate of the class Einstein level 0.5 is Albert Einstein himself who was granted the prize

not for substantiating STR or relativistic gravity theory (GR) but for the photoelectric effect - a relatively simple but very important phenomenon for applied usage. Assessing his work by granting the Nobel Prize was perceived by A. Einstein himself with irony, as he evaluated his own contribution to developing theoretical physics by criteria close to Landau curve.

I believe it was the scientific heritage of A. Einstein that helped me find a way out of the crisis situation the modern theoretical physics finds itself. The fundamental nature of the theory of Physical Vacuum is confirmed by the main strategic results [101,102] arising from its equations, namely:

1. The first problem of Einstein - geometrizing the equations of electrodynamics was solved;
2. It was solved the second problem of Einstein - geometrizing the energy-momentum tensor of matter in the Einstein equations;
3. It was discovered the third fundamental physical field - the field of inertia associated with the wave function ψ of quantum theory and the Yang-Mills gauge field;
4. It was solved the problem of the Unified Field Theory combining not only three fundamental fields - electromagnetic, gravitational and inertia - but also classical field theory with quantum theory;
5. There were found on the basis of the solutions to the equations of the Physical Vacuum theory short-range and long-range potentials allowing one to fundamentally describe the interactions of elementary particles (gravitational, electromagnetic, nuclear, weak (spin), quark);
6. The equations were found making it possible to analytically investigate psychophysical phenomena such as telekinesis, biogravity, levitation (of diamagnetics), etc. which both string theory and the Standard Model fail to explain or give any reasonable approaches for doing so;
7. The Physical Vacuum Equations can describe not only light and sublight objects (moving at the speed of light or less), but also superluminal and instantaneous signals allowing one to investigate supercausal and hypercausal processes, which represent, as shown earlier, an indirect proof of the existence of God.

The author expresses his gratitude to all his close people having selflessly helped him for many years to work on the development of the Einstein approach to the Unified Field Theory, and above all, to his wife Shipova (Krasnova) Tamara Borisovna who has courageously endured all the problems of her everyday life with the person being selflessly devoted to science.

I thank my learners and followers Andrey Nikolaevich Sidorov, Evgeny Alekseevich Gubarev, Maria Ivanovna Trukhanova for developing some tactical results of the theory of Physical Vacuum.

I express my gratitude to Marina Alexandrovna Lobova for supporting financially my theoretical and experimental work on the development of a fundamentally new principle of movement in outer space (2000) and for organizing the research on Nikola Tesla generators in Thailand (2005, 2013).

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I cannot help but express my special gratitude to a MEPhI graduate, thoughtful physicist, and deep philosopher Vadim Yuryevich Tatur for his continuing support of the publication of my works, and particularly for his 1993 financial support of the publication of my monograph Theory of Physical Vacuum [100]. It was a solid pillar for my further research in psychophysics and nonholonomic mechanics. My thanks also go to Mikhail Vasilyevich Klyukin for his financial support of the publication of this book.

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