True laws cannot be linear
and cannot be received
from linear laws.

A.Einstein

Development of the basic ideas in the theory of physical vacuum

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The beginnings of theoretical studies that form the subject of my book "A Theory of Physical Vacuum. A New Paradigm" [1] date back to 1967, when I, a graduate student at Moscow University, was doing my graduation research under L. V. Keldysh (now director of the Physics Institute of the Russian Academy of Sciences). Using Feynman diagram techniques to describe the interaction of strong electromagnetic radiation with matter, I ran into the problem of divergences in quantum electrodynamics, which Dirac [2] and Feynman [3] and some other theoreticians ranked among the main problems of modern field theory.

When in my third year at the university I began attending seminars on theoretical physics conducted by the major theoretician D. D. Ivanenko. It was at that time that I first got acquainted with the program of unified field theory proposed at the turn of the century by Albert Einstein [4]. As one of the first tasks on the way to its realization the great scientist considered the problem of geometrization of electrodynamics equations [5]. Intuitively at first, without any logical grounds, I sensed that the issue of divergences in quantum electrodynamics should be connected with Einstein's views on the geometrization of the equations of electrodynamics.

In order to be able to deal with Einstein's program of unified field theory in a more professional manner I joined in 1969 the post-graduate course at Peoples Friendship University after P. Lumumba and in 1972 wrote a thesis called "General-Relativistic Electrodynamics with a Tensor Potential [6]".

That was a geometrized version of electrodynamics, one that used for reference frames not only the inertial Lorentz reference frames, but also accelerated locally Lorentz-like frames, like those of elevators in free fall in Einstein's theory of gravitation. Now they also involved charges, however! The general-relativistic electrodynamics was a fundamental deviation from the principles of the Maxwell-Lorentz electrodynamics. It admitted coordinate transformations that corresponded to a transition from an inertial reference frame to an accelerated locally Lorentz frame, with electromagnetic fields, like

Christoffel symbols in Einstein's theory, following a nontensor law of transformation. The field equations in geometrized electrodynamics looked like Einstein's equations [6]

$$R_{ik} - \frac{1}{2} g_{ik} R = \frac{8\pi e}{mc^4} T_{ik} \tag{1}$$

with a new constant in front of the energy-momentum tensor of matter, T_{ik}. Strong electromagnetic fields satisfying the field equations (1) distort the space of events in geometrized electrodynamics. The potential of the electromagnetic field becomes a symmetrical second-rank tensor a_{ik} [6] that, together with the metric tensor of a flat space η_{ij}, forms the metric tensor of general relativistic electrodynamics $g_{ij} = \eta_{ij} + k\, a_{ij}$, where $k = e/m$ is the specific charge of a probe particle. Thus, instead of the Riemann geometry *I used parametrical Riemann geometry*.

When I had grasped the main principles and equations of general-relativistic electrodynamics, I noticed that it possessed an array of unusual properties. First, equations (1) became Maxwell's equations of electrodynamics in a weak-field approximation to not-very-high velocities. Second, it admitted acceleration radiationless motion of charges in a field of central forces (a general-relativistic analog of the Bohr principle [7]), i.e., its equations contained as a corollary one of its fundamental quantum principles. Third, solutions of the vacuum equations ($R_{ik} = 0$) of general-relativistic electrodynamics enabled one to obtain not only the Coulomb potential but also novel static potentials that were a short-range generalization of the latter. Fourth, the energy of the electrostatic field of a charge in geometrized electrodynamics appeared to be a finite quantity.

These intriguing properties of the geometrized equations of the electromagnetic field suggested to me that I was on the right track, although I understood that the issue of the unified field theory was far from its completion. The fact of the matter was that the energy-momentum tensor on the right-hand side of equations (1) had a phenomenological nature and, like the energy-momentum tensor for matter in Einstein's equations, was introduced into the equation sort of "manually". Einstein believed that this state of things was temporary and spared no effort to arrive at field equations with a geometrized right-hand side. The geometrization of fields that determine the energy-momentum tensor of matter was part of Einstein's program of unified field theory [8]. Einstein also believed that the geometrization of matter fields would enable us to find equations of "perfect quantum theory [9]".

In addition to that idea of fairly general nature proposed by Einstein, geometrized electrodynamics faced some questions that had to be answered for the theory to evolve further. Among these are:

– how to describe the radiation of a charge (e.g., in transition from one stationary orbit of an atomic electron to another)?

– in what way is general relativistic electrodynamics connected with modern quantum electrodynamics (e.g., with the Dirac equation)?

– in what way are Einstein's equations of gravitation related to the equations of electrodynamics (1); in other words, are there unified equations that would yield Einstein's equations and equations (1) as special cases?

But since the theory I developed was at the time accepted by the scientific community without much enthusiasm, it was only natural that providing answers to the above questions was my own business. I understand that these answers transcend the limits of Riemannian geometry, on which Einstein's theory of gravitation and general-relativistic electrodynamics described by (1) is based.

Having studied classical geometries from the works of Schouten, I came to the conclusion that the best answer to the problems at hand is the Riemann-Cartan geometry, which features not only the Riemannian curvature but torsion as well. In the 1970s this geometry was used by many theoretical physicists in general relativity.

At the time I reasoned as follows. The equations of the geodesics of the Riemann-Cartan space, upon multiplication by the probe mass, contain an additional (as compared with the geodesics of the Riemann space) force caused by torsion. When the force is zero, we obtain conventional equations of motion from Einstein's theory of gravitation or the equations of motion from general-relativistic electrodynamics [6].

In this case the reference frame associated with mass or charge is an accelerated, locally Lorentzian frame with a mass or a charge moving with an acceleration, although without radiation. Radiation only occurs when the accelerated frame associated with the charge or the mass ceases to be locally Lorentzian due to the additional force due to torsion in the equations of motion!

Support for the fact that the accelerated reference frame that moves according to the equations of the geodesics of the Riemann-Cartan space is not locally Lorentzian comes from the tensor law of torsion transformations relative to arbitrary coordinate transformations. Therefore, for local (or normal) coordinates the Christoffel symbols, which describe strong gravitational or electromagnetic fields, vanished locally, unlike the torsion tensor.

It appeared then that only those masses and charges can radiate that are tied with accelerated locally noninertial reference frames moving in a torsion field, so that the force engendered by the torsion was interpreted as a radiation reaction force.

Another property of the Riemann-Cartan geometry of importance for my studies was a possibility to represent the tensor of the total curvature of that space as a sum of the Riemannian curvature tensor and a certain combination of quadratic complexes of the torsion tensor and covariant derivatives of the torsion tensor. This made it possible (under certain conditions) to regard the torsion of space as a source of Riemannian curvature.

Although endowed with such interesting properties, the Riemann-Cartan geometry was unsuitable for solving the above problems for the following reasons:

– unlike the Christoffel symbols, the torsion tensor has no potential, i.e., it cannot be represented in terms of derivatives of some geometric quantities;

– torsion defines the Riemannian curvature only if we also assume that the complete curvature tensor of the Riemann-Cartan geometry is zero.

The last requirement means that a geometry needed to construct the theory should feature *absolute parallelism* (by definition, a space is said to have absolute parallelism if its curvature tensor vanishes).

I have studied Einstein's works (13 all in all) in which he used the geometry of absolute parallelism (A_4 geometry) in his search for the equations of unified field theory. They failed, however, to solve the problems he himself had posed, a fact pointed out by him many times.

One remarkable feature of the geometry of absolute parallelism is the fact that its torsion $\Omega_{jk}{}^{i} = -\Omega_{kj}{}^{i}$ has a "potential", which appears to be the tetrad $e^{a}{}_{k}$

$$\Omega_{jk}^{\cdot\cdot i} = e^{i}{}_{a}e^{a}{}_{[k,j]} = \frac{1}{2}e^{i}{}_{a}(e^{a}{}_{k,j} - e^{a}{}_{j,k}). \tag{2}$$

Relying on the properties of the A_4 geometry suitable for my studies, I published in 1976 a work [10] that showed that the right-hand sides of Einstein's equations and the equations of general-relativistic electrodynamics can be geometrized successfully, if for event space we use not a Riemannian geometry but the geometry of absolute parallelism. The new field equations were written as

$$R_{jm} - \frac{1}{2}g_{jm}R = \nu T_{jm}, \tag{3}$$

where the energy-momentum tensor

$$\begin{aligned} T_{jm} = -\frac{2}{\nu}\{(\nabla_{[i}T^{i}{}_{|j|m]} + T^{i}{}_{s[i}T^{s}{}_{|j|m]}) - \\ -\frac{1}{2}g_{jm}g^{pn}(\nabla_{[i}T^{i}{}_{|p|n]} + T^{i}{}_{s[i}T^{s}{}_{|p|n]})\}, \\ T_{[jm]} = 0 \end{aligned} \tag{4}$$

is geometric in nature and is defined using the "matter field"

$$T^{i}{}_{jk} = -\Omega_{jk}^{\cdot\cdot i} + g^{im}(g_{js}\Omega_{mk}^{\cdot\cdot s} + g_{ks}\Omega_{mj}^{\cdot\cdot s}) \tag{5}$$

through the torsion (2) of A_4 geometry.

It is easily seen that formally the equations (3) are similar to Einstein's equations if we assume that $\nu = \nu_g = 8\pi G/c^4$, or to the equations of general-relativistic electrodynamics (1), if we assume that $\nu = \nu_e = 8\pi e/mc^4$. On the other hand, the factor ν in the equations (3) is cancelled out if we substitute the relationship (4) into the equations (3); therefore, the field equations (3) initially contain no physical constants. Such was the price one has to pay for the geometrization of the energy-momentum tensor and its constituent fields.

For the case of Einstein's vacuum equations $R_{jm} = 0$ the left-hand side of (3) appears to be the same both in Einstein's gravitation theory and in a theory constructed using the A_4 geometry. The left-hand side of (3) is then given by the equations

$$\nabla_{[i}T^{i}{}_{|j|m]} + T^{i}{}_{s[i}T^{s}{}_{|j|m]} = 0,$$

which also satisfy the torsion field (2). Such equations are available neither in Einstein's theory nor in general-relativistic electrodynamics.

These remarkable properties of equations (3) suggested to me that I achieved a fundamental generalization of Einstein's equations and the equations of geometrized electrodynamics (1).

To tell Einstein's equations from those of general-relativistic electrodynamics (1) my friends advised be to refer to the equations (3) with the geometrized energy-momentum tensor (4) as the Shipov-Einstein equations.

As is always the case in science, solving some issue of principle generates other problems, now at another, much higher level, namely: what technique is to be used to solve the field equations (3); what physical field is associated with the matter field $T^i{}_{jk}$ (torsion field); what physical principle is expanding Einstein's general relativity principle should be introduced to yield some physical substantiation to (3), and so forth.

When handling the first of these questions I developed three methods of solving the Shipov-Einstein equations. Primarily, this was the method of the Newman-Penrose spin coefficients [11]; then comes the Debney-Kerr-Schild method of external differential forms [12], and the Vaidy method [13]. In contrast to the solution of Einstein's equations, any solution of the Shipov-Einstein equations (3) enables us to find not only the Riemannian metric, but also the explicit form of the energy-momentum tensor (4) that produces this metric.

Further, using the point solution of the Shipov-Einstein equations with a Schwarzschild-type Riemannian metric and substituting the solutions $\Gamma^i{}_{jk}$ and $T^i{}_{jk}$ into the equations of the geodesics of an A_4 space

$$\frac{d^2x^i}{ds^2} + \Gamma^i{}_{jk}\frac{dx^j}{ds}\frac{dx^k}{ds} + T^i{}_{jk}\frac{dx^j}{ds}\frac{dx^k}{ds} = 0, \tag{6}$$

which describe the motion of the probe mass m in this metric, we can look for similarity of (6) and well-known equations of physics.

These studies revealed [14] that the fields $T^i{}_{jk}$ which form the tensor of matter in fully geometrized Shipov-Einstein equations appear to be inertia fields that generate inertia forces in accelerated reference frames. It was also found that the equations (6) describe the motion of accelerated locally noninertial reference frames that become locally inertial only provided that the inertia force $F^i_1 = -mT^i{}_{jk}dx^j/dsdx^k/ds$ vanishes. It was also revealed that although in inertial (and locally inertial) reference frames the inertia forces are zero, the inertial field is different from zero (owing to the symmetry properties of the inertial field $T^i{}_{jk}$ that are determined by the relationship (5)).

This result attracted attention to the problems of fields and forces of inertia in theoretical physics, from classical mechanics to modern field theory. It appeared that this problem, which was formulated by Newton [15], still remains the least developed section of modern physics [16]. It then occurred to me that I found not only the right path to the equations of unified field theory but also a new fundamental object for research in theoretical physics, namely the inertial field.

My intensive search for dynamic equations that control the inertial field lead to publication in 1979 of my first book [17] at the Department of Chemistry of Moscow University. In it I proposed as the dynamic equations for the inertial fields $T^i{}_{jk}$ the following system of equations:

$$\overset{*}{\nabla}_{[k}\, e^a{}_{j]} = \nabla_{[k} e^a{}_{j]} + T^i{}_{[kj]} e^a{}_i = 0, \tag{7}$$

$$S^i{}_{jkm} = R^i{}_{jkm} + 2\nabla_{[k} T^i{}_{|j|m]} + 2T^i{}_{s[k} T^s{}_{|j|m]} = 0, \tag{8}$$

$$\overset{*}{\nabla}_{[k} P^i{}_{jk]m} = 0, \tag{9}$$

$$i, j, k... = 0, 1, 2, 3, \quad a, b, c... = 0, 1, 2, 3,$$

where $S^i{}_{jkm}$ is the curvature tensor for A_4 space, $\overset{*}{\nabla}_k$ is the covariant derivative with respect to connection of absolute parallelism

$$\triangle^i{}_{jk} = \Gamma^i{}_{jk} + T^i{}_{jk};$$

∇_k is the covariant derivative with respect to the connection $\Gamma^i{}_{jk}$ and $P^i{}_{jkm} = 2\nabla_{[k} T^i{}_{|j|m]} + 2T^i{}_{s[k} T^s{}_{|j|m]}$.

Equations (7)–(9) featured some interesting properties:

– equations (8) lead to the Shipov-Einstein equations (3) with the geometrized energy-momentum tensor (4);

– equations (7) and (8) coincided with the main relations of the Newman-Penrose formalism [11];

– they admitted spinor rendering, similar to the one used in the Newman-Penrose formalism;

– they could be represented as $SL(2, C)$ gauge Yang-Mills gravitation theory;

– a Lagrangian could be written from which these equations had been derived using variational principle, and so on.

It was also shown (although not rigorously enough by present-day standards) that in inertial reference frames the inertial fields form the density of matter and obey wave equations similar to the Schrödinger equation in modern quantum mechanics [17]. The wave function of quantum theory appears to be related with a real physical field – the inertial field – and is interpreted in deterministic terms [18].

An investigation of the physical behavior of inertial fields strongly suggested that these fields are of major importance in physics and that the phenomenon of inertia relates classical physics with quantum physics not only formally, but also at the level of physical principles. This means that the dynamical equations for the inertial fields (7) - (9) incorporate a minimum of Einstein's program on geometrization of the electromagnetic field and a maximum on the geometrization of matter fields, i.e., quantum fields.

Despite a serious of publications and appearances at scientific workshops and conferences (even a course of lectures at the I.M.Gubkin Institute of Oil and Gas in 1983-85) experts in general relativity were quite reticent concerning my results. The first international response that called my work [19] promising came in 1977 from an international commission on general relativity and gravitation [20]. This support was of great importance for me and I carried on my investigations drawing on my own results.

The equations of the dynamics of inertial fields (7)–(9), just like Einstein's vacuum equations and the Shipov-Einstein equations (3), contain no initial physical constants. Therefore, they can all be viewed as generalizations of Einstein's vacuum equations.

By replacing matter with the torsion of A_4 space we thereby change to a purely spatial description of matter fields and external fields. Following Clifford [21], we can now tell that in the world we find nothing but changes in curvature and torsion of space. This idea is even to a larger degree suggested by the dynamical equations for inertial fields (7)- (9). They contain nothing but geometrical characteristics of space with A_4 geometry, Minkowski's geometry being just a special case.

Now a physical substantiation was needed for the equations (7) , (8) to be introduced as new fundamental equations in physics. It was clear that for them to be accepted as new physical equations requires an expansion of the general principle of relativity. Search for this new principles was carried on through 1980-89. It was found that:

(1) equations (7) and (8) describe the structure of the ten-dimensional space of events of arbitrarily accelerated four-dimensional reference frames with four translational coordinates $x^0, x^1, x^2 and x^3$, and six angular coordinates – three spacial angles $\varphi^1, \varphi^2, \varphi^3$ and three pseudo-Euclidean angles $\theta^1, \theta^2, \theta^3$;

(2) besides the four equations of motion (6) that describe the motion of the origin O of an arbitrarily accelerated reference frame there also exist in A_4 geometry six torsion equations of motion [22],[23]

$$\frac{d^2e^i{}_a}{ds^2} + (\Gamma^i{}_{jk,m} + T^i{}_{jk,m} - \Gamma^i{}_{sk}\Gamma^s{}_{jm} - \Gamma^i{}_{sk}T^s{}_{jm} - \\ -T^i{}_{sk}\Gamma^s{}_{jm} - T^i{}_{sk}T^s{}_{jm} - \Gamma^i{}_{js}\Gamma^s{}_{km} - T^i{}_{js}\Gamma^s{}_{km} - \\ -\Gamma^i{}_{js}T^s{}_{km} - T^i{}_{js}T^s{}_{km})\frac{dx^k}{ds}\frac{dx^m}{ds}e^j{}_a = 0, \tag{10}$$

which describe the variation of the orientation of the four-dimensional frame;

(3) besides the translational Riemannian metric $ds^2 = e^a{}_i e_{ja} dx^i dx^j$, in the A_4 geometry there exists the rotational Killing-Cartan metric

$$d\tau^2 = d\chi^b{}_a d\chi^a{}_b = T^a{}_{bi} T^b{}_{ak} dx^i dx^k, \tag{11}$$

which characterizes the square of the infinitesimal rotation of the vectors that form the four-dimensional reference frame;

(4) the inertial field $T^i{}_{jk}$ is generated by the four-dimensional rotation of a reference frame, so that in the translational group T_4 these fields transform as a tensor, and in the rotation group $O(3.1)$ they transform according to a nontensor law;

(5) equations (9) are the Bianchi identities of the A_4 geometry and corollaries of (8); in the general case they are written as [23]

$$\nabla_{[n} R^a{}_{|b|km]} + R^c{}_{b[km} T^a{}_{|c|n]} + T^c{}_{b[n} R^a{}_{|c|km]} = 0. \tag{12}$$

Exact solutions of the dynamical equations for the inertial fields (7) and (8) made it possible to calculate not only the translational Riemannian metric but also the rotational Killing-Cartan metric (11). It became clear therefore as to what direction should one expand Einstein's principle of relativity. Einstein's translational relativity would have to be enriched by a rotational relativity concerned with transformations in angular coordinates in the $O(3.1)$ group and with the metric (11). For equations (7) and (8) the $O(3.1)$ group is a group of "internal" gauge symmetries. What is more, the rotations take into account chiral symmetries, thereby enabling right- and left-hand rotations to be distinguished.

Proceeding from the above, in 1988 I put forward the universal relativity principle [24], which generalized Einstein's relativity by enhancing it with rotational relativity along with gauge and chiral relativity. Rotational relativity has led to the relativity of matter fields (the field $T^i{}_{jk}$ can be made to vanish using transformations in the $O(3.1)$ group). Therefore, relative elements in (7) and (8) are not only the external fields (gravitational and electromagnetic), which are described by Christoffel symbols, but also the matter fields (quantum fields). I came thus to understand universal relativity as the relativity of all physical fields. It is this understanding of universal relativity that enables us to perceive emptiness (or the empty space A_4) as physical vacuum – the source of any matter.

The simplest A_4 geometry – Minkowski's geometry has a zero Riemannian curvature and a zero torsion tensor. This suggested the idea that it describes in the language of geometry the basic lowest state of all physical fields – the absolute vacuum.

Einstein's program of unified field theory was concluded by putting forward in 1988 a new scientific program – the program of universal relativity and the theory of physical vacuum [24] with the vacuum equations of the form [25]:

$$\nabla_{[k}e^a{}_{m]} - e^b{}_{[k}T^a{}_{|b|m]} = 0, \qquad (A)$$

$$R^a{}_{bkm} + 2\nabla_{[k}T^a{}_{|b|m]} + 2T^a{}_{c[k}T^c{}_{|b|m]} = 0, \qquad (B)$$

$$i, j, k... = 0, 1, 2, 3, \qquad a, b, c... = 0, 1, 2, 3.$$

These equations are essentially a matrix form of the equations (7) and (8), where the matrices $e^a{}_m$, $T^a{}_{bm}$ and $R^a{}_{bkm}$ appear as the main gauge potential and fields in the theory of physical vacuum. In the work of the Slovak physicist and philosopher V. Skalsky [26] they were first called by the author's name.

When a theoretical physicist comes up with some new physical equations that claim to generalize some well-known equations tested by experiment, he should subject the new equations to a number of requirements.

1. It is necessary to check whether or not the new equations satisfy the conformity principle, i.e., whether or not they turn into the old equations in some limiting case. Such a check was done for the vacuum equations (A), (B), and it was shown that they conform to the basic fundamental equations of physics (for details see Chapter 3 [1]).

2. If the equations proposed are fundamental in nature, to provide grounds for them one should introduce a new fundamental physical principle that would generalize old principle(s). The vacuum equations are based on universal relativity, which fuses the principles of quantum theory with those of general relativity (see Chapters 2 and 4 [1]).

3. The new equations should describe not only the phenomena covered by contemporary physics but also predict new, unknown ones. Moreover, the new equations should account for the observed phenomena that science based on old equations labels as anomalous. Equations (A) and (B) meet this requirement (see Chapter 4 [1]), since they, for example, predict the occurrence of novel physical objects, which have properties that can make them responsible for psychophysical phenomena.

4. The new theory should remove difficulties prevailing in the old one. The vacuum theory solves this problem (see Chapters 1, 3, and 4 [1]).

5. The new fundamental theory requires a new mathematical tool kit. The equations of the theory of physical vacuum are based on absolute parallelism geometry that possesses a spinor structure.

Wheeler [27] believed that the difficulties in the geometrical description of spinor fields consist in that "the idea of obtaining the concept of spin from classical geometry alone seems to be as impossible as the senseless hope of some researchers of years before to derive quantum mechanics from relativity theory."

Wheeler said this in 1960 in his lecture at the Fermi International Physics School. At the time he did not know that Penrose [28], [29] had already embarked on his brilliant works, in which he showed that it were spinors what could be laid at the foundation of classical geometry and that it is them that define the topological and geometrical properties of space-time, e.g., its dimensionality and signature.

Penrose wrote Einstein's vacuum equations $R_{ik} = 0$ in spinor form [11]

$$\Phi_{AB\dot{C}\dot{D}} = 0, \qquad A, B... = 0, 1, \quad \dot{C}, \dot{D}... = \dot{0}, \dot{1} \tag{13}$$

and, jointly with Newman, he proposed the system of nonlinear spinor equations

$$\begin{aligned}
&(a) \quad \partial_{A\dot{B}}\sigma^i{}_{C\dot{D}} - \partial_{C\dot{D}}\sigma^i{}_{A\dot{B}} = \varepsilon^{PQ}(T_{PAC\dot{D}}\sigma^i{}_{Q\dot{B}} - \\
&\qquad -T_{PCA\dot{B}}\sigma^i{}_{Q\dot{D}}) + \varepsilon\dot{R}\dot{S}(\bar{T}_{\dot{R}\dot{B}\dot{D}C}\sigma^i{}_{A\dot{S}} - \bar{T}_{\dot{R}\dot{D}\dot{B}A}\sigma^i{}_{C\dot{S}}), \\
&(b) \quad \Psi_{ACDF}\varepsilon_{\dot{E}\dot{B}} + \Phi_{AC\dot{B}\dot{E}}\varepsilon_{FD} + \Lambda\varepsilon_{\dot{E}\dot{B}}(\varepsilon_{CD}\varepsilon_{AF} + \varepsilon_{AD}\varepsilon_{CF}) - \\
&\qquad -\partial_{D\dot{B}}T_{ACF\dot{E}} + \partial_{FE}T_{A\dot{C}D\dot{B}} + \varepsilon^{PQ}(T_{APD\dot{B}}T_{QCF\dot{E}} + \\
&\qquad +T_{ACP\dot{B}}T_{QDF\dot{E}} - T_{APF\dot{E}}T_{QCD\dot{B}} - T_{ACP\dot{E}}T_{QFD\dot{B}}) + \\
&\qquad +\varepsilon^{\dot{R}\dot{S}}(T_{ACD\dot{R}}\bar{T}_{\dot{S}\dot{B}\dot{E}F} - T_{ACF\dot{R}}\bar{T}_{\dot{S}\dot{E}\dot{B}D}) = 0, \\
&(c) \quad \partial^P{}_{\dot{D}}\Psi_{ABPC} - \partial^{\dot{X}}{}_{(C}\Phi_{AB)\dot{D}\dot{X}} - 3\Psi_{PR(AB}T_{C)}{}^{PR}{}_{\dot{D}} - \\
&\qquad -\Psi_{ABCP}T^P{}_R{}^R{}_{\dot{D}} + 2T^P{}_{(AB}{}^{\dot{X}}\Phi_{C)P\dot{X}\dot{D}} - \\
&\qquad -\bar{T}_{\dot{X}\dot{D}\dot{V}(A}\Phi_{BC)}{}^{\dot{X}\dot{V}} - \bar{T}_{\dot{X}}{}^{\dot{V}}{}_{\dot{V}(A}\Phi_{BC)}{}^{\dot{X}}{}_{\dot{D}} = 0, \\
&\qquad 3\partial_{A\dot{B}}\Lambda + \partial^{P\dot{X}}\Phi_{AP\dot{B}\dot{X}} - \varepsilon^{\dot{V}\dot{W}}(\Phi_{AP}{}^{\dot{X}}{}_{\dot{W}}\bar{T}_{\dot{B}\dot{X}\dot{V}}{}^P + \\
&\qquad +\Phi_{AP\dot{B}}{}^{\dot{X}}\bar{T}_{\dot{X}\dot{W}\dot{V}}{}^P) + \Phi_{PR\dot{B}}{}^{\dot{X}}T_A{}^{PR}{}_{\dot{X}} + \Phi_{AP\dot{B}}{}^{\dot{X}}T^P{}_R{}^R{}_{\dot{X}} = 0,
\end{aligned} \tag{14}$$

$$A, B \ldots = 0, 1, \qquad \dot{C}, \dot{D} \ldots = \dot{0}, \dot{1}$$

to solve Einstein's vacuum equations (13).

The method of spinor coefficients [11] proposed by Newman and Penrose to solve Einstein's equations (13) appeared to be so productive that almost immediately it yielded a number of new solutions that generalized the Schwarzschild solution. These are the well-known solutions of Newman-Unti-Tamburino [30], Kinnersley [31] etc.

Using 2×2 complex matrices, Carmeli [32]-[34] wrote the equations in Penrose-Newman formalism (14) as the system of equations

$$
\begin{aligned}
(a) \quad & \partial_{C\dot{D}}\sigma^{i}{}_{A\dot{B}} - \partial_{A\dot{B}}\sigma^{i}{}_{C\dot{D}} = (T_{C\dot{D}})_{A}{}^{P}\sigma^{i}{}_{P\dot{B}} + \\
& +\sigma^{i}{}_{A\dot{R}}(T^{+}{}_{\dot{D}C})^{\dot{R}}{}_{\dot{B}} - (T_{A\dot{B}})_{C}{}^{P}\sigma^{i}{}_{P\dot{D}} - \sigma^{i}{}_{C\dot{R}}(T^{+}{}_{\dot{B}A})^{\dot{R}}{}_{\dot{D}}, \\
(b) \quad & R_{A\dot{B}C\dot{D}} = \partial_{C\dot{D}}T_{A\dot{B}} - \partial_{A\dot{B}}T_{C\dot{D}} - \\
& -(T_{C\dot{D}})_{A}{}^{F}T_{F\dot{B}} - (T^{+}{}_{\dot{D}C})^{\dot{F}}{}_{\dot{B}}T_{A\dot{F}} + (T_{A\dot{B}})_{C}{}^{F}T_{F\dot{D}} + \\
& +(T^{+}{}_{\dot{B}A})^{\dot{F}}{}_{\dot{D}}T_{C\dot{F}} + [T_{A\dot{B}}, T_{C\dot{D}}], \\
(c) \quad & \partial^{C\dot{D}} \overset{*}{R}_{E\dot{F}C\dot{D}} - (T^{C\dot{D}})^{A}{}_{E} \overset{*}{R}_{A\dot{F}C\dot{D}} - \\
& -(T^{+\dot{D}C})_{\dot{F}}{}^{\dot{B}} \overset{*}{R}_{E\dot{B}C\dot{D}} + (T_{P}{}^{\dot{D}})^{CP} \overset{*}{R}_{E\dot{F}C\dot{D}} + \\
& +(T^{+C}_{\dot{Q}})^{\dot{Q}\dot{D}} \overset{*}{R}_{E\dot{F}C\dot{D}} + [T^{C\dot{D}}, \overset{*}{R}_{E\dot{F}C\dot{D}}] = 0,
\end{aligned}
\tag{15}
$$

which can be represented as a $SL(2.C)$ gauge theory of the gravitational field with the field equations [35]

$$\nabla^{n} \overset{*}{R}_{kn} + [\overset{*}{R}_{kn}, T^{n}] = 0, \tag{16}$$

$$R_{kn} + 2\nabla_{[k}T_{n]} - [T_{k}, T_{n}] = 0, \tag{17}$$

$$\nabla_{[k}\sigma^{i]} - T_{[k}\sigma^{i]} - \sigma^{[i}T_{k]} = 0. \tag{18}$$

Here the spinor $SL(2.C)$ gauge indices at σ^{i}, T^{k} and R_{kn} matrices are discarded. Further, Carmeli noted that the equations (15b) can be split into Einstein's spinor equations

$$2\Phi_{AB\dot{C}\dot{D}} + \Lambda\epsilon_{AB}\epsilon_{\dot{C}\dot{D}} = \kappa T_{A\dot{C}B\dot{D}} \tag{19}$$

and equations for the Weyl spin tensor $C_{A\dot{B}C\dot{D}}$

$$
\begin{aligned}
& C_{A\dot{B}C\dot{D}} - \partial_{C\dot{D}}T_{A\dot{B}} + \partial_{A\dot{B}}T_{C\dot{D}} + \\
& +(T_{C\dot{D}})_{A}{}^{F}T_{F\dot{B}} + (T^{+}{}_{\dot{D}C})^{\dot{F}}{}_{\dot{B}}T_{A\dot{F}} - (T_{A\dot{B}})_{C}{}^{F}T_{F\dot{D}} - \\
& -(T^{+}{}_{\dot{B}A})^{\dot{F}}{}_{\dot{D}}T_{C\dot{F}} - [T_{A\dot{B}}, T_{C\dot{D}}] = -\kappa J_{A\dot{B}C\dot{D}},
\end{aligned}
\tag{20}
$$

where κ is the Einstein constant.

Unlike Einstein's gravitation theory, in quantum field theory there are no equations (similar to $R_{ik} = 0$) which would describe vacuum directly. On the other hand, in quantum theory all particles and fields are considered to be excited states of vacuum. Therefore, the equations of Schrödinger, Klein-Gordon and Dirac describe excited states of vacuum, i.e., appear to be simple "developed" vacuum equations. At the same time the equations of quantum theory are the simple equations of the unified field theory, the field being the wave function. In fact, using the wave function we can just as well describe electromagnetic, gravitational, nuclear and other physical phenomena. This idea has first been put forward by Ivanenko [36], [37] and then actively developed by Heisenberg [38], [39]. The Heisenberg-Ivanenko program, which attempts to construct all the particles of matter from particles of spin 1/2, is based on the nonlinear spinor equation

$$\gamma^{n}\frac{\partial\Psi}{\partial x^{n}} + l^{2}\gamma_{k}\gamma_{5}\Psi(\Psi^{*}\gamma^{k}\gamma_{5}\Psi) = 0 \tag{21}$$

with a cubic nonlinearity. This equation contains the fundamental length l, and the spinor field Ψ appears as a unified field against the background of a flat space.

Although we know enough about excited states of vacuum from quantum field theory, nevertheless the main objective is to find out which equations describe the principal state of all physical fields – the physical vacuum.

Common sense suggests that these equations can be found only by combining the Clifford-Einstein program with the Heisenberg program, i.e., by generalizing the spinor vacuum Einstein equations (13) so that they would lead to geometrized equations for matter fields like Heisenberg's equations (21).

It goes without saying that new equations will have to solve the problems of fundamental physical theories, namely of classical mechanics, electrodynamics, quantum theory, etc.

This approach relies on the universal principle of relativity and the equations of the physical vacuum (A),(B) [24], which coincide with Cartan's structural equations for the geometry of absolute parallelism [40].

The equations for the physical vacuum (A) and (B) can be represented in the form of an expanded set of Einstein-Yang-Mills equations

$$\nabla_{[k}e^{a}{}_{j]} + T^{i}{}_{[kj]}e^{a}{}_{i} = 0, \qquad (A)$$

$$R_{jm} - \tfrac{1}{2}g_{jm}R = \nu T_{jm}, \qquad (B.1) \qquad (22)$$

$$C^{i}{}_{jkm} + 2\nabla_{[k}T^{i}{}_{|j|m]} + 2T^{i}{}_{s[k}T^{s}{}_{|j|m]} = -\nu J^{i}{}_{jkm}, \qquad (B.2)$$

Unlike the conventional Einstein and Yang-Mills equations, in $(B.1)$ and $(B.2)$ the geometrized sources T_{jm} and J_{ijkm} are defined through the torsion of the geometry of absolute parallelism (A_4 geometry). Generalized vacuum Einstein's equations $R_{ik} = 0$ in the theory of the physical vacuum have the form

$$\nabla_{[k}e^{a}{}_{j]} + T^{i}{}_{[kj]}e^{a}{}_{i} = 0, \qquad (i)$$

$$R_{jm} = 0, \qquad (ii) \qquad (23)$$

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

Using spinor 2×2 Carmeli matrices the physical vacuum equations for right-hand matter (in theory one distinguishes right- and left-hand matter and antimatter [41]) are given as

$$
\begin{array}{ll}
(\overset{+}{A}{}^{s}) & \partial_{C\dot{D}}\sigma^{i}{}_{A\dot{B}} - \partial_{A\dot{B}}\sigma^{i}{}_{C\dot{D}} = \\
& = (T_{C\dot{D}})_{A}{}^{P}\sigma^{i}{}_{P\dot{B}} + \sigma^{i}{}_{A\dot{R}}(T^{+}{}_{\dot{D}C})^{\dot{R}}{}_{\dot{B}} - \\
& -(T_{A\dot{B}})_{C}{}^{P}\sigma^{i}{}_{P\dot{D}} - \sigma^{i}{}_{C\dot{R}}(T^{+}{}_{\dot{B}A})^{\dot{R}}{}_{\dot{D}}, \\
 & \\
(\overset{+}{B}{}^{s+}.1) & 2\Phi_{AB\dot{C}\dot{D}} + \Lambda\varepsilon_{AB}\varepsilon_{\dot{C}\dot{D}} = \nu T_{A\dot{C}B\dot{D}}, \\
 & \\
(\overset{+}{B}{}^{s+}.2) & C_{A\dot{B}C\dot{D}} - \partial_{C\dot{D}}T_{A\dot{B}} + \partial_{A\dot{B}}T_{C\dot{D}} + \\
& +(T_{C\dot{D}})_{A}{}^{F}T_{F\dot{B}} + (T^{+}{}_{\dot{D}C})^{\dot{F}}{}_{\dot{B}}T_{A\dot{F}} - \\
& -(T_{A\dot{B}})_{C}{}^{F}T_{F\dot{D}} - (T^{+}{}_{\dot{B}A})^{\dot{F}}{}_{\dot{D}}T_{C\dot{F}} - \\
& -[T_{A\dot{B}}, T_{C\dot{D}}] = -\nu J_{A\dot{B}C\dot{D}},
\end{array}
\tag{24}
$$

where the constant ν can assume the values $\nu = (8\pi G)/c^4 = \nu_g$ for the gravitational interaction case or $\nu = (8\pi e)/m_0c^4 = \nu_e$ for the electromagnetic interaction case [24]. Equations $(B^{s+}.1)$ are the spinor representation of fully geometrized (including the matter energy-momentum tensor) Einstein's equations, where the source $T_{A\dot{C}B\dot{D}}$ in the general case is defined through two-component spinors o_α, τ_β and their derivatives [42]. On the other hand, equations $(B^{s+}.2)$ represent fully geometrized Yang-Mills equations, where the current $J_{A\dot{B}C\dot{D}}$ is also defined through the two-component spinors o_α, ι_β. The two-component spinors ι^α, o^β plays the role of potentials of torsion fields in an A_4 geometry and obey the set of nonlinear spinor equations of the form [43]

$$
\begin{gathered}
\nabla_{\beta\dot{\chi}}o_\alpha = \gamma\ o_\alpha o_\beta \bar{o}_{\dot{\chi}} - \alpha\ o_\alpha o_\beta \bar{\iota}_{\dot{\chi}} - \\
-\beta\ o_\alpha \iota_\beta \bar{o}_{\dot{\chi}} + \varepsilon\ o_\alpha \iota_\beta \bar{\iota}_{\dot{\chi}} - \tau\ \iota_\alpha o_\beta \bar{o}_{\dot{\chi}} + \\
+\rho\ \iota_\alpha o_\beta \bar{\iota}_{\dot{\chi}} + \sigma\ \iota_\alpha \iota_\beta \bar{o}_{\dot{\chi}} - \kappa\ \iota_\alpha \iota_\beta \bar{\iota}_{\dot{\chi}}, \\
\\
\nabla_{\beta\dot{\chi}}\iota_\alpha = \nu\ o_\alpha o_\beta \bar{o}_{\dot{\chi}} - \lambda\ o_\alpha o_\beta \bar{\iota}_{\dot{\chi}} - \\
-\mu\ o_\alpha \iota_\beta \bar{o}_{\dot{\chi}} + \pi\ o_\alpha \iota_\beta \bar{\iota}_{\dot{\chi}} - \gamma\ \iota_\alpha o_\beta \bar{o}_{\dot{\chi}} + \\
+\alpha\ \iota_\alpha o_\beta \bar{\iota}_{\dot{\chi}} + \beta\ \iota_\alpha \iota_\beta \bar{o}_{\dot{\chi}} - \varepsilon\ \iota_\alpha \iota_\beta \bar{\iota}_{\dot{\chi}}, \\
\\
\alpha, \beta, \gamma ... = 0, 1, \qquad \dot{\chi}, \dot{\mu}, \dot{\nu} ... = \dot{0}, \dot{1},
\end{gathered}
\tag{25}
$$

which generalizes the nonlinear spinor Heisenberg-Ivanenko equations (21).

The spinor representation of the equations of the physical vacuum $(\overset{+}{A}{}^{s})$ and $(\overset{+}{B}{}^{s+})$ coincides with the Carmeli matrix equations (15a) and (15b) and is equivalent to the spinor equations (14a) and (14b). This means that Newman, Penrose and Carmeli (when using the Newman-Penrose formalism) have transcended the framework of Riemann's traditional geometry, which underlies Einstein's theory of gravitation and in actual fact dealt with Cartan's structural equation for the geometry of absolute parallelism [41].

From the point of view of theoretical physics such a step cannot be treated in purely formal terms and requires some ponderable physical substantiation. The universal principle of relativity allows this. Moreover, the principle holds that the equations for the Newman-Penrose formalism can be regarded as *new physical equations*.

The theory of physical vacuum based on the universal principle of relativity [1] thus proposes that the Clifford, Riemann-Einstein-Penrose-Heisenberg program be realized within the framework of the geometry of absolute parallelism with a spinor structure. In so doing, the structural equations of the geometry of absolute parallelism (A) and (B) are proclaimed to be the equations of the physical vacuum.

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