Conformal Geometrodynamics as the Basis for the Unified Description of Nature

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Abstract

The present essay shows that conformal geometrodynamics (CGD), which is based on the ideas of A. Einstein and H. Weyl and serves as the exact expression of the causality principle and absence of absolute dimensional scales in nature, may be used not only to analyze astronomical and cosmic phenomena but also the micro world, which is explored typically within the framework of the quantum theory. The CGD is closely connected with different areas of advanced theoretical physics and mathematics (conformal field theory, superstrings, knots, Monster group, Leech lattice, integrable equations, etc.). The CGD development could lead to emergence of new technologies and upgrade of existing ones including efficient conformal computational methods.

One of the often considered problems in mathematical analysis is the problem of closure of open set M that is finding its completion $\overline{M}$. The most 'interesting' limit points are located on the boundary of M, which belongs to $\overline{M}$. Our approach to the essay topic is similar to the mathematical one. We suppose that the analog of the set M is well-known and stable part of theoretical physics including quantum mechanics and gravitation, and the analog of $\overline{M}$ is conformal geometrodynamics, which is a synthesis and completion of M, and the information of physics limits is contained on the boundary $\overline{M} - M$. So let us start with explanation of what conformal geometrodynamics (CGD) is.

1. Conformal Geometrodynamics (CGD)

1.1. According to Einstein, the space-time is pseudo Riemannian. In the regions, where there is no matter and electromagnetic field but only the gravitational, the space-time is described by the equation $R_{\alpha\beta} = 0$. Here $R_{\alpha\beta} = R^{\varepsilon}{}_{\alpha\varepsilon\beta}$ is the Ricci tensor that is the convolution of the curvature tensor $R^{\lambda}{}_{\alpha\sigma\beta}$. The equations are invariant relatively to smooth coordinate transformations.

Einstein wrote: "The effort to find the concept of complete field and obtain the equation for it seemed rather hopeless to me at the time and I didn't dare to try. I preferred to introduce formal preliminary frames to picture the entire physical reality" [1]. Thus Einstein came to the following equation:

$$R_{\alpha\beta} - \frac{1}{2} g_{\alpha\beta} R = \kappa T_{\alpha\beta}, \tag{1}$$

Here $R = g^{\mu\nu} R_{\mu\nu}$. “The second term in the left part is added from formal considerations meaning that the left part is written so that its divergence would be identical to zero. The right part is written on analogy to the Poisson equation $\Delta\varphi = 4\pi\kappa\rho$, where φ is the potential of gravity and ρ is the density of the matter. It (i.e. the right part) embraces everything that cannot yet be integrated by the unified theory of the field. Certainly, I didn't doubt that such formulation was only a temporarily way out from the situation aiming at giving a kind of closed-loop expression to the general principle of relativity. This theory was sufficient for the expression of the observed facts of celestial mechanics. However, it resembled to me a building, one wing of which is made from beautiful marble (the left part of the equation), while the other one is constructed from poor quality wood (the right part of the equation). The phenomenological representation of matter is an imperfect substitution for such representation, which would correspond to all known properties of matter” [1].

1.2. In 1919 H.Weyl drew attention to the fact that the general theory of relativity is not a consistent theory of close-range interaction [3]. This theory assumes that the length and time scales may be chosen equal over the entire space-time. Though, any physical value is relative: both the measured object and standard are constituent participants of the measuring process. So, if there are no absolutely solid bodies, then, generally speaking, there is not the method, which implies “rigid” carryover of scales in the space-time. Therefore, it should be formulated such a theory, which would be just for arbitrary predefined scale changes in case of their transport. Weyl wrote: “only the principle of the length transport from one point to the other one, which is infinitely close to the initial one, should be recognized in real geometry of the close-range interaction. In this case there are as few grounds to assume in advance that the problem of the length transport from one point to another, which is remote from it at a finite distance, is integrable, as in regard to the problem of the direction transport” [4]. The type of distortions introduced by Weyl is sometimes referred to as the Weyl deformation, or scale deformation. In the assumption of the Weyl deformation, not the straightedge lengths should be distributed over the world, but rather lengths of their relative increments, while such increments depend on four displacement directions, i.e. present the vector gauge field. In accordance with the aforementioned, in case of a parallel transfer (displacement) on vector dx^{α} the vector length change is $d\ln l = A_{\alpha} dx^{\alpha}$, where A_{α} - Weyl vector field. If we change scales we receive other value $l' = l + dl$ and other Weyl field. So in this approach it is possible to change reference frame: by coordinates change and by scales change. If we change scales by $\lambda(x)^{-1}$ then the length of displacement will change by the $\lambda(x)$. Marking with the prime the values, which refer to the new system, we will get $ds'^2 = \lambda^2 ds^2$ for the interval square. The constituent displacements $dx'^{\mu} = dx^{\mu}$ do not change because the system of coordinates remained the same. So, the following is obvious, namely:

$$g'_{\mu\nu} = \lambda^{-2} g_{\mu\nu} .$$

Assume that $\lambda = e^{\sigma(x)}$, we will obtain the following expression:

$$A'_{\mu} = A_{\mu} - \frac{\partial\sigma}{\partial x^{\mu}}, \quad g'_{\mu\nu} = e^{2\sigma} g_{\mu\nu} . \tag{2}$$

The rotor of the vector A_α does not depend on the choice of the scale system. This implies that the Weyl geometry depends on 14 values: 10 $g_{\mu\nu}$ values and 4 A_μ values. These functions might be subjected both to the coordinate and scale transformations.

1.3. The logical question arises as to how the Einstein equations may be generalized in case of the scales, which are dependent on the coordinates. Weyl himself identified the Weyl vector with the electromagnetic potential thus proposing his approach as a variant of the unified field theory. However, he refused from such approach as a result of Einstein's criticism. If Weyl would have formulated his gauge theory fifteen years later, he had hardly insisted on such identification. Probably, a wider outlook is required. Under the pressure of quantum mechanics Weyl transferred the gauge transformation to the wave function phase. Still, which is the simplest way to find the gauge-invariant equation like $R_{\mu\nu}=0$? In order to do so, the Ricci tensor should be set equal zero in the Weyl space, i.e. first the generalized Christoffel symbols should be written, while then the Riemann tensor should be represented in the invariant (relatively to the scale transformations) forms. In order to fulfill such calculations, let us re-write the expression $d\ln l = A_\alpha dx^\alpha$ in the following form: $\nabla_\sigma g_{\alpha\beta} = 2A_\sigma g_{\alpha\beta}$, or $\tilde{\nabla}_\sigma g_{\alpha\beta}=0$, where the marked nabla corresponds to the "elongated" derivative. The calibration Weyl field in such form acquires the sense of a compensating field. In order to calculate the calibration connection, it is now sufficient to calculate the Christoffel symbol $\Gamma^\gamma_{\alpha\beta}$ in a standard way, though with the elongated covariant derivative. As a result, we will obtain the scale invariant Christoffel symbol ${}^*\Gamma^\gamma_{\alpha\beta} = \Gamma^\gamma_{\alpha\beta} + \delta^\gamma_\beta A_\alpha + \delta^\gamma_\alpha A_\beta - g_{\alpha\beta}A^\gamma$. In terms of the Weyl connection ${}^*\Gamma^\gamma_{\alpha\beta}$, the conventional approach is used to formulate the Riemann and Ricci tensors ${}^*R_{\alpha\beta} = R_{\alpha\beta} + 2A_\alpha A_\beta - 2g_{\alpha\beta}A^2 - g_{\alpha\beta}A^\nu{}_{;\nu} - A_{\alpha;\beta} - A_{\beta;\alpha}$. Getting the latter expression equal to zero, we obtain the gauge-invariant equation, which in the Einstein's terminology describes the true gravitational field ${}^*R_{\alpha\beta}=0$. However, if to write it as follows:

$$R_{\alpha\beta} - \frac{1}{2}g_{\alpha\beta}R = -2A_\alpha A_\beta - g_{\alpha\beta}A^2 - 2g_{\alpha\beta}A^\nu_{;\nu} + A_{\alpha;\beta} + A_{\beta;\alpha}, \tag{3}$$

we see that the resulting equation is that with the non-phenomenological energy-momentum tensor, which has a purely geometric origin, i.e.:

$$T_{\alpha\beta} = -2A_\alpha A_\beta - g_{\alpha\beta}A^2 - 2g_{\alpha\beta}A^\nu{}_{;\nu} + A_{\alpha;\beta} + A_{\beta;\alpha}. \tag{4}$$

Further, we may make a logical assumption that the equations are as well just for the spaces, which are not conformally plane. Considering that such spaces do not contain anything else but the metric tensor and Weyl gauge field, these were called the equations of conformal geometrodynamics. Another approach to deducing (3) is based on non-trivial use of the variation principle with imposing of nonholonomic constraints, which is described in the work [1]. The gauge-invariant expressions for the connection and curvature tensor have been known for quite along time (e.g. [4]). However, for the first time the equations (3) as the dynamic equations for the generalized space appeared in the work by M.V. Gorbatenko and A.V. Pushkin in 1984 [5].

The equations (3) admit certain expansion, which is based on the introduction of the λ-function, i.e. the conformally invariant version of the λ-term. In doing so, into the right part of the equation (3) it is added the term $\lambda \cdot g_{\alpha\beta}$, while the transformation $\lambda' = \lambda \cdot \exp(-2\sigma)$ is added to the gauge transformation (2).

1.4. How to correlate the conformal geometrodynamics (CGD) and general relativity (GR)? The GR is confirmed by a lot of experimental data in the area of weak gravitational fields and it serves as the basis for the analysis of the astronomical and cosmic phenomena. Any other more general theory should reproduce the GR results in the range of its applicability. Nevertheless, even "the most beautiful theory" (the citation is from "The Theory of Field" by L.D Landau and E.M. Lifshitz) cannot be impeccable. For example, in the GR the problem is formulated with the obligatory condition of fulfillment of four non-linear differential constraints in regard to the data at the initial moment. This does not allow considering the GR equations as the dynamic ones for arbitrary Riemann spaces. Besides, in the GR there are no rules governing the construction of the tensor $T_{\alpha\beta}^{Matter}$, while the GR equations allow including different components, which correspond to various types of fields and particles. Such freedom of the energy-momentum tensor choice reduced the predictive reliability of the GR.

In terms of the two aforementioned features, the CGD is different from GR. First, for the CGD equations (with the lambda term) the Cauchy problem is formulated without constraints on the initial data. Second, within the framework of the CGD the energy-momentum tensor $T_{\alpha\beta}^{CGD}$ should coincide with the right part of the equation (3). Still, don't we weaken the theory, when requiring the equality $T_{\alpha\beta}^{Matter} = T_{\alpha\beta}^{CGD}$? It turns out that in a certain region of space all known exact solutions of the GR (internal and external solutions by Schwarzschild, de Sitter, Friedmann, etc.) may be approximated with arbitrary exactness by solutions of the CGD equations. Besides, it was obtained a special two-parametric family of the axially symmetrical solutions of the CGD equations, which present the generalization of the Kerr and Kerr-Newman solutions. So, there are the reasons to suppose that not only the GR but also the CGD can be used to describe large scale physical processes.

2. Hydrogen atom in the CGD

The presence of rich symmetry in the CGD allows projecting the solutions of the basic physical equations towards the CGD solutions and vice versa. In particular, among conformal transformations there is the inversion transformation $r \to 1/r$, which connects small and large scales. It is sufficient to see that the connection can exist between the solutions describing large system (the cosmos) and small systems (the micro world). These connections are multiple and rich.

Let us show, for example, how according to A.V. Pushkin, a non-relativistic atom of Hydrogen is described in the CGD. The principle consequence of deriving the geometrodynamics equations, while quantizing the gravity, is the necessity to consider the Euclidean 4-dimensional spaces with the signature (2,2) along with the Lorentz manifolds. This is connected with the fact that in geometrodynamics the vacuum states have a multitude of local minimums divided by barriers. The probability of the tunnel transition from one minimum to another is found from the solutions - instantons, which have the signature different from that of the vacuum solutions.

The bound states of the hydrogen atom correspond to the 4-dimensional Weyl space with the signature $(++++)$, while the radiation transitions between these states are described by the states in the external branch of the Weyl space with the signature $(-+++)$. In all manifold the space is conformally plane and present the solution of the CGD equations. The Weyl field is gradient of scalar field: $A_\alpha = \varphi_{,\alpha}$. In the Euclid's gauge the scalar field φ is solution of the 4-dimensional Laplace equation. The 4-dimensional harmonic functions present an infinite set of solutions for this equation. These functions define such solutions, which are regular in zero and are finite polynomials. Let us introduce the dimensional scale as a radius of the simplest compact manifold, i.e. a 3-dimensional sphere $x_1^2 + x_2^2 + x_3^2 + x_4^2 = a^2$, and consider the projection of the solutions onto it. Let us pass over to the inverse coordinates p_i on the sphere (i.e. actually, to the 4-impulse representation):

$$\vec{x} = \frac{2p_4}{\vec{p}^2 + p_4^2}\vec{p}, \quad x_4 = \frac{p_4^2 - \vec{p}^2}{\vec{p}^2 + p_4^2}, \quad p_4 = \sqrt{-2E_0}.$$

The resulting set of functions $f(p_i)$ forms a complete system of the Schrödinger equation wave functions for the hydrogen atom. The geometric constant, i.e. the 3-dimensional sphere radius a , defines the only dimensional constant, which is the bond energy E_0, i.e. the energy of the ground state of the Schrödinger hydrogen atom. The demonstrated solution method is the reverse one in regard to the V.A.Fock method and explains an additional degeneration of the hydrogen atom levels by their classification with help of the group O_4 representations.

The hydrogen atom states with different energies are connected in geometrodynamics with the help of the general (not spherically symmetrical) solution in the signature sector $(-+++)$, which is a representation of a photon in geometrodynamics. Existence of such "instanton" solutions leads to a non-zero width ΔE_n of the of the hydrogen atom levels. Considering the conformal invariance of the geometrodynamics equations, the three main dimensional values for the hydrogen atom (i.e. the energy of the first excited state E_1 , it width ΔE_1 and full mass $E_{total} = M_H c^2$ are connected by the expression $24 \cdot (E_1^2) = E_{total} \cdot \Delta E_1$. The term 24=4! is connected with the averaging

by all the permutations of the four Euclidean coordinates. This formula defines the fundamental dimensionless value for the hydrogen atom, which is the oscillator force for the transition from the first excited level to the ground state $f_1 \cong 0{,}427$. In quantum electrodynamics the Bete formula gives the number 0.416 for the aforementioned value. It is interesting that Coulomb law (electrical field) does not seen on the "surface of tensor (4), it hides in the impulse infrastructure of the solution. Notably, the discussed formula, as the CGD equations, does not contain any dimensional constant. Moreover, the oscillator force does not depend on the size of the chosen length scale. This example illustrates the method used to connect different physical values within the framework of the CGD, which initially does not contain any scales. Besides, it should be stressed that the CGD solution for the atom in general is not a direct multiplication of the solutions for the nucleus and electron: i.e. the solution for the electron is conformally fitted to the solution for the nucleus. The demonstrated derivation of the connection between the three solutions (the system and subsystems) is extrapolated towards other physical systems and situations that explains emergence of the golden section relations in different fields of science including biology, when analyzing phenomena empirically.

3. The Dirac Equations in CGD

3.1. Dynamic equations

Dynamic equations for the particle and fields in the CGD may be obtained from the momentum conservation law $T_{\alpha\ ;\beta}^{\ \beta} = 0$, which is fulfilled exactly on the CGD solutions. If such approach is applied to the CGD equations with the λ term, the resulting equations may be formulated in the form of a system of the equations of the 1st order for the fields of the vector J_α and anti-symmetrical tensor $H_{\alpha\beta}$

$$\left(J_{\beta,\alpha} - J_{\alpha,\beta}\right) = 4m \cdot H_{\alpha\beta}, \quad H_{\alpha\ ;\nu}^{\ \nu} = -m \cdot J_\alpha, \tag{5}$$

Where m is a nonzero constant. Let us introduce the Hermitian matrix $M = J^\alpha \cdot \left(\gamma_\alpha D^{-1}\right) + H^{\mu\nu} \cdot \left(S_{\mu\nu} D^{-1}\right)$ and extract a "square root" from it, i.e. find the matrix Z, fitting the equation $M = ZZ^+$. Here, the γ_α are constant by the space Dirac 4×4 matrix, $S_{\mu\nu} = \frac{1}{2}(\gamma_\mu \gamma_\nu - \gamma_\nu \gamma_\mu)$, matrix D defined by relation $D\gamma_\mu D^{-1} = -\gamma_\mu^+$. The procedure for determining the matrix Z provided to be unique only if M matrix eigenvalues are positive [6]. In this case M matrix is the polarization density matrix. It turns out that the matrix Z satisfies the Dirac equation

$$\gamma^\nu \left(\nabla_\nu Z\right) = m \cdot Z, \tag{4}$$

where the symbol ∇_α means the covariant derivative $\nabla_\alpha Z = Z_{;\alpha} - Z\Gamma_\alpha$. The value Γ_α is bispinor connection.

It presents by set of real anti-Hermitian matrices: $\Gamma^*_\alpha = \Gamma_\alpha$, $\Gamma^+_\alpha = -\Gamma_\alpha$. Thus bispinor connection field is gauge field corresponding to $SO(4)$ gauge group. Unlike Yang-Mills equations Z matrix dynamics completely determine Γ_α dynamics.

So, as a result of the CGD equations analysis in the conformally plane space, we obtained the bispinor matrix Z containing 4 bispinors, the gauge field Γ_α corresponding to the symmetry group $SO(4)$, and the Dirac equation. Therefore, there emerges the possibility to interpret the CGD equation solutions in the terms of the quantum theory for bispinor multiplets and bosons, interactions carriers [7]. The dynamics of the Weyl freedom degrees is described by the equations (3) at any structure of the matrix M. Though, the quantum field interpretation of these equation solutions is possible only, when all eigenvalues of the matrix M are positive. Those regions of space, where such approach is possible, are the particles confinement regions. In such regions the matrix M corresponds to the usual requirements imposed on the polarization density matrices in quantum theory.

3.2. CGD and the Standard Model

The approach presented may be used, in order to give theoretical justification to the particle multiplet structures in the Standard Model. Actually, the particle production and annihilation operators with the spin ½ and different sets of the other quantum numbers result from the multiplication of the bispinor matrix by the projectors on the right. The system of the projectors includes $P_\pm = \frac{1}{2}\left[E \pm I\right]$, where the matrix of reflections in the $SO(4)$ group of the invariant transformations is I. The projectors $P_{\pm}$ have the ranks 1 and 3 and allow dividing the 4 bispinors $ZP_{\eta,\lambda}$ $(\eta, \lambda = \pm)$ into 2 groups. One group includes the three states, which differ by two quantum numbers. The other group consists of one state with zero quantum numbers ("sterile" state similar to the right neutrino). Such division of the states coincides with the division inside each of the lepton and quark generations in the Standard Model. From the standpoint of understanding the confinement, it is important that bispinors and matrix connection exist only in those regions of the space, where the matrix M is positive. Probably, different states inside the confinement regions of such space-localized bispinor matrix fields and matrix connection may be correlated with different elementary particles.

4. Dissipative Properties of the Energy Tensor- CGD Momentum

The ten equations of geometrodynamics admit different representations in the form suitable for various applications. In particular, these might be written in the form of the relativistic hydrodynamics equations in the presence of the dissipative processes, i.e. "viscosity" and "thermal conductivity".

In doing so, the kinetic coefficients terms out to be the functions of medium motion invariants. The entropy production equation, along with the typical terms, contains the component describing the entropy outflow in the regions with large 4-dimensional accelerations. Therefore, the following conjecture presents itself, namely: the total algebraic sum of the entropy and information in the Universe is equal to zero.

The "dissipative" properties of the tensor $T_{\alpha\beta}^{CGD}$ provide such smoothing of 4-dimensional manifold structure that admits the existence of the global time-like vector field. This field defines a preferable in the Riemannian space-time. The reference frame of this kind is the one, where the relict (i.e. microwave background) radiation is isotropic.

The dissipative nature of the CGD energy-momentum tensor means that the dissipation and friction are fundamental physical phenomena that agree with the view of R. Penrose [8]. The direct consequence of such conclusion is the absence of time reversibility at the fundamental level. In this regard, the CGD equations correspond to 't Hooft's idea [9] that the quantum theory should be based on classical equations with necessary presence of the dissipative terms.

5. On A.V. Pushkin's Data (1947-2004)

One of the authors of the CGD was Alexander Vasilyevich Pushkin. His untimely decease in 2004 did not allow implementing a wide scope research program on different CGD problems and publish the data obtained. We have already mentioned above certain data obtained by him personally or in co-authorship with him. We would like to present briefly without proofs some more of his results, which might present the interest for the readers, considering the nature of the present essay. Partially, his data may be found in the book [9], which was published in Russian. These data can be deemed as the reflection of Pushkin's view on several problems of modern physics.

5.1. The World as a Whole and its Parts

The geometrodynamics equations strictly connect the behavior of any subsystem and the world upon the whole. The symmetry of the equations is sufficient, in order to connect constants for integration of different subsystems with the complete system of algebraic connections. The latter prove to be structurally soluble that provides the algebraic classification of the boundary and initial conditions. Besides, the connections lead to dimensionless correlations between physical values, i.e. solution invariants. The Monster group defines the symmetry with the ultimate accuracy and completeness. The topological and differential geometric invariants describe separate properties of the complete system of connections.

5.2. Manifold Global Structure

The geometrodynamics equations describe non-linear dynamics of one-dimensional contours "sweeping" over two-dimensional surfaces, which are inserted globally into the 4-dimensional Riemann manifold. This property shows that the CGR solutions may be described in the algebraic language of knots theory that, along with the Floer homologies, is suitable for the analysis of topological laws of conservation for complex nonuniform flows in continuum, and, more generally, for reconstruction of the global structure of manifold.

The complete set of the geometrodynamics solutions implements the infinite dimensional representation of the Griss-Fisher affine algebra. For this particular reason the geometrodynamics equations pertain to the class of totally integrable equations. These may be reduced to well known hierarchies of the mathematical physics, i.e. those of Kadomtsev-Petviashvilli, Korteweg-de Vries, (non-linear) Schroedinger, sin-Gordon etc. And vice versa, the aforementioned hierarchies are met everywhere because these are the consequence of the universal equations of geometrodynamics.

5.3. Connection with Quantum Field Theory

The CGD tensor (4) may be interpreted as the vacuum polarization tensor that emerges in quantum conformal field theory. Such quantum theory exists, it is unique and connected with the infinite dimensional module in the Griss-Fisher algebra. The symmetry of the theory is described by the largest finite simple Monster group. The group finiteness is connected with the fact that it defines the symmetry of replacements of the finite discrete elements (points, simplex) in the piecewise-linear topology. It is based on the 24-dimensional even unimodular Leech lattice.

The equations of geometrodynamics permit the ultimately possible "complexification" by way of using octonions (the Caley numbers). The octonions multiplication is not only non commutative but nonassociative either. The latter property is extrapolated to the Griss-Fisher algebra, which is nevertheless commutative. The non-associative quality of operators algebra of the secondly quantized field theory expressed the property of T-irreversibility at the micro-level. Due to conformal invariance this property is translated towards macroscopic phenomena.

5.4. CGD and Superstrings

Which is the last step to make in the theory of superstrings towards the construction of the unique unified theory? Certainly, this step is quantizing of gravity. As a result, in theory will disappear the last dimensional scale – the fundamental scale of string. In this case, the theory will possess the properties of the local scale invariance, while nonperturbative methods will be applicable for quantitative calculations by way of translating the algebraic correlations between physical values to different levels of scales, including the level of ordinary phenomena, which emerge in case of continua motion under normal conditions.

To a certain extent, the multi-loop amplitudes of physical processes in the quantum theory of superstrings serve as solutions of classical differential equations, which are generated in the infinite dimensional representations theory due to its algebraic structure. If to introduce the quantized gravitation fields into the theory, the relation between such quantum object and such classical object become isomorphism. Notably, this isomorphism provides the nonperturbative mathematical technique in the form of the integrable system of non-linear differential equations. Basically, all the aforementioned is expressed by the CGD equations in the closed form.

Now let us turn right to the theme for this ESSAY contest.

6. What is ultimately possible in physics?

6.1. What role does 'impossibility' principles in fundamental physics and cosmology?

The laws underlying CGD may be formulated in the form of 'impossibility' principles:

1) causality is impossible to be violated;
2) absolute scales do not exist.

The direct consequence of the second principle is the fact that the fundamental physical constants $c, \hbar, G$ are secondary. Accordingly to this at present the velocity of light in free space is set by definition 2,997925 cm/sec. The possibility to remove Planck's constant $\hbar$ from theoretical description was demonstrated above on the example of hydrogen atom. Another consequence is the following conjecture: Heisenberg uncertainty principle is the consequence from CGD. Other mentioned principles such as the holographic if they true must be the consequences. More ambiguous issue is the second law of thermodynamics. CGD brings to the principle of entropy increasing, but in the areas with large four-accelerations entropy may temporary decrease. As for cosmology, all solutions of the Schwarzschild, Kerr, and Friedmann types must be corrected in the accordance with CGD. Correspondingly, the analysis of observations brought to the concepts of dark energy, dark matter and so on, must be adjusted basing on CGD solutions. In the frameworks of CGD even the problem of uniqueness of the Solar System becomes meaningful.

6.2. What are the limits of physics explanatory and predictive power?

From the CGD point of view the Universe has hierarchical structure, and all its part of various scales are connected with each other in some way. CGD allows quantitative analysis of this hierarchy, and it can be built both upwards, starting from the smallest structures, and from the top to the bottom, starting from the Universe as a whole. One example is the calculations of the fine structure constant and proton to electron mass ratio totally based on CGD. These values are dimensionless and depend only on the structural constants, which characterize geometric and algebraic properties of the structures, which emerge in theory. Another Pushkin data point connects the Hubble constant H_0 with micro- physical parameters defining the vacuum states of fermions comprising the hydrogen atom:

$H_0^2 = \frac{8\pi G}{3}\left\{\left(\frac{m_p}{\lambda\!\!\!^{-}{}_p^3}\right) + \left(\frac{m_e}{\lambda\!\!\!^{-}{}_e^3}\right)\right\}\cdot\frac{1}{24}\cdot\frac{1}{[N_0]}$, where G is the gravity constant, m_p, m_e и $\lambda\!\!\!^{-}{}_p, \lambda\!\!\!^{-}{}_e$ are the mass and Compton wavelength length of proton (electron), and $[N_0] =$ 8.080174...$\cdot 10^{44}$ is a number of elements in the Monster Group, which is factorized by the group of displacements. Numerically, this expression gives $H_0^{-1} = 13.9 \cdot 10^9$ years. Theoretically controlled computational accuracy is comparable with the accuracy of advanced measurements. CGD predictive power was demonstrated also by calculations one phenomenological parameter of Standard Model – electroweak mixing angle [11]. The problems of present technology also fall into the sphere of this approach (for example [12], where some problem issues of plutonium alloys are considered) and life science as well (for example, [9], where the issue of DNA coagulation is discussed).

In some sense CGD is the base for unifying all known fundamental forces. In CGD it is possible simultaneously to change coordinates and scales. As the result we can obtain the finite domain in space-time where the curvature is null. In such domain operators of bispinor and gauge fields satisfy to Dirac equation. But boundary conditions in CGD and standard form of quantum theory are different: in quantum theory they are only approximate. In theory of gravitation it is usually preferable to put Weyl vector equal to zero, in this case the curvature is nonzero in many situations (Schwarzschild, Kerr solutions). In CGD unification it is possible to resolve singularity problem due to possibility to find the regular branches of exact solutions at any initial conditions and to existence of discontinuity surfaces.

Computing possibilities also could be improved in essence if hardware and software will be adjusted to CGD principles. We have good reasons to believe that CGD equations are fully integrable so it is possible to develop analytical algorithms for calculations of fluid complex movements. A.V. Pushkin named as operational violation of causality the impossibility to calculate accurately the characteristics of complex system, like a uranium atom, because of exponential growth of the number of the required operations and fast growth of the phase space dimensionality in quantum theory. In [9] he suggests the approach which relying on CGD may improve significantly the computational methodology. Presumably, such approach may prove to be much closer to the most perfect computer, i.e. the Nature.

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