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GEOMETRIZATION OF PHYSICAL INTERACTIONS, 5-DIMENSIONAL THEORIES AND THE MANY-WORLD PROBLEM

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From an analysis of 5-dimensional unification theories, it is concluded, in particular, that the Dirac spinors, as well as the gravi-electromagnetic field, are 5-dimensional objects. A picture of multiple parallel universes, connected with different values of the cyclic 5th coordinate, is suggested.

Two fundamental interactions with an infinite range are known, the gravitational and electromagnetic ones, which therefore are observable on the macroscopic level. In General Relativity the gravitational field is geometrized and manifests itself as the curvature of the space-time, considered to be a 4-dimensional Riemannian manifold with the invariant metric $ds^2 = g_{\alpha\beta}dx^\alpha dx^\beta \ \ (\alpha, \beta = 1, 2, 3, 4)$. The space-time curvature is induced by the matter distributions according to the Einstein equations $R_{\alpha\beta} - \frac{1}{2}R_{\alpha\beta} = æT_{\alpha\beta}$.

The most successful solution to the problem of geometrization of the electromagnetic field is obtained in the frames of the 5-dimensional Kaluza theory, which was recently improved and generalized [1]. According to this theory, the world is considered as a 5-dimensional manifold with the signature $(-++++)$. The 5-dimensional Einstein vacuum equations are used as the field equations:

$$ {}^5R_{AB} - \frac{1}{2}{}^5R g_{AB} = 0 \ \ (A, B = 1, 2, 3, 4, 5), \tag{1} $$

or the corresponding variational equations obtainable from an extremal action principle where the 5-dimensional curvature scalar ${}^5R$ is used as the Lagrangian. The ten components of the 4-dimensional space-time metric tensor of

$$ \tilde{g}_{\alpha\beta} = g_{\alpha\beta} - \frac{g_{\alpha 5}g_{\beta 5}}{g_{55}} \ \ (\alpha, \beta = 1, 2, 3, 4) \tag{2} $$

and the four components of the electromagnetic potential A_α

$$ A_\alpha = \frac{c^2}{2\sqrt{k}} g_{\alpha 5}/\sqrt{g_{55}} \tag{3} $$

are constructed from the fifteen components of the 5-dimensional metric tensor g_{AB}. The g_{55} component determines specific geometric scalar field.

This procedure is made conveniently in the frames of the monad formalism, where a monad vector λ^A, orthogonal to the 4-dimensional space-time ($\lambda^A \tilde{g}_{AB} = 0$), and a chronometric gauge are used:

$$ \lambda_A = g_{A5}/\sqrt{g_{55}}; \ \ \lambda_A \lambda^A = 1. \tag{4} $$

Then the admissible coordinate transformations of the Einstein group $x'^A = x'^A(x^A)$ reduce to transformations corresponding to the chronometric gauge:

$$ \begin{aligned} x'^5 &= x'^5(x^1, x^2, x^3, x^4, x^5); \\ x'^\mu &= x'^\mu(x^\mu). \end{aligned} \tag{5} $$

When the geometric scalar field is absent ($g_{55} \equiv \varphi^2 = 1$) and one postulates the cylindricity condition for the metric component dependence on x^5: $g_{AB} = g_{AB}(x^\alpha)$, the 5-dimensional Einstein equations (1) are reduced to the Einstein-Maxwell set of equations by means of the (4+1)-splitting procedure:

$$ \begin{aligned} &{}^4\tilde{R}_{\alpha\beta} - \frac{1}{2}{}^4\tilde{R}\tilde{g}_{\alpha\beta} = \frac{k}{c^4}(-F_{\alpha\sigma}F_{\beta\cdot}^{\ \sigma} + \frac{1}{4}F_{\mu\nu}F^{\mu\nu}g_{\alpha\beta}); \\ &F^{\alpha\beta}{}_{;\beta} = 0. \end{aligned} \tag{6} $$

where $F_{\alpha\beta} \equiv c^2/\sqrt{k}(\partial_\alpha g_{\beta 5} - \partial_\beta g_{\alpha 5})$ is the Maxwell stress tensor. The curvature is calculated here using the effective metric tensor of the 4-dimensional space-time $\tilde{g}_{\alpha\beta} = g_{\alpha\beta} - g_{\alpha 5}g_{\beta 5}$. The cylindricity condition reduces the class of admissible coordinate transformations to

$$ \begin{cases} x'^5 = x^5 + f(x^\alpha) & (a); \\ x'^\mu = x'^\mu(x^\mu) & (b). \end{cases} \tag{7} $$

The transformations (7a) create gradient transformations for the electromagnetic potentials $A_\mu \equiv g_{5\mu}/2\sqrt{k}c^2$:

$$ A'_\mu = A_\mu + \partial_\mu(\frac{c^2}{2\sqrt{k}}f). \tag{8} $$

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So gauge (gradient) transformations of the electromagnetic field follow from the 5th coordinate transformations, i.e. are an effect of the 5th dimension.

The geodesic equations in the 5-dimensional space-time

$$\frac{d^2x^A}{dI^2} + \Gamma_{BC}{}^A \frac{dx^A}{dI}\frac{dx^B}{dI} = 0 \qquad (dI^2 = g_{AB}dx^A dx^B)$$

are transformed using the (4+1)-decomposition into four standard equations of motion of a charged particle in gravitational and electromagnetic fields:

$$\frac{du^\mu}{ds} + \tilde{\Gamma}_{\alpha\beta}{}^\mu u^\alpha u^\beta + qF_{\alpha\cdot}{}^\mu u^\alpha = 0 \quad \left(u^\mu = \frac{dx^\mu}{ds}\right) \tag{9}$$

and the electric charge conservation law

$$mu^5 \equiv \frac{q}{2\sqrt{k}} = \text{const} \quad \left(u^5 \equiv \frac{dx^5}{ds} + \lambda_\mu u^\mu\right) \tag{10}$$

where the electric charge q coincides with the 5th momentum component.

There is a wonderful similarity between the space-time differential operators in the 5-dimensional space

$$\tilde{\partial}_\sigma = \frac{\partial}{\partial x^\sigma} - g_{\sigma 5}\frac{\partial}{\partial x^5} \tag{11}$$

and the differential operators in standard electrodynamics

$$\partial_\sigma = \frac{\partial}{\partial x^\sigma} - A_\sigma. \tag{12}$$

If in (11) the identification $g_{\sigma 5} = \frac{2\sqrt{k}}{c^2}A_\sigma$ is made and the wave function of the charged matter fields depends on x^5 cyclically,

$$\psi(x^A) = \psi(x^\alpha)\exp\left(\frac{ice}{2\sqrt{k}h}x^5\right), \tag{13}$$

then we have

$$\tilde{\partial}_\mu\psi = \left(\frac{\partial}{\partial x^\mu} - \frac{2\sqrt{k}}{c^2}A_\mu\frac{\partial}{\partial x^5}\right)\psi = \left(\frac{\partial}{\partial x^\mu} - \frac{ie}{\hbar c}A_\mu\right)\psi. \tag{14}$$

It is easy to notice that the $U(1)$ phase transformations follow automatically from the transformations of x^5 (7a):

$$\psi \to \psi\,\exp\left(\frac{iec}{2\sqrt{k}h}f(x^\mu)\right);$$
$$A_\mu \to A_\mu + \partial_\mu\left(\frac{c^2}{2\sqrt{k}}f\right). \tag{15}$$

From the viewpoint of 5-dimensional theory, the electric charge conservation law is a manifestation of the 5-dimensional momentum conservation law which follows from homogeneity of the 5-dimensional space-time in accordance with the Noether theorem.

These results show that the Maxwell theory is entirely described in the frames of the 5-dimensional theory and the gravi-electromagnetic field is the gravitational field in the 5-dimensional space-time.

As an example of application of this 5-dimensional theory of the gravi-electromagnetic interaction, let us take the spherically symmetric static solution to the vacuum 5-dimensional Einstein equations. The 5-dimensional line element has the form

$$dI^2 = -e^{\nu(r)}dt^2 + e^{\lambda(r)}dr^2 + e^{\mu(r)}(d\theta^2 + \sin^2\theta d\varphi^2) + 2\phi dt\,dx^5 + \varphi^2(r)(dx^5)^2.$$

Here

$$e^\mu = r^2 \quad\text{and}\quad \varphi^2 = G_{55} = 1; \quad \phi = \frac{2\sqrt{k}}{c^4}\varphi_c$$

where φ_c is the electric potential. This is an example of the 5-dimensional Reissner-Nordström problem. The 5-dimensional vacuum Einstein equations are written in the following way:

$$\begin{cases} \phi'' + \left(\frac{2}{r} - \frac{\lambda'}{2} - \frac{\tilde{\nu}'}{2}\right)\phi' = 0; \\ \lambda' + \nu' = 0; \ \ e^{-\lambda}\left(\frac{1}{r^2} + \frac{\tilde{\nu}'}{r}\right) = \frac{1}{r^2} - \phi'^2. \end{cases} \tag{16}$$

Here $\tilde{\nu}' = (e^\nu\nu' + 2\phi\phi')/(e^\nu + \phi^2)$; $e^{\tilde{\nu}} = e^\nu + \phi^2$. From (16) we obtain:

$$\phi'' + \frac{2}{r}\phi' = 0; \quad \phi = \frac{c}{r}; \quad \varphi_c = \frac{q}{r};$$
$$e^{-\lambda} = e^{\tilde{\nu}} = 1 - \frac{r_g}{r} + \frac{l_e^2}{r^2}$$
$$(l_e^2 = \frac{k}{c^4}q^2, \quad q = \text{electric charge}),$$

i.e., we have obtained the Reissner-Nordström solution. When 4-dimensional gravity is absent ($\lambda = \nu = 0$, or in the general case $g_{\alpha\beta} = \eta_{\alpha\beta}$), the function $\phi(r)$ is described by the nonlinear equation

$$\phi'' + \left(\frac{2}{r} - \frac{\phi\phi'}{1+\phi^2}\right)\phi' = 0. \tag{17}$$

One can get the following solution:

$$\phi = \sinh(\frac{\beta q}{r}); \ \varphi_c = \frac{1}{\beta}\sinh\frac{\beta q}{r} = \frac{q}{r} + \frac{\beta^2 q^3}{r^3} + \ldots \tag{18}$$

i.e. the Coulomb solution is the first iteration of the total solution (18).

In the general case, when 4-dimensional gravity is absent ($g_{\alpha\beta} = \eta_{\alpha\beta}$), the geometric 5-dimensional Lagrangian $\sqrt{-^5g}\,^5R$ reduces to that of nonlinear electrodynamics:

$$L_g = F_{\alpha\beta}F^{\alpha\beta}/\left(1 - \frac{4k}{c^4}A_\alpha A^\alpha\right). \tag{19}$$

When the geometric scalar field is present ($g_{55} = \varphi^2 \neq \text{const}$), we have the following solution to this problem:

$$\begin{aligned} e^{\nu} &= \left(\frac{ar+b-2\sqrt{3}}{ar+b+2\sqrt{3}}\right)^{\sqrt{3}/3}; \qquad e^{\lambda} = e^{-2\nu}; \\ e^{\mu} &= \frac{1}{16}\frac{(ar+b+2\sqrt{3})^{2/\sqrt{3}+1}}{(ar+b-2\sqrt{3})^{2/\sqrt{3}-1}}; \\ \phi &= \frac{2\sqrt{k}}{c^2} q e^{\nu/2}; \qquad \varphi^2 = k^2 e^{\nu}. \end{aligned} \tag{20}$$

(here $a = 4/r_g$, $b = (4l_q^2 - 2r_g^2)/r_g^2$).

As the gravi-electromagnetic field is the curvature of the 5-dimensional space-time, i.e., a 5-dimensional object, matter which consists of quarks and leptons may be regarded as a 5-dimensional object too. Indeed, the spinor wave functions for quarks and leptons, which are determined by the Dirac equation, belong to the 5-dimensional space rather than the 4-dimensional one. It is explained by the fact that Dirac spinors are the Clifford algebra representations of $C(4,1)$ type. The Clifford algebra $C(4,1)$ corresponds to the 5-dimensional manifold with the signature $(- \; + \; + \; + \; +)$ and the Dirac matrices $\gamma_1\gamma_2\gamma_3\gamma_4\gamma_5 = (1/24!)\varepsilon_{\alpha\beta\lambda\sigma}\gamma^\alpha\gamma^\beta\gamma^\lambda\gamma^\sigma$, are generators of the Clifford algebra $C(4,1)$. Consequently, the Dirac equation can be written in the 5-dimensional space-time: $\gamma^A\nabla_A\psi + \mu\psi = 0$, where five Dirac matrices γ_A are determined by the condition of fundamental connection of space with spin:

$$\gamma_A\gamma_B + \gamma_B\gamma_A = 2g_{AB}. \tag{21}$$

Apparently, the Dirac spinors, just as the gravi-electromagnetic field, are 5-dimensional objects. The Lagrangian of the Dirac spinor field in the 5-dimensional space-time can be written in the form

$$L = \frac{\hbar c}{2}\left[\nabla_A\overline{\psi}\gamma^A\psi - \overline{\psi}\gamma^A\nabla_A\psi - \mu\overline{\psi}\psi\right]. \tag{22}$$

Here $\nabla_A\psi$ is the spinor covariant derivative: $\nabla_A\psi = \partial_A\psi - \Gamma_A\psi$, where Γ_A is the spinor connection, determined by the formula

$$\Gamma_A = \frac{1}{4}\gamma_B({\Gamma_{AB}}^D\gamma_D - \partial_A\gamma_B). \tag{23}$$

Eq. (23) is derived from the condition $\nabla_A\gamma_B = 0$ using the tetrad formalism. Here ${\Gamma_{AB}}^C$ are the connection coefficients of the 5-dimensional space-time. As was pointed out before [2, 3, 4], it is better to consider the spinor field in a space equipped with torsion ${Q_{AB}}^C = {\Gamma_{[AB]}}^C$, used in the spinor connections (23). In general, the connections coefficients ${\Gamma_{AB}}^C$ in the affine-metric space are decomposed into the following parts:

$${\Gamma_{AB}}^C = \left\{{}^{\,C}_{AB}\right\} + {Q_{AB}}^C + Q^C_{\cdot AB} + Q^C_{\cdot BA} + {\Omega_{AB}}^C, \tag{24}$$

where ${\Omega_{AB}}^C$ is the segmentary curvature tensor determined in terms of the metric covariant derivative $\nabla_A g_{BC}$. It was shown [4] that the spinor field can interact only with antisymmetric torsion and the trace of the segmentary curvature tensor $V_A = \frac{1}{5}{\Omega_{AC}}^C$. Consequently, when we consider the spinor field, the connection coefficients may be written in the form

$${\Gamma_{AB}}^C = \left\{{}^{\,C}_{AB}\right\} + {Q_{AB\cdot}}^C + V^C g_{AB} - \delta^C_A V_B - \delta^C_B V_A. \qquad (Q_{ABC} = Q_{[ABC]}) \tag{25}$$

We shall assume that the spinor field depends on the 5th coordinate cyclically: $\psi(x^A) = \psi(x^\mu)e^{i\alpha x^5}$, ($\alpha$ is a constant). Then the spinor Lagrangian (22), taking into account (23), (25) and using the (4+1)-decomposition procedure, is represented in the following form:

$$L = L_c(\partial_\mu\psi) + \hbar c(\mu\overline{\psi}\psi - \alpha\overline{\psi}\gamma_5\psi + 2V\overline{\psi}\gamma_5\psi) + L_{\text{int}}. \tag{26}$$

Here $L_c(\partial_\mu\psi)$ is the kinetic part of the spinor Lagrangian depending on spinor derivatives alone, L_{int} is the interaction Lagrangian and $V = V^A\lambda_A$ is the projection of the non-metricity vector V^A on the monade vector λ_A;

$$L_{\text{int}} = ie\hbar c A^\alpha\overline{\psi}\gamma_\alpha\psi + \frac{\hbar c}{2}(3Q^\alpha + \omega^\alpha)\overline{\psi}\gamma_\alpha\gamma_5\psi + 2\hbar c\tilde{V}^\alpha\hbar\psi\gamma_\alpha\psi. \tag{27}$$

Here $A_\alpha = \dfrac{c^2}{2\sqrt{k}}g_{5\alpha}$, $Q^\alpha = \dfrac{1}{6}\varepsilon^{\alpha\beta\lambda\sigma}\tilde{Q}_{\beta\lambda\sigma}$ is the pseudotrace of the 4-dimensional torsion $\tilde{Q}_{\beta\lambda\sigma} = Q_{ABC}\tilde{g}^A_\beta\tilde{g}^B_\lambda\tilde{g}^C_\sigma$, $\tilde{V}_\alpha = V_A\tilde{g}^A_\alpha$, $\omega^\alpha = \frac{1}{2}\varepsilon^{\alpha\beta\lambda\sigma}h^{(a)}_\beta h_{(a)\lambda;\sigma}$ is the rotation angular velocity of the 4-dimensional space-time ($h^{(a)}_\beta$ are the tetrad vectors). Besides, we have excluded the anomalous magnetic moment (AMM) term $(3F_{\alpha\beta} + {Q^5}_{\alpha\beta})\overline{\psi}\gamma_5\gamma^\alpha\gamma^\beta\psi$, where ${Q^5}_{\alpha\beta} = Q_{ABC}\lambda^A g^B_\alpha g^C_\beta$, which appears in the L_{int}. It may be done owing to the fact that the condition for Dirac matrices $\gamma_A\gamma_B + \gamma_B\gamma_A = 2g_{AB}$ is invariant under gauge transformations:

$$\nabla_A\gamma_B \to \nabla_A\gamma_B + K_A\gamma_B - \gamma_B K_A,$$

where K_A is an arbitrary spintensor. These transformations induce the spin connection transformations:

$$\Gamma_A \to \Gamma_A + K_A. \tag{28}$$

If we decompose the spintensor K_A, using the spintensor Dirac matrix basis γ_A, $\gamma_A\gamma_5$, $\gamma_{[\alpha}\gamma_{\beta]}$, into independent parts:

$$K_A = \varphi\gamma_A + b\gamma_A\gamma_5 + a_{[\alpha\beta]}\gamma^\alpha\gamma^\beta, \tag{29}$$

where φ, b, $a_{[\alpha\beta]}$ are the decomposition coefficients, then, using the gauge transformation of the spinor connection (28), we subject the spinor Lagrangian to the gauge transformation

$$L \to L + a^{\alpha}\overline{\psi}\gamma_{\alpha}\psi + \varphi\overline{\psi}\psi + b\overline{\psi}\gamma_5\psi + a_{[\alpha,\beta]}\overline{\psi}\gamma_5\gamma^{[\alpha}\gamma^{\beta]}\psi \qquad (30)$$

Choosing the conterterms $\varphi, b, a_{[\alpha,\beta]}$, we can exclude the AMM term and the scalar and pseudoscalar terms $(V-\alpha)\overline{\psi}\gamma_5\psi, \mu\overline{\psi}\psi$ in (26) and obtain $L_{\rm int}$ (27). The resulting spinor Lagrangian in the 5-dimensional space-time with torsion

$$L = L_c(\partial_\mu\psi) + ie\hbar c A_\alpha\overline{\psi}\gamma^\alpha\psi + \hbar c(3Q^\alpha + \omega^\alpha)\overline{\psi}\gamma_\alpha\gamma_5\psi + 2\hbar c V^\alpha\overline{\psi}\gamma_\alpha\psi \qquad (31)$$

coincides with the Lagrangian of the electron field interacting with neutral vector fields, electromagnetic field A_α and the Z^0 boson field in the electroweak interactions theory:

$$L = L_\mu(\partial_\mu\psi) + ie\hbar c A^\alpha\overline{\psi}\gamma_\alpha\psi + \frac{\sqrt{g_1^2+g_2^2}}{2}Z^\alpha\overline{\psi}\gamma_\alpha\gamma_5\psi + \frac{3g_1^2-g_2^2}{\sqrt{g_1^2+g_2^2}}iZ^\alpha\overline{\psi}\gamma_\alpha\psi \qquad (32)$$

A comparison of (31) and (32) leads to the identification

$$\begin{aligned} 3\hbar c Q^\alpha &= \frac{\sqrt{g_1^2+g_2^2}}{2}Z_\alpha; \\ 2\hbar c V_\alpha &= \frac{i(3g_1^2-g_2^2)}{4\sqrt{g_1^2+g_2^2}}Z_\alpha, \end{aligned} \qquad (33)$$

i.e., the Z^0 boson coincides with the torsion pseudotrace, and the nonmetricity induces the P invariance violation. The identification (33) and the Lagrangian (31) may be induced by the P-noninvariant connection $\tilde{\Gamma}_{\alpha\beta}{}^{\lambda}$ of the 4-dimensional space-time, derived from the 5-dimensional connection $\Gamma_{AB}{}^{C}$ in (25), using the space-time projecting procedure:

$$\tilde{\Gamma}_{\alpha\beta}{}^{\lambda} = \widetilde{\left\{ {\lambda \atop \alpha\beta} \right\}} + \varepsilon_{\alpha\beta}{}^{\lambda}{}_{\cdot\sigma}Q^\sigma + \frac{3}{4}i\frac{3g_1^2-g_2^2}{g_1^2+g_2^2}(Q^\lambda\tilde{g}_{\alpha\beta} - \delta^\lambda_\beta Q_\alpha - \delta^\lambda_\alpha Q_\beta)$$

Thus the assumption can be expressed, that the P-invariance violation in weak interaction is induced by the space-time P-noninvariance due to the presence of a P-noninvariant connection in it.

A similar result can be obtained using the P-noninvariant connection

$$\tilde{\Gamma}_{\alpha\beta}{}^{\lambda} = \widetilde{\left\{ {\lambda \atop \alpha\beta} \right\}} + \frac{2}{3}(\tilde{g}^\lambda_\beta Q_\alpha - Q^\lambda\tilde{g}_{\alpha\beta}) + \varepsilon_{\alpha\beta}{}^{\lambda}{}_{\cdot\sigma}Q^\sigma \qquad (34)$$

which is the 4-dimensional projection of the 5-dimensional connection

$$\Gamma_{AB}{}^{C} = \left\{ {C \atop AB} \right\} + \frac{1}{2}(\delta^C_B Q_A - Q^C g_{AB}) + Q_{[ABD]}g^{DC}, \qquad (35)$$

where $Q_A = Q_{AC}{}^{C}$ is the torsion tensor trace, if the spinor field can interact with the torsion trace, when quantum corrections are taken into account [5]. In this case a nonmetricity is not used, but the torsion trace is. The present consideration shows that, in the frames of a 5-dimensional theory, the electroweak interaction may be geometrized too, at least the neutral sector of the electroweak interaction theory is obtained automatically.

Investigations in this direction show that a geometrization of the charged sector of electroweak interaction theory requires a significant generalization of the geometry, in particular, its complexification. The present situation leads to the suggestion, that the electroweak interaction is actually a composition of two interactions of the same intensity: the first one corresponds to the neutral sector of the theory, while the second one corresponds to the charged sector.

Thus we have seen that both the gravi-electromagnetic field and the matter particles, fermions (quarks, leptons) are 5-dimensional objects and act in a 5-dimensional space-time, i.e., the 5-dimensional space-time is real.

We know, however, that the observed physical space-time is 4-dimensional, selected by its properties of simplicity and stability:

1. The atom is stable in only in a 4-dimensional space-time.
2. Orbits of test bodies in a central gravitational field (such as planetary orbits in the Solar field) are stable in spaces with the dimension $n \leq 4$ and are unstable when $n \geq 5$.
3. The Huygens principle is valid in even-dimensional space-times.
4. In a 4-dimensional space-time spherical waves can propagate and information is not distorted.
5. Quantum electrodynamics is renormalized only in a space-time with $n \leq 4$.
6. There are two extreme kinds of statistics: the Fermi-Dirac one and the Bose-Einstein one only in 4-dimensional and 8-dimensional spaces. In spaces with other dimensions intermediate kinds of statistics (parastatistics) are possible as well.
7. The vacuum Maxwell equations are conformally invariant only in a 4-dimensional space-time.
8. The 4-dimensional space-time is the least dimension when the Einstein theory in vacuum is nontrivial, i.e., the vacuum Einstein equations ($R_{\alpha\beta} = 0$) do not reduce to flat space and consequently propagation of the gravitational interaction through empty space is possible.

9. $n = 4$ is the smallest dimension when a nontrivial conform-invariant Weyl tensor exists, i.e., the one untransformed to zero in empty space.

There are many other arguments which point out the unique nature of the 4-dimensional space-time, exhibiting an optimal combination of simplicity, stability and physical consistence.

As a result, we arrive at the following situation: The real world (space-time and matter contained in it) is 5-dimensional, but its subspace, the 4-dimensional space-time, possesses optimal correlational properties of simplicity, stability and physical pithiness as compared with spaces of other dimensions.

This situation may be explained by an assumption that for nature "it is advantageous" to stratify the 5-dimensional world to a great number of stable 4-dimensional worlds along the 5-th coordinate. The real 5-dimensional Universe is evolving and is accomplishing a phase transition to the stable state by such a stratification. Thus the real 5-dimensional space-time consists of a totality of 4-dimensional stable worlds of a very small thickness along the 5-th coordinate, which form a periodic sequence, if the cyclicity in the 5-th coordinate is interpreted as the periodicity of the sequence of worlds. So we come to a conclusion on the existence of a great number of parallel universes.

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