Graviweak Unification in the Visible and Invisible Universe and Inflation from the Higgs Field False Vacuum

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Abstract

In the present paper we develop the self-consistent $Spin(4,4)$-invariant model of the unification of gravity with weak $SU(2)$ interactions in the assumption of the existence of visible and invisible sectors of the Universe. It was shown that the consequences of the multiple point principle predicting two degenerate vacua in the Standard Model (SM) suggest a theory of Inflation, in which the inflaton field σ starts trapped in a cold coherent state in the "false vacuum" of the Universe at the value of the Higgs field's VEV $v \sim 10^{18}$ GeV (in the visible world). Then the inflations of the two Higgs doublet fields, visible ϕ and mirror ϕ', lead to the emergence of the SM vacua at the Electroweak scales with the Higgs boson VEVs $v_1 \approx 246$ GeV and $v_1' = \zeta v_1$ (with $\zeta \sim 100$) in the visible and invisible worlds, respectively.

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1 Introduction

In Ref. [1] a model of unification of gravity with the weak $SU(2)$ gauge and Higgs fields was constructed. We imagine that at the early stage of the evolution of the Universe the GUT-group was broken down to the direct product of gauge groups of internal symmetry and Spin(4,4)-group of the Graviweak unification.

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In the assumption that there exist visible and invisible (hidden) sectors of the Universe, we presented the hidden world as a Mirror World (MW) with a broken Mirror Parity (MP). In the present paper we give arguments that MW is not identical to the visible Ordinary World (OW). We started with an extended $\mathfrak{g} = \mathfrak{spin}(4,4)_L$-invariant Plebanski action in the visible Universe, and with $\mathfrak{g} = \mathfrak{spin}(4{,}4)_R$-invariant Plebanski action in the MW. Then we have shown that the Graviweak symmetry breaking leads to the following sub-algebras: $\tilde{\mathfrak{g}} = \mathfrak{su}(2)_L^{(grav)} \oplus \mathfrak{su}(2)_L$ – in the ordinary world, and $\tilde{\mathfrak{g}}' = \mathfrak{su}(2)'^{(grav)}_R \oplus \mathfrak{su}(2)'_R$ – in the hidden world. These sub-algebras contain the self-dual left-handed gravity in the OW, and the anti-self-dual right-handed gravity in the MW. Finally, at low energies, we obtain a Standard Model (SM) group of symmetry and the Einstein-Gilbert's gravity. In this approach we have developed a model of Inflation, in which the inflaton σ, being a singlet, decays into the two Higgs doublets of the SM: $\sigma \to \phi^\dagger\phi$, and then the interaction between the ordinary and mirror Higgs fields (induced by gravity) leads to the hybrid model of the Inflation.

In Section 2 we considered the Plebanski's theory of gravity, in which fundamental fields are 2-forms, containing tetrads, spin connections and auxiliary fields. Then we have used an extension of the Plebanski's formalism of the 4-dimensional gravitational theory, and in Section 3 we constructed the action of the Graviweak unification model, described by the overall unification parameter g_{uni}. Section 4 is devoted to the Multiple Point Model (MPM), which allows the existence of several minima of the Higgs effective potential with the same energy density. The MPM assumes the existence of the SM itself up to the scale $\sim 10^{19}$ GeV, and predicts that there exist two degenerate vacua into the SM: the first one – at the Electroweak scale (with the VEV $v_1 \simeq 246$ GeV), and the second one – at the Planck scale (with the VEV $v = v_2 \sim 10^{18}$ GeV). In Section 5 we consider the existence in the Nature of the Mirror World (MW) with a broken Mirror Parity (MP): the Higgs VEVs of the visible and invisible worlds are not equal,[1] $\langle\phi\rangle = v$, $\langle\phi'\rangle = v'$ and $v \neq v'$. The parameter characterizing the violation of the MP is $\zeta = v'/v \gg 1$. We have used the result $\zeta \simeq 100$. In Section 6 we suggest a hybrid model of Inflation provided with the visible Higgs field ϕ and mirror Higgs boson ϕ', which interact during Inflation via gravity. This interaction leads to the emergence of the SM vacua at the Electroweak scales with the Higgs boson VEVs $v_1 \approx 246$ GeV and $v'_1 = \zeta v_1$ (with $\zeta \sim 100$) in the visible and invisible worlds, respectively, while the original "false vacuum" exists at the Planck scale and has VEV $v = v_2 \sim 10^{18}$ GeV. Section 7 contains conclusions.

2 Plebanski's formulation of General Relativity

General Theory of Relativity (GTR) was formulated by Einstein as dynamics of the metrics $g_{\mu\nu}$. Later, Plebanski [3] and other authors (see for example [4, 5]) presented GTR in the self-dual

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[1] In this paper the superscript 'prime' denotes the M- or hidden H-world.

approach, in which fundamental variables are 1-forms of connections A^{IJ} and tetrads e^I :

$$A^{IJ} = A^{IJ}_\mu dx^\mu, \qquad e^I = e^I_\mu dx^\mu. \tag{1}$$

Also 1-form $A = \frac{1}{2}A^{IJ}\gamma_{IJ}$ is used, in which generators γ_{IJ} are products of generators of the Clifford algebra $Cl(1,3)$: $\gamma_{IJ} = \gamma_I\gamma_J$. Indices $I, J = 0, 1, 2, 3$ belong to the space-time with Minkowski's metrics $\eta^{IJ} = \mathrm{diag}(1, -1, -1, -1)$, which is considered as a flat space, tangential to the curved space with the metrics $g_{\mu\nu}$. In this case connection belongs to the local Lorentz group $SO(1,3)$, or to the spin group $Spin(1,3)$. In general case of unifications of gravity with the $SU(N)$ or $SO(N)$ gauge and Higgs fields, the gauge algebra is $\mathfrak{g} = \mathfrak{spin}(p,q)$, and we have $I, J = 1, 2...p+q$. In our model of unification of gravity with the weak $SU(2)$ interactions we consider a group of symmetry with the Lie algebra $\mathfrak{spin}(4,4)$. In this model indices I, J run over all 8×8 values: $I, J = 1, 2.., 7, 8$.

For the purpose of construction of the action for any unification theory, the following 2-forms are also considered:

$$\mathrm{B}^{IJ} = e^I \wedge e^J = \tfrac{1}{2}e^I_\mu e^J_\nu dx^\mu \wedge dx^\nu,$$

$$\mathrm{F}^{IJ} = \tfrac{1}{2}F^{IJ}_{\mu\nu} dx^\mu \wedge dx^\nu,$$

where $F^{IJ}_{\mu\nu} = \partial_\mu A^{IJ}_\nu - \partial_\nu A^{IJ}_\mu + [A_\mu, A_\nu]^{IJ}$, which determines the Riemann-Cartan curvature: $R_{\kappa\lambda\mu\nu} = e^I_\kappa e^J_\lambda F^{IJ}_{\mu\nu}$. Also 2-forms of B and F are considered :

$$B = \frac{1}{2}B^{IJ}\gamma_{IJ}, \qquad F = \frac{1}{2}F^{IJ}\gamma_{IJ}, \qquad F = dA + \frac{1}{2}[A, A]. \tag{2}$$

The well-known in literature Plebanski's BF-theory is submitted by the following gravitational action with nonzero cosmological constant Λ:

$$I_{(GR)} = \frac{1}{\kappa^2}\int \epsilon^{IJKL}\left(B^{IJ} \wedge F^{KL} + \frac{\Lambda}{4}B^{IJ} \wedge B^{KL}\right), \tag{3}$$

where $\kappa^2 = 8\pi G_N$, G_N is the Newton's gravitational constant, and $M^{red}_{Pl} = 1/\sqrt{8\pi G_N}$.

Considering the dual tensors:

$$F^*_{\mu\nu} \equiv \frac{1}{2\sqrt{-g}}\epsilon^{\rho\sigma}_{\mu\nu}F_{\rho\sigma}, \qquad A^{\star IJ} = \frac{1}{2}\epsilon^{IJKL}A^{KL},$$

we can determine self-dual(+) and anti-self-dual(-) components of the tensor A^{IJ}:

$$A^{(\pm)\,IJ} = (\mathcal{P}^\pm A)^{IJ} = \frac{1}{2}\left(A^{IJ} \pm iA^{\star IJ}\right). \tag{4}$$

Two projectors on the spaces of the so-called self- and anti-self-dual tensors

$$\mathcal{P}^\pm = \frac{1}{2}\left(\delta^{IJ}_{KL} \pm \epsilon^{IJ}_{KL}\right)$$

carry out the following homomorphism:

$$\mathfrak{so}(1,3) = \mathfrak{su}(2)_R \oplus \mathfrak{su}(2)_L. \tag{5}$$

As a result of Eq. (5), non-zero components of connections are only $A^{(\pm)i} = A^{(\pm)0i}$. Instead of (anti-)self-duality, the terms of left-handed (+) and right-handed (-) components are used.

Plebanski [3] and other authors [4, 5] suggested to consider a gravitational action in the (visible) world as a left-handed $\mathfrak{su}(2)_L^{(grav)}$- invariant action, which contains self-dual fields $F = F^{(+)i}$ and $\Sigma = \Sigma^{(+)i}$ (i=1,2,3):

$$I_{(grav)}(\Sigma, A, \psi) = \frac{1}{\kappa^2} \int \Big[\Sigma^i \wedge F^i + \left(\Psi^{-1}\right)_{ij} \Sigma^i \wedge \Sigma^j \Big]. \tag{6}$$

Here $\Sigma^i = 2B^{0i}$, and Ψ_{ij} are auxiliary fields, defining a gauge, which provides equivalence of Eq. (6) to the Einstein-Gilbert gravitational action.

3 Graviweak unification model

On a way of unification of the gravitational and weak interactions we considered an extended $\mathfrak{g} = \mathfrak{spin}(4,4)$-invariant Plebanski's action:

$$I(A, B, \Phi) = \frac{1}{g_{uni}} \int_{\mathfrak{M}} \Big\langle BF + B\Phi B + \frac{1}{3} B\Phi\Phi\Phi B \Big\rangle, \tag{7}$$

where $\langle ... \rangle$ means a wedge product, g_{uni} is an unification parameter, and Φ_{IJKL} are auxiliary fields.

Having considered the equations of motion, obtained by means of the action (7), and having chosen a possible class of solutions, we can present the following action for the Graviweak unification (see details in Refs. [1, 2]):

$$I(A, \Phi) = \frac{1}{g_{uni}} \int_{\mathfrak{M}} \langle \Phi F F \rangle, \tag{8}$$

where

$$\langle \Phi F F \rangle = \frac{d^4x}{32} \epsilon^{\mu\nu\rho\sigma} \Phi_{\mu\nu}{}^{\varphi\chi IJ}{}_{KL} F_{\varphi\chi IJ} F_{\rho\sigma}{}^{KL}, \tag{9}$$

and

$$\Phi_{\mu\nu}{}^{\rho\sigma ab}{}_{cd} = (e^f_\mu)(e^g_\nu)\epsilon_{fg}{}^{kl}(e^\rho_k)(e^\sigma_l)\delta^{ab}_{cd}. \tag{10}$$

A spontaneous symmetry breaking of our new action that produces the dynamics of gravity, weak $SU(2)$ gauge and Higgs fields, leads to the conservation of the following sub-algebra:

$$\tilde{\mathfrak{g}} = \mathfrak{su}(2)_L^{(grav)} \oplus \mathfrak{su}(2)_L.$$

Considering indices $a, b \in \{0, 1, 2, 3\}$ as corresponding to $I, J = 1, 2, 3, 4$, and indices m, n as corresponding to indices $I, J = 5, 6, 7, 8$, we can present a spontaneous violation of the Graviweak unification symmetry in terms of the 2-forms:

$$A = \frac{1}{2}\omega + \frac{1}{4}E + A_W,$$

where $\omega = \omega^{ab}\gamma_{ab}$ is a gravitational spin-connection, which corresponds to the sub-algebra $su(2)_L^{(grav)}$. The connection $E = E^{am}\gamma_{am}$ corresponds to the non-diagonal components of the matrix A^{IJ}, described by the following way (see [2]): $E = e\varphi = e^a_\mu\gamma_a\varphi^m\gamma_m dx^\mu$. The connection $A_W = \frac{1}{2}A^{mn}\gamma_{mn}$ gives: $A_W = \frac{1}{2}A^i_W\tau_i$, which corresponds to the sub-algebra $su(2)_L$ of the weak interaction. In the present paper σ_i and τ_i are the Pauli matrices with $i = 1, 2, 3$.

Assuming that we have only singlet field $\varphi^m = (\varphi, \varphi^i = 0)$, we can consider a symmetry breakdown of the Graviweak unification leading to the following OW-action [1]:

$$\begin{aligned} I_{(OW)}\left(e, \varphi, A, A_W\right) &= \frac{3}{8g_{uni}}\int_{\mathfrak{M}} d^4x|e|\left(\frac{1}{16}|\varphi|^2R - \frac{3}{32}|\varphi|^4\right. \\ &\left. + \frac{1}{16}R_{ab}{}^{cd}R^{ab}{}_{cd} - \frac{1}{2}\mathcal{D}_a\varphi^\dagger\mathcal{D}^a\varphi - \frac{1}{4}F^i_{Wab}F^{i\ ab}_W\right). \end{aligned} \tag{11}$$

In Eq. (11) we have the Riemann scalar curvature R; $|\varphi|^2 = \varphi^\dagger\varphi$ is a squared Higgs field; $\mathcal{D}\varphi = d\varphi + [A_W, \varphi]$ is a covariant derivative of the Higgs field, and $F_W = dA_W + [A_W, A_W]$ is a curvature of the gauge field A_W. The third member of the action (11) is a topological term in the Gauss-Bone theory of gravity (see for example [6]).

Lagrangian in the action (11) leads to the nonzero vacuum expectation value (VEV) of the Higgs field: $v = \langle\varphi\rangle = \varphi_0$, which corresponds to a local minimum of the effective Higgs potential at $v^2 = R_0/3$, where $R_0 > 0$ is a constant de Sitter space-time background curvature [2].

According to (11), the Newton gravitational constant G_N is defined by the ratio

$$8\pi G_N = (M_{Pl}^{(red.)})^{-2} = \frac{64g_{uni}}{3v^2}, \tag{12}$$

a bare cosmological constant is equal to

$$\Lambda_0 = \frac{3}{4}v^2,$$

and $g^2_W = 8g_{uni}/3$.

The coupling constant g_W is a bare coupling constant of the weak interaction, which also coincides with a value of the constant $g_2 = g_W$ at the Planck scale. Considering the running $\alpha_2^{-1}(\mu)$, where $\alpha_2 = g_2^2/4\pi$, we can carry out an extrapolation of this rate to the Planck scale, what leads to the following estimation [7, 8]: $\alpha_2(M_{Pl}) \sim 1/50$, i.e. $g_{uni} \sim 0.1$. Using this value of the parameter g_{uni}, it is impossible to obtain a correct value of the Newton constant G_N from Eq. (12), if we consider the well-known Higgs VEV at the Electroweak scale ($v_1 \approx 246$ GeV).

4 Multiple Point Model

The radiative corrections to the effective Higgs potential, considered in Refs. [9,10], bring to the emergence of the second minimum of the effective Higgs potential at the Planck scale. It was shown that in the 2-loop approximation of the effective Higgs potential, experimental values of all running coupling constants in the SM predict an existence of the second minimum of this potential located near the Planck scale, at the value $v_2 = \varphi_{min2} \sim M_{Pl}$.

In general, a quantum field theory allows an existence of several minima of the effective potential, which is a function of a scalar field. If all vacua, corresponding to these minima, are degenerate, having zero cosmological constants, then we can speak about the existence of a multiple critical point (MCP) at the phase diagram of theory considered for the investigation (see Refs. [12,13]). In Ref. [12] Bennett and Nielsen suggested the Multiple Point Model (MPM) of the Universe, which contains simply the SM itself up to the scale $\sim$ 1019 GeV. In Ref. [14] the MPM was applied (by the consideration of the two degenerate vacua in the SM) for the prediction of the top-quark and Higgs boson masses, which gave:

$$M_t = 173 \pm 5 \text{ GeV}, \qquad M_H = 135 \pm 9 \text{ GeV}. \tag{13}$$

Later, the prediction for the mass of the Higgs boson was improved by the calculation of the two-loop radiative corrections to the effective Higgs potential [9, 10]. The predictions: 125 GeV $\lesssim M_H \lesssim$ 143 GeV in Ref. [9], and 129 $\pm$ 2 GeV in Ref. [10] – provided the possibility of the theoretical explanation of the value $M_H \approx 126$ GeV observed at the LHC. The authors of the recent paper [11] have shown that the most interesting aspect of the measured value of M_H is its near-criticality. They have thoroughly studied the condition of near-criticality in terms of the SM parameters at the high (Planck) scale. They extrapolated the SM parameters up to large energies with full 3-loop NNLO RGE precision. All these results mean that the radiative corrections to the Higgs effective potential lead to the value of the Higgs mass existing in the Nature.

Having substituted in Eq. (12) the values of $g_{uni} \simeq 0.1$ and $G_N = 1/8\pi(M^{red}_{Pl})^2$, where $M^{red}_{Pl} \approx 2.43 \cdot 10^{18}$ GeV, it is easy to obtain the VEV's value v, which in this case is located near the Planck scale: $v = v_2 \approx 3.5 \cdot 10^{18}$ GeV. Such a result takes place, if the Universe at an early stage stayed in the "false vacuum", in which the VEV of the Higgs field is huge: $v = v_2 \sim 10^{18}$ GeV. The exit from this state could be carried out only by means of the existence of the second Higgs field, say, ϕ'. A similar model of the hybrid inflation was considered, for example, in Ref. [15]. In the present paper we assume that the second Higgs field, participating into the Inflation, arises from the interaction between visible and invisible sectors of the Universe.

5 Mirror world with broken mirror parity

As it was noted at the beginning of this paper, we assumed the parallel existence in the Nature of the visible (OW) and invisible (MW) (mirror) worlds. The used model was described in Ref. [16, 17] (see also [18]). The group of symmetry G_{SM} of the Standard Model was enlarged to $G_{SM} \times G'_{SM'}$, where G_{SM} stands for the observable SM, while $G'_{SM'}$ is its mirror gauge counterpart. Here O(M)- particles are singlets of the group G_{SM} ($G_{SM'}$).

If the ordinary and mirror worlds are identical, then O- and M-particles should have the same cosmological densities. But this is immediately in conflict with recent astrophysical measurements. Astrophysical and cosmological observations (see for example [19, 20]) have revealed the existence of the Dark Matter (DM), which constitutes about 25% of the total energy density of the Universe. This is five times larger than all the visible matter, $\Omega_{DM} : \Omega_M \simeq 5 : 1$. Mirror particles have been suggested as candidates for the inferred dark matter in the Universe (see references in [16, 17]). Therefore, the mirror parity (MP) is not conserved, and the OW and MW are not identical. It was assumed that the VEVs of the Higgs doublets ϕ and ϕ' are not equal:

$$\langle\phi\rangle = v, \quad \langle\phi'\rangle = v', \quad \text{and} \quad v \neq v'.$$

The parameter characterizing the violation of the MP is $\zeta = v'/v \gg 1$. Astrophysical estimates give: $\zeta > 30$, $\zeta \sim 100$ (see references in [16, 18]).

The action $I_{(MW)}$ in the mirror world is represented by the same integral (11), in which we have to make the replacement of all OW-fields by their mirror counterparts: $e, \phi, A, A_W, R \to e', \phi', A', A'_W, R'$. Then $G'_N = \zeta G_N$, $\Lambda'_0 = \zeta^2 \Lambda_0$, $M'^{red.}_{Pl} = \zeta M^{red.}_{Pl}$. However, $g'_W = g_W$: it is supposed that at an early stage of the evolution of the Universe,when the GUT takes place, mirror parity is unbroken, what gives $g'_{uni} = g_{uni}$.

6 Inflation model

It is well-known that the hidden (invisible) sector of the Universe interacts with the ordinary (visible) world only via gravity, or another very weak interaction (see for example [21–23]). In particular, the authors of Ref. [24] assumed, that along with gravitational interaction there also exists the interaction between the initial Higgs fields of both OW- and MW-worlds:

$$V_{int} = \alpha(\varphi^\dagger\varphi)(\varphi'^\dagger\varphi'), \tag{14}$$

which begin to interact during the Inflation via gravitational interactions. The existence of the second Higgs field φ' could be the cause of the hybrid inflation (compare with Ref. [15]), bringing the Universe out of the "false vacuum" with the VEV $v_2 \sim 10^{18}$ GeV. This circumstance provided the subsequent transition to the vacuum with the Higgs VEV v_1 existing at the Electroweak scale. Here $v_1 \approx 246$ GeV is a vacuum, in which we live at the present time.

Indeed, assuming the de Sitter space-time, which is a maximally symmetric Lorentzian manifold with a constant and positive background scalar curvature R_0, we obtain a nontrivial vacuum solution corresponding to the action (11). This de Sitter space-time has a non-vanishing Higgs vacuum expectation value (VEV): $\varphi_0 = v$, because the standard Higgs potential in Eq. (11) has an extremum at $v^2 = R_0/3$. Then the Higgs field is $\varphi = v + \sigma$, where the scalar field σ is an inflaton. Considering the expansion of the Lagrangian (11) around the background value $R \simeq R_0$ in powers of the small value σ/v, and leaving only the first-power terms, we can present the gravitational part of the action (11) as:

$$I_{(grav)} \simeq -\int_{\mathfrak{M}} d^4x\sqrt{-g}\left[M_{Pl}^2\left(\frac{1}{2}R(1+\sigma/v)^2 - \Lambda_0(1+\sigma/v)^4\right) + ...\right]. \qquad (15)$$

We assume that during Inflation the inflaton σ decays into the two SM Higgs doublets ϕ, and we obtain $\sigma = |\phi|^2$. Then the further expansion gives:

$$\begin{aligned} I_{(grav)} \simeq & -\int_{\mathfrak{M}} d^4x\sqrt{-g}\left[M_{Pl}^2\left(\frac{1}{2}R_0\left(1 +2|\phi|^2/v+ |\phi|^4/v^2\right)\right.\right. \\ & \left.\left. -\Lambda_0\left(1+4|\phi|^2/v+6|\phi|^4/v^2+...\right)\right)+...\right], \end{aligned} \qquad (16)$$

and near the local "false vacuum" we have:

$$I_{(grav)} \simeq -\int_{\mathfrak{M}} d^4x\sqrt{-g}\left[M_{Pl}^2\left(\Lambda_0 - 3|\phi|^4\right)\right]. \qquad (17)$$

Finally, it is necessary to end the inflation and to consider a transition to a radiation dominated era. The mirror Higgs field ϕ' gives a point of the end of Inflation, say, at the value ϕ'_F. Then a sum of all the Higgs potentials at the end of inflation is given by the following expression:

$$\begin{aligned} V_{Higgs} + V_{int} + V(\varphi_F) &= -3(\phi^\dagger\phi)^2 + \alpha(\phi_F)|\phi'_F|^2\phi^\dagger\phi + V(\phi'_F) \\ &= -3(\phi^\dagger\phi - v_1^2)^2 + 3v_1^4 + V(\phi'_F), \end{aligned} \qquad (18)$$

where

$$v_1^2 = \frac{\alpha(\phi_F)}{6}|\phi'_F|^2 \approx (246\ \mathrm{GeV})^2 \qquad (19)$$

is the squared VEV of the Higgs field in the first (Electroweak) vacuum of the Universe, in which we live.

A similar inflation is carried out in the Mirror World of the Universe. Details of the hybrid inflation are presented in Ref. [15] and in the references cited there. The Graviweak unification leads to the modern theory of Inflation, which in principle can explain all astrophysical experimental data predicting a correct value of the tensor-to-scalar ratio r (see for example [25]).

7 Conclusions

In the present paper we constructed a model of unification of gravity with the weak $SU(2)$ gauge and Higgs fields. Imagining that at the early stage of the evolution the Universe was described by a GUT-group, we assumed that this Grand Unification group of symmetry was quickly broken down to the direct product of the gauge groups of internal symmetry and Spin(4,4)-group of the Graviweak unification.

Also we assumed the existence of visible and invisible (hidden) sectors of the Universe. We have given arguments that modern astrophysical and cosmological measurements lead to a model of the Mirror World with a broken Mirror Parity (MP), in which the Higgs VEVs of the visible and invisible worlds are not equal: $\langle\phi\rangle = v, \quad \langle\phi'\rangle = v'$ and $v \neq v'$. We estimated a parameter characterizing the violation of the MP: $\zeta = v'/v \gg 1$. We have used the result: $\zeta \sim 100$ obtained by Z. Berezhiani and his collaborators. In this model, we showed that the action for gravitational and $SU(2)$ Yang–Mills and Higgs fields, constructed in the ordinary world (OW), has a modified duplication for the hidden (mirror) sector of the Universe (MW).

Considering the Graviweak symmetry breaking, we have obtained the following sub-algebras: $\tilde{\mathfrak{g}} = \mathfrak{su}(2)_L^{(grav)} \oplus \mathfrak{su}(2)_L$ – in the ordinary world, and $\tilde{\mathfrak{g}}' = \mathfrak{su}(2)'^{(grav)}_R \oplus \mathfrak{su}(2)'_R$ – in the hidden world. These sub-algebras contain the self-dual left-handed gravity in the OW, and the anti-self-dual right-handed gravity in the MW. We assumed, that finally at low energies, we have a Standard Model and the Einstein-Gilbert's gravity.

We reviewed the Multiple Point Model (MPM) by D.L. Bennett and H.B.Nielsen, who assumed the existence of several minima of the Higgs effective potential with the same energy density (degenerate vacua of the SM). In the assumption of zero cosmological constants, MPM postulates that all the vacua, which might exist in the Nature (as minima of the effective potential), should have zero, or approximately zero, cosmological constant. The prediction that there exist two vacua into the SM: the first one – at the Electroweak scale ($v_1 \simeq 246$ GeV), and the second one – at the Planck scale ($v_2 \sim 10^{18}$ GeV), was confirmed by calculations in the 2-loop approximation of the Higgs effective potential. The prediction of the top-quark and Higgs masses was given in the assumption that there exist two vacua into the SM.

In the above-mentioned theory we have developed a model of Inflation. According to this model, a singlet field σ, being an inflaton, starts trapped from the "false vacuum" of the Universe at the value of the Higgs field's VEV $v = v_2 \sim 10^{18}$ GeV. Then during the Inflation σ decays into the two Higgs doublets of the SM: $\sigma \to \phi^\dagger\phi$. The interaction between the ordinary and mirror Higgs fields ϕ and ϕ', induced by gravity, generates a hybrid model of the Inflation in the Universe. Such an interaction leads to the emergence of the SM vacua at the Electroweak scales: with the Higgs boson VEVs $v_1 \approx 246$ GeV – in the OW, and $v_1' = \zeta v_1$ – in the MW.

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