On the Relationship between the Cosmological Background Field and the Higgs Field

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Summary
It is shown that the relationship between gravity and quantum physics can be described in terms of the symmetry break of space due to elementary constituents, dubbed as "darks", which constitute a universal energetic background field that extends from the cosmological level down to the nuclear level. It requires (a) the awareness of the polarisable second elementary dipole moment of a recently discovered third Dirac particle type, next to the electron-type and the Majorana-type, and (b) the awareness that Einstein's Lambda is not a constant of nature, but, instead, a covariant integration constant with a value that depends on the scope of the cosmological system under consideration, such as solar systems and galaxies, eventually showing up as the Cosmological Constant at the level of the universe. The relationship has been made explicit by relating the two major gravitational constants of nature (the gravitational constant and Milgrom's acceleration constant) with the two major nuclear constants of nature (the weak interaction boson and the Higgs boson).

Keywords: cosmological constant; Higgs field; Milgrom's constant; Dirac particle; unification

1. Introduction

Present-day theory of quantum physics as well as present-day theory of gravity rely upon the presence of an omni-present energetic background field. In quantum physics, this field is known as the "Higgs field". It is required for explaining the origin of mass. It has an axiomatic definition, conceived in 1964,[1]. In gravity, the existence of the background field is required to explain the accelerated expansion of the universe, known since 1998, [2]. This cosmological background field has been defined on the basis of Einstein's Cosmological Constant [3]. It is also known as "dark energy". It would be odd if two different energetic background fields would exist next to each other. More logical would be if the Higgs field and the cosmological background field would be the same. In both cases the unavoidable conclusion is that there is not such a thing as "empty space", but that space is filled with an energetic fluidum. This conclusion has given rise to the idea of conceiving the vacuum as an entropic medium filled with energetic constituents, in this article to be annotated as *darks*. As long as these darks are not subject to any directional energetic influence, their motions remain fully chaotic. In that state the vacuum is fully symmetric, because its state before and after a time interval of "closed eyes" with an arbitrary translation or rotation of the observer, is just the same [4]. It means that the awareness of a Higgs field and a Cosmological Constant implies a symmetry break, respectively in nuclear space and in cosmological space. This is the issue that will be discussed in this article.

In [5,6,7,8,9] it has been argued that if the cosmological background field would consist of energetic uniformly distributed polarisable vacuum particles, the dark energy would give an explanation for the dark matter problem as well, because vacuum polarization would evoke a gravitational equivalent of the well-known Debije effect [10]. With the difference, though,

that the central force from a gravitational nucleus is enhanced just opposite to the suppression of the Coulomb force from an electrically charged nucleus in an ionized plasma. This picture fits to the Higgs field of nuclear particle physics as well, albeit that the energetic background particles would show the true Debije effect, in the sense that they would exponentially suppress a central nuclear force such as required to explain the short range of nuclear forces. It corresponds more or less with the common view that mass-less force carrying particles are retarded by a surrounding field of energy, thereby gaining mass [11,12].

The modeling of the omni-present background energy by energetic vacuum particles, requires a model for its elementary constituent (the *dark*). This element must be a source of energy, and must be force feeling as well. In those aspects it resembles an electron, which is ultimately the source of electromagnetic energy, and which is sensitive to the fields spread by other electrons. However, where the dark in the cosmological background field must be polarisable under the gravitational potential, an electron is non-polarisable under an electric potential. The electric dipole moment of an electron is zero, while a dark should have a non-zero gravitational dipole moment. In [9, 13,14] the suggestion has been made that these particles could be of the particular Dirac type as theorized back in 1937 by Ettore Majorana [15]. There is, however, no convincing argument why a Majorana particle would have a dipole moment that is polarisable in a scalar potential field. It is recognized, though, that Dirac's theory contains some heuristic elements. Recently, the author of this article found a third type Dirac particle, next to the electron type and the Majorana type [16]. This *third* has the unique property that, unlike the electron type, it possesses a dipole moment that is polarisable in a scalar potential field. It is my aim to show in this article that this *third* matches with the *dark*. In the next paragraph first a summary will be given of the *third*. Thereafter a view will be given on the cosmological background energy and its impact on gravity.

The cosmological and gravity view to be developed in this article relies, next to the awareness of the darks, on a particular interpretation of the Λ parameter in Einstein's Field Equation. Different from the common perception that Einstein's Λ is a constant of nature, usually identified as the Cosmological Constant, it is in the author's view a covariant integration constant that may have different values depending on the scope of a cosmological system under consideration. Because it may depend on other attributes but just time-space coordinates, such as mass content, for instance, it may have different values at the level of solar systems, galaxies and the universe. Only at the latter level, it is justified to identify the Λ as the Cosmological Constant indeed. At that level, by the way, the cosmological system is in a state of maximum symmetry and maximum entropy. The viability of this view will be proven by a calculation of Milgrom's empirical acceleration constant of dark matter.

After that, it will be shown that the novel Dirac particle applies to quarks as well, ending up in a model for the nuclear domain, in which the common Lagrangian description of the Higgs field is harmonized with a nuclear energetic background field with similar characteristics as the cosmological one. Finally it is shown in verifiable formulae how these fields are related.

2. Summary of the *third*

The canonic formulation of Dirac's particle equation reads as [17,18],

$$(i\hbar\gamma^{\mu}\partial_{\mu}\psi - \beta m_0 c\psi) = 0.$$

In which β is the 4 x 4 unity matrix and in which the 4 x 4 gamma matrices have the properties,

$$\gamma_{\mu}\gamma_{\nu} + \gamma_{\nu}\gamma_{\mu} = 0 \text{ if } \mu \neq \nu; \text{ and } \gamma_0^2 = 1; \gamma_i^2 = -1. \tag{1}$$

As usual, c is the vacuum light velocity, $\hbar$ is the reduced Planck constant and m_0 is the rest mass of the particle. Whereas the canonical set is given by,

$$\gamma_0 = \begin{bmatrix} I & 0 \\ 0 & -I \end{bmatrix}; \gamma_1 = \begin{bmatrix} 0 & \sigma_1 \\ -\sigma_1 & 0 \end{bmatrix}; \gamma_2 = \begin{bmatrix} 0 & \sigma_2 \\ -\sigma_2 & 0 \end{bmatrix}; \gamma_3 = \begin{bmatrix} 0 & \sigma_3 \\ -\sigma_3 & 0 \end{bmatrix}; \beta = \begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix}, \tag{2a}$$

the γ-set of the third type has been found as [16],

$$\gamma_0 = \begin{bmatrix} 0 & -I \\ -I & 0 \end{bmatrix}; \gamma_1 = \begin{bmatrix} i\sigma_1 & 0 \\ 0 & -i\sigma_1 \end{bmatrix}; \gamma_2 = \begin{bmatrix} i\sigma_2 & 0 \\ 0 & -i\sigma_2 \end{bmatrix}; \gamma_3 = \begin{bmatrix} i\sigma_3 & 0 \\ 0 & -i\sigma_3 \end{bmatrix}; \beta = \begin{bmatrix} 0 & I \\ -I & 0 \end{bmatrix}, \tag{2b}$$

where σ_i are the Pauli matrices.

Although the wave equation of the electron type and that of the "third" are hardly different, there is a major difference in an important property. Both have *two* dipole moments. A first one, to be indicated in this text as the *first dipole moment*, is associated with the elementary angular momentum $\hbar$. The second one, to be indicated as the *second dipole moment* is associated with the vector $\hbar/c$. These dipole moments show up in the calculation of the excess energy of the particle in motion subject to a vector potential $A(A_0, A_x, A_y, A_z)$. In the canonic case (2a) we have,

$$\Delta E = \frac{e\hbar}{2m_0}\begin{bmatrix} \overline{\sigma} \cdot \mathbf{B} & 0 \\ 0 & \overline{\sigma} \cdot \mathbf{B} \end{bmatrix} + \frac{e\hbar}{2m_0 c}\begin{bmatrix} 0 & i\overline{\sigma} \cdot \mathbf{E} \\ i\overline{\sigma} \cdot \mathbf{E} & 0 \end{bmatrix}$$

where $\overline{\sigma}$ is the Pauli vector, defined by

$$\overline{\sigma} = \sigma_1 \mathbf{i} + \sigma_2 \mathbf{j} + \sigma_3 \mathbf{k}, \tag{3}$$

In which ($\mathbf{i}, \mathbf{j}, \mathbf{k}$) are the spatial unit vectors and in which $\mathbf{B}$ and $\mathbf{E}$ are field vectors derived from the vector potential. The redundancy in (3) allows writing it as,

$$\Delta E = \frac{e}{2m_0}(\overline{\sigma} \ \hbar \cdot \mathbf{B} + i\overline{\sigma} \ \hbar/c \cdot \mathbf{E}), \tag{4}$$

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The electron has a real first dipole moment ($e\hbar/2m_0$), known as the magnetic dipole moment, and an imaginary second dipole moment ($ie\hbar/2m_0c$), known as the anomalous electric dipole moment. The spin vector $\boldsymbol{S} = \overline{\sigma}/2$ has an eigen value $|\boldsymbol{S}| = 1/2$. In the case that the Dirac particle is of the third type, as defined by (2b), we have [16],

$$\Delta E = \frac{e}{2m_0}(\overline{\sigma}\ \hbar \cdot \boldsymbol{B} \pm \overline{\sigma}\ \hbar/c \cdot \boldsymbol{E}), \tag{5}$$

This third type Dirac particle has two real dipole moments, generically without identifying it as an electromagnetic one, to the amounts of $\overline{\sigma}\hbar$, respectively $\overline{\sigma}\hbar/c$. If the *dark* would be of the electron type, it would not be polarisable in a gravitational field, because such a field is Coulomb-like and is unable to polarize an imaginary second dipole moment. If, however, the *dark* is a third type, its second dipole moment can be polarized under influence of a scalar potential field. This field is not necessarily the electromagnetic one. The coupling factor is not necessarily the elementary electric charge. If the field is just a static one, eq. (5) can be written as,

$$\Delta E = -\frac{g\overline{\sigma}}{2m_0}(\ \hbar/c \cdot \nabla A_0), \tag{6}$$

In which g is a generic coupling factor. Hence, taking into account that the eigen value of the spin vector with the state variable $\overline{\sigma}$ is $|\boldsymbol{S}| = |\overline{\sigma}/2| = 1/2$, the dipole moment p of a single particle in a gravity field (where $g = m_0$), is given by,

$$p = \frac{\hbar}{2c}. \tag{7}$$

Hence, the third type is a candidate for being the elementary constituent of the cosmological background energy. Further profiling of this constituent will be given in the next paragraph.

3. The cosmological background field

The presence of an omnipresent background field is imposed by the vacuum solution of Einstein's Field Equation with Einstein's (cosmological) constant Λ, [19,20]. This Field Equation reads as,

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}\ ; \ G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu}, \tag{8}$$

in which $T_{\mu\nu}$ is the stress-energy function, which describes the energy and the momenta of the source(s) and in which $R_{\mu\nu}$ and R are, respectively, the so-called Ricci tensor and the Ricci scalar. These can be calculated if the metric tensor components $g_{\mu\nu}$ are known [21,22]. In the case that a particle under consideration is subject to a central force only, the time-

space condition shows a spherical symmetric isotropy. This allows to read the metric elements g_{ij} from a simple line element that can be written as

$$ds^2 = g_{tt}(r,t)dq_0^2 + g_{rr}(r,t)dr^2 + r^2\sin^2\vartheta d\varphi^2 + r^2 d\vartheta^2 ,$$ (9)

In which $q_0 = ict$ and $i = \sqrt{-1}$.

Note: The author of this article has a preference for the "Hawking metric" (+,+,+,+) for (ict, x, y, z), like, for instance, also used by Perkins [23]. By handling time as an imaginary quantity instead of a real one, the ugly minus sign in the metric (-,+,+,+) disappears owing to the obtained full symmetry between the temporal domain and the spatial one.

It means that the number of metric elements g_{ij} reduce to a few, and that only two of them are time and radial dependent. With inclusion of the constant Λ, a wave equation for a particle under central force can be derived from (8-9) as

$$-\frac{\partial^2 g_{tt}}{c^2 \partial t^2} + \frac{1}{r}\frac{\partial^2 (rg_{tt})}{\partial r^2} + 2\Lambda = -g_{rr}\frac{8\pi G T_{tt}}{c^2}\delta^3(r)U(t) .$$ (10)

If T_{tt} were a pointlike source $T_{tt} = Mc^2\delta^3(r)U(t)$, in which $U(t)$ is Heaviside's step function, the static solution of this equation would be provided by the Schwarzschild-de Sitter metric, also known as Kottler metric, [24,25,26,27]. Unfortunately, (10) does not allow deriving a meaningful wave equation. Taking the view that the vacuum is something else but empty space, makes a difference. Where an empty space with $\Lambda = 0$ corresponds with virtual sources $T_{\mu\mu} = 0$, the vacuum with $\Lambda \neq 0$ is a fluidal space with virtual sources $T_{\mu\mu} = -p\Lambda$, with $g_{\mu\mu} = (1,1,r^2\sin^2\vartheta, r^2)$, in which $p = c^4/8\pi G$ [28,29,30]. (Owing to the Hawking metric, p is equal for all diagonal elements). This particular stress-energy tensor, with equal diagonal elements, corresponds with the one for a perfect fluid in thermodynamic equilibrium [22]. Inserting a massive source in this fluid will curve the vacuum to $g_{\mu\mu} = (g_{tt}, g_{rr}, r^2\sin^2\vartheta, r^2)$. This allows rewriting (10) as,

$$-\frac{\partial^2}{c^2\partial t^2}(r\Phi) + \frac{\partial^2}{\partial r^2}(r\Phi) + \lambda^2(r\Phi) = -r\frac{8\pi GM}{c^2}\delta^3(r)U(t) ,$$ (11)

In which $\lambda^2 = 2\Lambda$.

The validity of this equation is restricted between a low spatial limit and a high spatial limit. It can be found in ref. [31]. The static format of the wave equation (11) is a potential field set up by a pointlike source with a format that shows up as a modification of Poisson's equation, such that

$$\frac{\partial^2}{\partial r^2}(r\Phi) + \lambda^2(r\Phi) = -r\frac{8\pi GM}{c^2}\delta^3(r) .$$ (12)

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Under positive space-time curving, (12) can be solved by

$$\Phi = \Phi_0 \frac{\cos \lambda r + \sin \lambda r}{\lambda r}; \quad \Phi_0 = MG\lambda . \tag{13}$$

This solution gives a fit with Milgrom's empirical enhanced gravity law for, [31],

$$\lambda^2 = \frac{2}{5}\frac{a_0}{MG} \rightarrow M\lambda^2 = \frac{2}{5}\frac{a_0}{G}, \tag{14}$$

in which a_0 is Milgrom's acceleration constant that characterizes the dark matter effect. This relates the anti-decay parameter λ with the mass of a galaxy. Because $\lambda^2 = 2\Lambda$ as shown by (11), and because a_0 has appeared being a constant, Einstein's Λ is an integration constant with a value that is galaxy dependent. While at the level of the whole universe, Λ may be considered as an invariant cosmological constant, it will not be the case at the level of galaxies. If in (12) the sign of λ^2 would have been "minus" instead of "plus", the resulting field would have had the format,

$$\Phi = \Phi_0 \frac{\exp(-\lambda r)}{\lambda r} . \tag{15}$$

Such a "screened" field shows up as the field of an electric pointlike charge in an ionized atomic plasma. As shown by Debije [10], the ambient field around the pointlike charge can be modeled in terms of polarized electric dipoles that suppresses the source field. Apparently, the opposite is true for gravity. The gravity field is not suppressed, but enhanced instead. For a proper understanding of the role of λ in (12) it is instructive writing it as,

$$\nabla^2 \Phi + \lambda^2 \Phi = -\frac{4\pi GM}{c^2}\delta^3(r), \tag{16}$$

and subsequently into Poisson's format for gravity as,

$\nabla^2 \Phi = -4\pi G\rho(r)$, in which

$$\rho(r) = \frac{M}{c^2}\delta^3(r) + \rho_D(r); \ \rho_D(r) = \frac{\lambda^2}{4\pi G}\Phi(r) . \tag{17}$$

Apart from the constant $4\pi G$, this format is similar to Laplace's format for electromagnetism.

In Debije's theory of electric dipoles [10,32,33],

$$\rho_D(r) = -\nabla \cdot \mathbf{P_g} . \tag{18}$$

The vector $\mathbf{P_g}$ is the dipole density. From (18),

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$$\rho_D = \frac{1}{r^2}\frac{d}{dr}\{r^2 P_g(r)\}. \tag{19}$$

Assuming that in the static condition the space fluid is eventually fully polarized by the field of the pointlike source, $P_g(r)$ is a constant P_{g0}. Hence, from (19),

$$\rho_D(r) = 2\frac{P_{g0}}{r}. \tag{20}$$

Taking into account that to first order,

$$\Phi(r) = \frac{MG}{r}, \tag{21}$$

we have from (20) and (21),

$$\rho_D(r) = \frac{2P_{g0}}{MG}\Phi(r). \tag{22}$$

Hence, from (13), (14) and (20-22),

$$P_{g0} = \frac{a_0}{20\pi G}. \tag{23}$$

Taking the elementary dipole value $h/2c$ into account, the volume density N/m^3 of the *darks* is found as,

$$N/m^3 = \frac{a_0}{20\pi G}\frac{2c}{\hbar}. \tag{24}$$

These results allow deriving an expression for Milgrom's acceleration constant by two independent ways. Applying (14) to a cosmos conceived as a Hubble bubble with distributed baryonic mass, is a first option. Appling (24) to the universe conceived as a virtual black hole subject to Hawking-Bekenstein entropy is a second option. As proven in [31], both approaches result into the same expression,

$$a_0 = \frac{15}{4}\Omega_B a_L; \quad a_L = \frac{c}{t_H},$$

in which $\Omega_B = 0.0486$ is the baryonic share of the matter content in the universe and in which $t_H \approx 13.8$ Gyear is the Hubble timescale. It can be easily verified that this expression yields $a_0 \approx 1.25$ x 10^{-10} m/s², which corresponds with the known observational value.

4. Profiling a quark as a third type Dirac particle

Let us proceed trying to set up a similar model for the nuclear background energy similar to the cosmological background energy. To do so, let us suppose, as usual by the way, that a quark is a Dirac particle [34]. In this text, however, under the assumption that a quark is a Dirac particle of the third type, the second dipole moment of which is polarisable. Hence, we may conceive its potential field as the sum of a far field from the monopole and a near field from the dipole moment. The second dipole moment $m_p d = \hbar / 2c$, where m_p and d are unknown quantities, creates a near field potential field $\Phi_{GN}(x)$ along the dipole axis x such that,

$$\Phi_{GN}(x) = \frac{Gm_p d}{x^2} \rightarrow \Phi_{GN}(x) = \frac{\hbar}{2c} \frac{\lambda_0^2 G}{(\lambda_0 x)^2} \rightarrow \Phi_{GN}(x) = \Phi_0' \frac{1}{(\lambda_0 x)^2} \; ; \; \Phi_0' = \frac{\hbar}{2c} G \lambda_0^2 . \qquad (25)$$

Note that Φ_0' is expressed in energy per unit of mass (hence signed by '). Note that there is no particular reason yet to identify the λ_0 in (25) as the Λ-related one in (11,12). Apart from the near field $\Phi_{GN}(x)$, the quark spreads a far field $\Phi_{GF}(r)$. The far field is the result of the (monopole) mass m_{qu} $(\neq m_p)$ of a bare quark. Under absence of any mass generation mechanism, only the eigen value $\hbar / 2$ of the quark's elementary angular momentum is left as the manifestation of this bare mass (as discussed and proven in [35], the bare mass is different from the quark's constituting mass resulting from the mass generation mechanism). Interpreting the angular momentum as a virtual rotation with light speed at a fictitious radius $r_0 = 1/w\lambda_0$, in which w is an unknown dimensionless weighting constant, we have

$$\frac{\hbar}{2} = \frac{m_{qu} c}{w\lambda_0} \rightarrow m_{qu} = w \frac{\hbar}{2} \frac{\lambda_0}{c} . \qquad (26)$$

The quantity g_m is an unknown *gyrometric* constant. Hence, from classical field theory,

$$\Phi_{GF}(r) = \frac{m_{qu} G}{r} = w \frac{\hbar}{2} \frac{\lambda_0}{c} \frac{G}{r} = w \frac{\hbar}{2} \frac{G\lambda_0^2}{c} \frac{1}{\lambda_0 r} , \qquad (27)$$

and, under consideration of Φ_0 as defined in (25),

$$\Phi_{GF}(r) = w \frac{\hbar}{2} \frac{G\lambda^2}{c} \frac{1}{\lambda_0 r} = \Phi_0' \frac{w}{(\lambda_0 r)} . \qquad (28)$$

Hence, the potential field of the quark along the axis set up between the dipole axis can be expressed as an energy $\Phi(\lambda x)$ such that

$$\Phi(\lambda x) = \Phi'_0 \{ \frac{1}{(\lambda_0 x)^2} - w \frac{1}{\lambda_0 x} \} \; ; \quad \Phi'_0 = \frac{\hbar}{2c} G \lambda_0^2 . \tag{29}$$

Similarly as the field of darks, the quark field is influenced by the energetic background field. However, where the gravitational field is enhanced under polarization of the background particles, the nuclear field is suppressed. This can be understood by re-inspection of (11). There is no reason why space-time curving would be restricted to massive energy. It may occur under a more general interpretation of energy as well. Moreover, the curving might be negative instead of positive like assumed for gravity. Hence, let us rewrite (11) as,

$$-\frac{\partial^2}{c^2 \partial t^2}(r\Phi) + \frac{\partial^2}{\partial r^2}(r\Phi) - \lambda^2 (r\Phi) = -r \frac{8\pi \Phi_0}{c^2} \delta^3(r) U(t) , \tag{30}$$

Like noted before, its solution under static conditions is given by (15). By taking the influence of λ^2 in account, (29) is modified into,

$$\Phi(\lambda x) = \Phi_0 \exp(-\lambda x) \{ \frac{1}{(\lambda_0 x)^2} - w \frac{1}{\lambda_0 x} \} ; \quad \Phi_0 = m_{qu} \frac{\hbar}{2c} G \lambda_0^2 , \tag{31}$$

Where m_{qu} is the unknown mass of the bare quark and where λ is identified as the unknown decay parameter of the field due to the background energy. Note that, unlike λ_0 , this λ has the same semantics now as in the gravity case, i.e., related with Einstein's Λ as $\lambda^2 = 2\Lambda$. Rewriting (31) in terms of λx gives,

$$\Phi(\lambda x) = \Phi_0 \exp(-\lambda x) \{ (\frac{\lambda}{\lambda_0})^2 \frac{1}{(\lambda x)^2} - (\frac{\lambda}{\lambda_0}) w \frac{1}{\lambda x} \} = \Phi_0 (\frac{\lambda}{\lambda_0})^2 \exp(-\lambda x) \{ \frac{1}{(\lambda x)^2} - w' \frac{1}{\lambda x} \} ,$$

and $\Phi_0 = m_{qu} \frac{\hbar}{2c} G \lambda_0^2 = m_{qu} \frac{\hbar}{2c} G \lambda^2 (\frac{\lambda_0}{\lambda})^2 \to \Phi_0 (\frac{\lambda}{\lambda_0})^2 = m_{qu} \frac{\hbar}{2c} G \lambda^2 .$

Hence, (31) is rewritten as,

$$\Phi(\lambda x) = \Phi_0 \exp(-\lambda x) \{ \frac{1}{(\lambda x)^2} - w' \frac{1}{\lambda x} \} ; \; \Phi_0 = m_{qu} \frac{\hbar}{2c} G \lambda^2 . \tag{32}$$

Note that m_{qu} still is the mass of the bare quark. The only difference is the change of the unknown w into the unknown w' .

As proven in ref. [35], this quark profile (32) fits to the one that can be derived from the heuristic Lagrangian of the Higgs field conceived in the Standard Model of particle physics. Other nuclear particles may couple to the field of a quark. The quantities Φ_0 and λ are subject to a particular invariant relationship,

$$g\frac{\Phi_0}{\lambda} = \frac{\alpha\pi\hbar c}{2d'_{\min}}, \tag{33}$$

in which g, $d'_{\min}$ and α are dimensionless constants. Its derivation is beyond the scope of this article. It can be found in previous studies such as [36,37]. The generic quantum mechanical coupling factor g is the square root of the electromagnetic fine structure constant ($g^2 \approx 1/\sqrt{137}$). The constant $d'_{\min}$ is the normalized spacing $d'_{\min} = d\lambda$ between the quark and the antiquark in the archetype meson (pion), and α is a numerical factor of order 1, the value of which is eventually established as $\alpha \approx 0.69$. This invariance, dubbed in [35] as the quark scaling theorem, leaves some individual freedom and can therefore be different for different quark flavours.

The relationship with the Higgs field can be illustrated after a particular evaluation from its Lagrangian density $U_H(\Phi)$ that heuristically is defined as [1],

$$U_H(\Phi) = -\mu_N^2\frac{\Phi^2}{2} + \lambda_N^2\frac{\Phi^4}{4}, \tag{34}$$

where μ_N and λ_N are characteristic real constants. Supposing that this field is the background field of a pointlike quark, its potential function can be derived from application of the Euler-Lagrange equation on the Lagrangian,

$$L = -\frac{1}{2}\partial_\mu\Phi\partial^\mu\Phi + U_H(\Phi) + \rho\Phi, \tag{35}$$

In which $\rho\Phi$ is the source term. Unfortunately the particular format of the (broken) field $U_H(\Phi)$ prevents deriving an analytical solution $\Phi(r)$ of from (35) subject to (34). However, a numerical procedure allows deriving a two-parameter expression for $\Phi(r)$ that closely approximates a true analytical solution. The result is,

$$\Phi(r) = \Phi_0\frac{\exp(-\lambda r)}{\lambda r}\{\frac{\exp(-\lambda r)}{\lambda r} - 1\}, \tag{36}$$

in which,

$$-\frac{1}{2}\mu_N^2 = 1.06\lambda^2 \text{ and } -\frac{1}{4}\lambda_N^2 = 32.3\frac{\lambda^2}{\Phi_0^2}. \tag{37}$$

This result is indistinguishable from the three-parameter format derived for a third-type Dirac particle shown by (32),

$$\Phi(\lambda x) = \Phi_0\exp(-\lambda x)\{\frac{1}{(\lambda x)^2} - w'\frac{1}{\lambda x}\}, \tag{38}$$

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under the condition that $w' = 1/0.55$.

If two bare quarks, more particularly a quark and an antiquark, each producing a generic flow of energy of non-baryonic nature, are interacting, a quasi-stable bond is created, thereby producing the archetype meson, i.e. the pion. In that condition, the spacing $2d'_{min} = 2d\lambda$ between quark and antiquark is determined by the condition retrieved from (36) as [35],

$$\exp(-d'_{min})/d'_{min} = \frac{1}{2} \rightarrow d'_{min} \approx 0.853, \tag{39}$$

The bond between the quark and the antiquark can be modelled as a quantum mechanical oscillator with a center of baryonic mass. Something similar happens between the three quarks in a baryon that create a three-body quantum mechanical oscillator. The vibration energy of the oscillator is the dominant part of the rest mass of the pion. The contribution of the bare masses of the quarks to the baryonic mass is negligible. All quarks show the same potential function. As noted before, their Φ_0 and λ values are subject to the scaling theorem (33). It means that, similarly as in the case of darks, λ is a variable that get a particular value in a particular scope. Details can be found in [35], as well as the proofs that the decay and spatial range parameter λ in the scope of the pion is a measure of the energetic mass equivalence of the Higgs boson, i.e. $m'_H \approx 2\lambda(\hbar c)$ and that its numerical value of about 126.5 GeV can be determined by theory.

The assignment of a classical potential field to a quark is unconventional. In this paragraph the field has been derived from the view that the quark is a Dirac particle of a particular type that up to recently was unknown. It has been shown in this paragraph that the derived potential function is consistent with a numerical solution from the heuristic Higgs Lagrangian. In that respect the unconventional view on the quark as expressed by (46) is not in conflict with the Standard Model of particle physics.

5. Relating cosmological properties with nuclear properties

From the analyses made so far, it is fair to conclude that quarks in a meson and the cosmological darks are Dirac particles. In that sense they are similar to electrons. However, where the field of an electron is not affected in vacuum, the field of a quark is shielded by an energetic background field while the field of a dark is enhanced by such a field. To enable a proper comparison between the three particle types, a generic force F will be defined as the spatial derivative of a generic potential Φ in units of energy, such that for electrons, darks and quarks, respectively,

$$F = \frac{\partial}{\partial y}\Phi = e\frac{\partial}{\partial y}\Phi_e$$

$$F = \frac{\partial}{\partial y}\Phi = m_0 \frac{\partial}{\partial y}\Phi_G$$

(40)

$$F = \frac{\partial}{\partial y}\Phi = g\frac{\partial}{\partial y}\Phi_{qu}$$

where q, m_0 and g, are the coupling factors of, respectively, an electron, a classical massive particle and a quark to respectively, an electric potential Φ_e, a gravitational potential Φ_G and a nuclear potential Φ_{qu}. Electroweak unification relates the nuclear coupling factor g with the electromagnetic coupling factor e by the fine structure relationship $e^2 = 4\pi\varepsilon_0 \hbar c g^2$. Where these potential fields are specific and have specific dimensionalities, they are all derived from a generic potential Φ in the dimension of energy.

As discussed in paragraph 3, a classical (baryonic) mass m_0 feels a gravitational force from another classical mass m_0 as,

$$F = m_0 \frac{\partial}{\partial x}\Phi_G ; \quad \Phi_G = -m_0 G\lambda \frac{\cos\lambda x + \sin\lambda x}{\lambda x} .$$

(41)

The potential field of the quark modeled has been found in (38) as, as

$$\Phi(\lambda x) = \Phi_0 \exp(-\lambda x)\{\frac{1}{(\lambda x)^2} - w'\frac{1}{\lambda x}\} ; \quad \Phi_0 = \frac{\hbar}{2c}G\lambda^2 .$$

(42)

According to the theory developed in the previous chapters, a quark feels a force from another quark as,

$$F = g\frac{\partial}{\partial r}\Phi_{qu} .$$

(43)

The format of the field Φ_{qu} matches with the format of the field (42). Expressing the far field component of the nuclear force in terms of a Newtonian field as

$$F = g\frac{\partial}{\partial r}\Phi = m_{qu}\frac{\partial}{\partial r}\Phi_G ,$$

(44)

in which m_{qu} is defined as the quark's bare mass and considering that Φ_0 in (42) is energy per unit of mass, we get from (44),

$$\rightarrow g(km_{qu}\frac{\hbar}{2}\frac{G\lambda^2}{c}) = m_{qu}^2 kG\lambda \rightarrow m_{qu} = g\frac{\hbar}{2c}\lambda .$$

(45)

It implies that the bare mass m_{qu} of the quark depends on an elementary dipole moment with eigen value $\hbar/2c$ with dimensionality [mass x length] multiplied by λ with dimensionality [length^{-1}]. This mass quantity seems identifying the weak interaction between quarks as the equivalent of a Newtonian gravitational interaction as if a quark were an ordinary massive particle in classical gravitational sense. However, if the quark would have the same gravitational properties as a baryonic pointlike mass, the shielding of its potential field by the energetic background field would be the same. In fact, relationship (45) reveals that whereas two baryonic masses attract under Newton's law, two quark bare masses repel under Newton's law. It also means that whereas the gravitational dipoles in the energetic background field enhance the potential field of a baryonic source, modeled as a pointlike mass, the same dipoles shield the nuclear potential field of the quark.

Recognizing the role of λ in gravity in terms of Einstein's $\lambda_M^2 = 2\Lambda$, we have from (14), under the recognition that the quark's bare mass m_{qu} is a Newtonian anti-gravitational particle,

$$M\lambda_M^2 = m_{qu}\lambda^2 = \frac{2}{5}\frac{a_0}{G}.\tag{46}$$

This is a basic formula for the unification of gravity with quantum physics. From (45) and (46),

$$\frac{a_0}{G} = \frac{5}{2}g\frac{\hbar}{2c}\lambda^3.\tag{47}$$

The remaining issue for relating the relationship between cosmological quantities with nuclear quantities is establishing a value for the quark's quantity λ. This value is closely related with the massive energy m_H' of the Higgs boson by,

$$m_H' = 2\lambda\hbar c \rightarrow \lambda = \frac{m_H'}{2\hbar c}.\tag{48}$$

Because this relation holds in the center of mass frame of a pion, a relativistic correction is needed from $\lambda \rightarrow \lambda_0$. Considering that the energy of the pion is dominated by the binding energy between the quark and the antiquark in a meson, which is provided by the weak interaction boson, we may relate the massive energy $\hbar\omega_\pi$ of a pion in rest with the massive energy $\hbar\omega_W$ of the weak interaction boson as,

$$\frac{\hbar\omega_W}{\hbar\omega_\pi} = \alpha\frac{\lambda}{\lambda_0},\tag{49}$$

in which α is a dimensionless correction factor of order 1.

Hence, from (46-49),

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$$\frac{a_0}{G} = \frac{5}{2} g \frac{\hbar}{2c} (\alpha \frac{\hbar \omega_\pi}{2 \hbar c} \frac{m'_H}{\hbar \omega_W})^3 . \qquad (50)$$

With G = 6.67 10^{-11} kg^{-1} m^3 s^{-2}, $\hbar \omega_\pi \approx 140$ MeV (pion), $\hbar \omega_W \approx 80.4$ GeV (weak interaction boson), $m'_H \approx 126.5$ GeV, $g = 1/\sqrt{137}$, the dimensionless correction facto should amount to $\alpha \approx 0.67$ for giving a fit with Milgrom's acceleration constant $a_0 \approx 1.25$ 10^{-10} m/s^2.

Discussion and conclusion

Expression (50) relates the gravitational constant G and Milgrom's acceleration constant a_0 as the major gravitational parameters with three major nuclear parameters (Higgs boson, the weak interaction boson and the pion's rest mass). The need for the heuristic correction factor $\alpha \approx 0.67$ may seem a shortcoming. However, its numerical value rings a bell. The same factor shows up in the theoretically assessed relationship between the Higgs boson m'_H and the weak interaction boson $m'_W = \hbar \omega_W$, which has been derived as [35],

$$m'_H = \frac{4 d'_{min} m'_W}{\alpha \pi} . \qquad (51)$$

In this expression the factor α is a correction factor that adapts the spacing $2 d_{min}$ to the half wavelength of the weak interaction boson. This correction factor has been assessed by the author as $\alpha \approx 0.69$ already back in 2011, and later in 2016, in studies that revealed a numerically verifiable expression of the gravitational constant G in terms of quantum mechanical quantities [35,36]. The quark model in these references are not different from the one described in paragraph 4 of this article, but, unfortunately, the justification as a third type Dirac particle was missing. Hence, the relationship between gravity and quantum physics shown in these articles has not been credited. Considering that $d'_{min} = 0.853$ as shown in (39), $m'_W \approx 80.4$ GeV and $\alpha \approx 0.69$ it is found from (51) that $m'_H \approx 127$ GeV, which nicely fits with experimental evidence from the detection in 2012 by CERN of a 126.5 GeV bosonic particle. Identifying the α in (51) as the very same α in (50), the relationship (50) between gravity and quantum mechanics simplifies to,

$$\frac{a_0}{G} = \frac{5}{2} g \frac{\hbar}{2c} (\frac{\hbar \omega_\pi}{2 \hbar c} \frac{4 d'_{min}}{\pi})^3 ; \ \exp(-d'_{min})/d'_{min} = \frac{1}{2} . \qquad (52)$$

It will be clear that this result reveals an extremely simple relationship between gravity and quantum physics. It is obtained by a theory that solves the so called "Cosmological Constant catastrophe" as well. This catastrophe is the disagreement between the observed values of vacuum energy density and the theoretical enormously large value of zero-point energy between quantum field energy. The problem vanishes in the theory developed in this article, in which the cosmological background energy and the nuclear background energy have appeared being the same as being captured in elementary polarisable energetic particle with a volume density shown by (24) as,

$$N/\mathrm{m}^3 = \frac{a_0}{20\pi G}\frac{2c}{\hbar}.$$

(53)

The equivalence is the same for the reason that both gravity and quantum physics have been described as the modulation of space-time curving on top of a bias in a weak-field approximation of Einstein's Field Equation. In this view the bias is considered as an irrelevancy that can be ignored.

Summarizing:

In this article, *quarks*, as the elementary nuclear particles, and *darks* as elementary constituents of the cosmological background energy, have been described as Dirac particles of a particular kind, dubbed as *thirds*, being subject to a classical potential field. This has been possible by recognizing that these particular Dirac particles show a real valued polarisable second elementary dipole moment next to the well known elementary angular moment. Quite surprisingly, while the dark behaves as a common gravitational Newtonian particle, the bare quark behaves as an anti-gravitational Newtonian particle (while the constituent mass of a quark is gravitational, the bare mass is anti-gravitational). As a result of this difference, the potential field of quarks is shielded by the darks, while the gravitational field of a baryonic kernel is enhanced by the darks, thereby giving an explanation for the dark matter effect in cosmology. It has been shown that the theory developed in this article has resulted in the view that gravity and quantum physics can be unified. The viability of the theory is proven by two verifiable relationships. The first one, documented by me before [9], is the calculated value of Milgrom's acceleration constant a_0 from the baryonic content Ω_B (= 0.0486) of the universe, shown in (14) as,

$$a_0 = \frac{15}{4}\Omega_B \frac{c}{t_H},$$

(54)

where t_H ($\approx$ 13.8 Gyear), which gives a_0 = 1.25 10^{-10} m/s^2. The second one is the novel relationship, shown by (52), between Milgrom's acceleration constant as characteristic cosmological quantity with the energetic equivalent $\hbar\omega_\pi$ of the pion mass as the characteristic nuclear quantity, with constants of nature, $G, \hbar, c$ and g ($g^2 = 1/137$). The calculated value of Milgrom's acceleration constant from (54) amounts to 1.44 10^{-10} m/s^2. It is slightly different from the one expressed by (52). It seems fair to conclude, considering that the correspondence between the results (52) and (54) the two is close enough for believing that both results strengthen each other, that the nuclear background field known as the Higgs field and the cosmological background field assigned to the Cosmological Constant are identical and embodied by the *darks* with a particle density shown in (53).

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