The unification of gravity and quantum physics due to the isospin of Dirac particles

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Summary
It is shown that gravity and quantum physics can be unified upon the basis of a quark description in terms of a gravitational Dirac particle. It requires the awareness of a second elementary dipole moment (isospin) next to the angular moment (spin) of Dirac particles and the awareness of an (unbroken) omnipresent energetic cosmological background field. The unification has been made explicit by an expression that relates 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: quantum physics; grand unification; isospin; SSB; Dirac particle; Milgrom's constant

1. Introduction

In his classic paper on electrons, Dirac [1] has derived expressions for two elementary dipole momenta. The first one is the well known elementary angular momentum, eventually dubbed as spin $S = \hbar/2$, which manifests itself physically as a magnetic dipole moment, with a magnitude linearly proportionate to S. The second one is an elementary linear momentum with magnitude $\hbar/2c$, which is less known. It has been waived away by Dirac, because it showed up as an imaginary quantity for which he could not find a physical justification. If it would have a physical justification, one might expect that it would show up as an elementary electrical moment. This view has been adopted by Hestenes [2,3] in his studies on the jitter ("zitterbewegung") of electrons. In present day quantum physics, quite some studies are going on, aiming to establish values for the electrical moment of electrons if it would exist [4,5,6,7]. The existence of an electric moment of electrons is put in doubt, because it would violate the CPT pillar of the Standard Model of particle physics [8]. This would be the case indeed if the electrical moment would be the result of a possible distribution of electric charge in a spatial structure. Curiously, in those studies usually no reference is given to Dirac's paper, who took the pointlike format of an electron as an axiom.

It is my aim to show in this article that, in spite of Dirac's conclusion, the elementary linear momentum of a Dirac particle, which we shall indicate for short as isospin, is not an imaginary quantity, but a real one. I wish to show the impact of this isospin on the structure of nuclear particles composed by quarks, in particular on the structure of mesons. Doing so, various axioms of present day quantum physics will be discussed and put into a new light. Among these are the Higgs field, the isospin of quarks and nucleons, the large amount of elementary particles and the hadronic mass spectrum. In addition, it will be shown that the isospin of a Dirac particle is the key to unify quantum physics with gravity.

Before discussing the details, it might be useful to give an outline of the approach first, before discussing details. The outline will be given in the next paragraph.

2. The concept

The Standard Model of particle physics heavily relies upon the concept of an omnipresent energetic nuclear background field, dubbed as the Higgs field. In its most simple representation, this field is characterized by its Lagrangian density $U(\Phi)$. This density is heuristically defined as [9],

$$U_N(\Phi) = \mu_N^2 \frac{\Phi^2}{2} - \lambda_N^2 \frac{\Phi^4}{4}. \tag{1}$$

The justification for this format is the simple fact that many predictions from the theoretical elaboration of this underlying axiom of the Standard Model are in agreement with experimental evidence. It is instructive to compare this heuristically conceived energetic background field with the background field around an electric pointlike charge in an ionized plasma [10], where the background field has the format

$$U_{DB} = \lambda_{DB}^2 \frac{\Phi^2}{2}. \tag{2}$$

The energetic field Φ flowing from the pointlike charge is influenced by this background field and can be derived by the overall Lagrangian density L with the generic format

$$\mathrm{L} = -\frac{1}{2}\partial_\mu \Phi \partial^\mu \Phi + U(\Phi) + \rho\Phi, \tag{3}$$

where $U(\Phi)$ is the potential energy of the background field and where $\rho\Phi$ is the source term. By application of the Euler-Lagrange equation, the potential Φ of the pointlike source of the Debije field can be derived as,

$$\Phi = \Phi_0 \frac{\exp(-\lambda_{DB} r)}{\lambda_{DB} r}, \tag{4}$$

with $\Phi_0 = Q\lambda / 4\pi\varepsilon_0$, where Q is the electric charge and ε_0 the vacuum electric permeability.

Supposing that a quark is an energetic pointlike source, we may try to establish its potential, thereby expecting it being influenced by the energetic background field. Unfortunately, the format of the Higgs background field prevents obtaining straightforwardly an analytical expression. However, by profiling a solution, a numerical procedure may serve for establishing a good fit. The procedure to do so has been documented in [11]. The result is a quark field with the format,

$$\Phi(r) = \Phi_0 \frac{\exp(-\lambda r)}{\lambda r}\{\frac{\exp(-\lambda r)}{\lambda r} - 1\}, \tag{5}$$

where the parameter λ determines the spatial range of the field. Its value depends on the Higgs parameters μ_N and λ_N. The far field behaves similarly as the Debije field, i.e. as a field where the free energetic flow is suppressed by an energetic background field. Particle physicists use to say: mass less bosons are hindered by the surrounding (Higgs) field and gain inertial mass. The potential field has the well known liquid drop model, known from the potential field between nucleons. Each of two quarks in a meson are coupled to the field of the other with a coupling factor g . Hence, the combined field from two quarks in a meson aligned along the $x-$axis, spaced at a $2d$ distance, can be expanded as,

$$V(x) = \Phi(d+x) + \Phi(d-x) = g\Phi_0(k_0 + k_2\lambda^2 x^2 + ...), \tag{6}$$

where $k_0$and k_2 are dimensionless coefficients with magnitudes that depend on the spacing d . The interesting feature of the meson configuration now is, that its center of mass is subject to a potential that (almost) depends on the square of x . Hence, the meson shows the characteristics of a quantum mechanical oscillator. It is therefore subject to excitation, which is the underlying mechanism for the systematic characteristic of the mass spectrum of mesons [12]. The two quarks in the meson align themselves in the condition of minimum energy, such they are spaced at $d\lambda = d'_{\min}$ ($\approx$0.856).

There is one nasty thing though. Where the far field can be explained in conventional field theory by considering it as the description of a repelling force from one quark to another, like in the electromagnetic case, the gluing near field is not clear. Therefore, the open question is, how to explain the attracting force that keeps two forces in equilibrium toward a quasi stable configuration. Particle physics theory is rather vague here. The problem is settled by defining a force of unknown origin, dubbed as color force, which make mesons and baryons quasi stable. This color force is conceived in a frame work of mathematical formalism, but, in fact, a true physical justification is lacking. Nevertheless, Quantum Chromatic Dynamics (QCD) is one of the pillars of present day quantum physics. Another way out could be a kinematic equilibrium, such as proposed by Comay [13] in his positronium model for mesons. Such a model however, does not provide an excitation mechanism for explaining the mass spectrum of hadrons (for which the Standard Model of particle physics has no explanation either).

Except this, the justification of the Higgs field is not very convincing, because it is mainly based upon analogies [9], from which it is not clear why those should apply to all space. If, on the other hand, an explanation would be found for the field as described by the profiled solution (5), the Higgs field (1) would be explained as well. In previous works, I have adopted the quark field profile (5) by simply assuming that, next to a vectorial bosonic far field, a scalar near field exists with the desired properties. It is my aim in this work to show that this assumption can be justified and improved because of two recent obtained results. The first of these is the awareness of Dirac's second dipole moment of electrons. The second of these is the awareness of an omnipresent cosmological energetic background field, which shows up as the vacuum solution of Einstein's Field Equation under adoption of a non-zero value for the Cosmological Constant [14].The combined effect from the two novel views result in a theoretically based liquid drop model for the quark potential similar to (5). Such without the need for adopting the spontaneous symmetry breaking (SSB) mechanism, which so far has been proposed to justify the Higgs field format (1). The crux is the adoption of the Dirac particle description for quarks, including its potential to eject an energetic flow like electrons do, and the validation of isospin for Dirac particles next to spin. The interaction between the isospins, i.e., the linear dipole moments of quarks, is the reason that they attract. Because dipole fields are decaying rapidly, the attracting near field range show a r^{-2} dependency of the potential, while the range of the repelling far field from the energetic flow, shows the regular r^{-1} dependency. The additional exponential decay is due to an energetic background field with a format as shown by the Debije effect. The logic consequence from this consideration is a split of the profiled field (a) into a near field and a far field such that,

$\Phi(r) = \Phi_N(r) + \Phi_F(r)$, with

$$\Phi_N(r) = \Phi_0 \frac{\exp(-\lambda r)}{(\lambda r)^2} \text{ and } \Phi_F(r) = \Phi_0 \frac{\exp(-\lambda r)}{\lambda r}. \tag{7}$$

The latter one, i.e. $\Phi_N(r)$, has the same format as an electric field if $\lambda r \to 0$. It has the characteristics of a Debije field, where the free energetic flow from the source is suppressed by surrounding background field. In line with my earlier studies, I propose to adopt the view that this field is the cause for the nuclear weak interaction, implying that the energetic flow from the quark is carried by the weak interaction bosons. The near field $\Phi_N(r)$ shows the characteristics of an electric dipole field, or, more precisely, the characteristics of a field from an linear dipole moment on the axis perpendicular on the dipole center. There is a slight difference, though, with the profile of the field that has been applied for the numerical solution of the Euler-Lagrange equation under adoption of the Higgs potential. It will be shown later in this article, that the difference between the liquid drop model (5) and the liquid drop model (7) is of minor influence.

It will be clear that the justification for the replacement of the Sponteneous Symmetry Breaking (SSB) Higgs mechanism by a classical field description heavily relies upon (a) the viability of a second dipole moment of a quark conceived as a Dirac particle and (b) on the presence of a energetic background field subject to polarization similar to an ionized plasma. If this would be true, quite some phenomena in particle physics would get a comprehensible explanation. In the paragraph 3, I wish to show the viability of an elementary linear dipole moment (isospin) of Dirac particles, next to the well known angular moment (spin). Thereafter, in paragraph 4, the result will be used to justify the quark potential (7). In paragraph 5 the viability of the polarizable energetic background field will be shown. In paragraph 6 the results will be used to unify gravity with particle physics.

3. The elementary dipole moment of a Dirac particle

Let us first suppose that the Dirac particle is a free moving particle. Its Einsteinean energy is given as,

$$E_W = \sqrt{(m_0 c^2)^2 + (c|\mathbf{p}|)^2}, \tag{8}$$

where m_0 is the particle's rest mass and where $\mathbf{p}$ is the threevector momentum (ds/dt, not be confused with the fourvector momentum $\boldsymbol{p}$). Aligning the particle's free motion along the $x-$axis in Hawking metric (ict, x, y, z), $i = \sqrt{-1}$ and squaring (8) gives,

$$E_W^2 = -p_0^2 c^2 = (m_0 c^2)^2 + c^2 p_1^2 , \tag{9}$$

which can be normalized as,

$$p_0'^2 + p_1'^2 + 1 = 0 ; \; p_\mu' = \frac{p_\mu}{m_0 c} . \tag{10}$$

Note: I prefer to use the Hawking metric (ict, x, y, z) or (+,+,+,+) to avoid the ugly minus sign in (-,+,+,+), which shows up as metric if the time dimension is defined as real instead of imaginary. As long as the temporal dimension is included, the bold italic notation for the vector $\boldsymbol{p}$ will be maintained.

Dirac wrote this equation as,

$$p_0'^2 + p_1'^2 + 1 = (\beta + \overline{\alpha} \cdot \boldsymbol{p}')(\beta + \overline{\alpha} \cdot \boldsymbol{p}') = 0 \text{, with } \overline{\alpha} = \overline{\alpha}(\alpha_0, \alpha_1) \text{ and } \boldsymbol{p}'(p_0', p_1'), \tag{11}$$

thereby leaving freedom for the type of the number β and for the type of components of the two-dimensional vector $\overline{\alpha}$. The elaboration of the right-hand term is:

$$\begin{aligned} &(\beta + \overline{\alpha} \cdot \boldsymbol{p}')(\beta + \overline{\alpha} \cdot \boldsymbol{p}') = (\beta + \sum_\mu \alpha_\mu p_\mu')(\beta + \sum_\nu \alpha_\nu p_\nu') \\ &= \beta^2 + \beta \sum_\nu \alpha_\nu p_\nu' + \beta \sum_\mu \alpha_\mu p_\mu' + \sum_\mu \sum_\nu \alpha_\mu \alpha_\nu p_\mu' p_\nu' \\ &= \beta^2 + \beta \sum_{\mu \neq \nu} (\alpha_\mu \alpha_\nu + \alpha_\nu \alpha_\mu) p_\mu' p_\nu' + \sum_\mu \alpha_\mu^2 p_\mu'^2 . \end{aligned} \tag{12}$$

To equate (12) with the left hand term of (11) the following conditions should be true:

$$\alpha_\mu \alpha_\nu + \alpha_\nu \alpha_\mu = 0 \text{ if } \mu \neq \nu ; \; \beta^2 = 1, \text{ and } \alpha_\mu^2 = 1 \text{ for } \mu = 0,1 . \tag{13}$$

From these expressions it will be clear that the numbers α_μ and β have to be of special type. To this end we could use the following (Pauli) matrices,

$$\alpha_0 = \sigma_1 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} , \quad \alpha_1 = \sigma_3 = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}, \text{ and } \beta = \sigma_2 = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}, \tag{14}$$

where σ_i are the Pauli-matrices. It can be easily verified that (14) meets the condition (13). As the momentum relationship is two-dimensional, the wave function is two-dimensional as well. Under non-relativistic conditions, one of the components is dominant over the other hand. The minor component is usually indicated as the spin component.

The interpretation of spin requires an extension of the analysis from the free moving condition to the condition of motion under influence of a potential field. In the following analysis we shall make use of the following identities,

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$$(\overline{\alpha}\cdot\mathbf{v})(\cdot\overline{\alpha}\cdot\mathbf{w}) = \mathbf{v}\cdot\mathbf{w} + |\mathbf{v}\times\mathbf{w}|$$
$$(\mathbf{v}+\mathbf{w})\times(\mathbf{v}+\mathbf{w}) = (\mathbf{v}\times\mathbf{w}) + (\mathbf{w}\times\mathbf{v}) \tag{15}$$
$$\nabla\times(\mathbf{v}\psi) = \psi(\nabla\times\mathbf{v}) + \nabla\psi\times\mathbf{v}$$

In these relationships, $\mathbf{v}$ and $\mathbf{w}$ are two-dimensional vectors, the quantity $\overline{\alpha} = \overline{\alpha}(\alpha_0, \alpha_1)$ consists of components equal to the 2x2 Pauli- type matrices in (14) and the quantity ψ is a scalar field. The first relationship is a vector identity that relies upon the properties of the Pauli-type matrices [15]. The second identity is a property from elementary vector calculus. The third one is the expansion of the curl operation on the product of a spatial vector and a spatial scalar field.

Eq. (12) in terms of (16) is equivalent with

$$(\overline{\alpha}\cdot\boldsymbol{p}')(\overline{\alpha}\cdot\boldsymbol{p}') + \beta^2 = (\boldsymbol{p}'\cdot\boldsymbol{p}') + |\boldsymbol{p}'\times\boldsymbol{p}'| + 1 = 0\,. \tag{16}$$

This might seem a trivial result, because the vector product of a vector with itself is zero. Hence, this is just a retrieval of the Einsteinean energy expression (11). The expression however changes under the change of momenta components as a consequence of the (normalized) vector potential $\boldsymbol{A}'$ of a conservative field, such that

$$\boldsymbol{p}' \to \boldsymbol{p}' + \boldsymbol{A}'$$

Hence (17) transforms as

$$(\boldsymbol{p}'+\boldsymbol{A}')(\boldsymbol{p}'+\boldsymbol{A}') + |(\boldsymbol{p}'+\boldsymbol{A}')\times(\boldsymbol{p}'+\boldsymbol{A}')| + 1 = 0\,. \tag{17}$$

The vector product in this expression still seems being irrelevant, because of its zero value. This, however, changes after the quantum mechanical transform from momenta to operations on a wave function, defined by

$$p'_\mu \to \hat{p}_\mu\psi \quad \text{with} \quad \hat{p}'_\mu = \frac{1}{m_0 c}\frac{\hbar}{\mathrm{i}}\frac{\partial}{\partial x_\mu}\,. \tag{18}$$

Applying these transforms on the identity

$$(\boldsymbol{p}'+\boldsymbol{A}')\times(\boldsymbol{p}'+\boldsymbol{A}') = (\boldsymbol{p}'\times\boldsymbol{A}') + (\boldsymbol{A}'\times\boldsymbol{p}')$$

we have

$$(\boldsymbol{p}'\times\boldsymbol{A}') + (\boldsymbol{A}'\times\boldsymbol{p}') \to (\hat{\boldsymbol{p}}'\times\boldsymbol{A}')\psi + (\boldsymbol{A}'\times\hat{\boldsymbol{p}}')\psi\,. \tag{19}$$

Where the operator in the first term operates on ψ as well as on $\boldsymbol{A}'$, the operator in the second term only operates on ψ. As a consequence (19) is evaluated as,

$$(\hat{\boldsymbol{p}}'\times \boldsymbol{A}')\psi + (\boldsymbol{A}'\times \hat{\boldsymbol{p}}')\psi = \frac{\hbar}{\mathrm{i}m_0 c}\psi(\nabla\times \boldsymbol{A}'). \tag{20}$$

Where the vector product of the momentum representation is zero, the equivalent wave function representation is not. Apparently, the expression (8) of the Einsteinean energy under influence of spin changes via (20) as,

$$(\boldsymbol{p}'+\boldsymbol{A}')(\boldsymbol{p}'+\boldsymbol{A}')+1+\frac{\hbar}{\mathrm{i}m_0 c}(\nabla\times \boldsymbol{A}')=0. \tag{21}$$

Let us proceed by expanding this equation under consideration that the potential field is generically vectorial, i.e., that next to its scalar component Φ, a vector component $\mathbf{A}$ has to be taken into consideration. In spite of the particle's motion in one spatial direction, we shall suppose that, next to a zero component A_x, the vectorial component has a zero valued transversal component A_y. Moreover, we suppose that the scalar component is orthogonal to the motion, i.e. independent of x. Hence

$$\boldsymbol{p}'=\boldsymbol{p}'(p'_0,p'_1);\ \boldsymbol{A}'=\boldsymbol{A}'(\mathrm{i}\frac{\Phi/c}{m_0 c},0,0)$$ and

$$\nabla\times \boldsymbol{A}'=\begin{bmatrix}\mathbf{e}_\mathrm{t} & \mathbf{e}_\mathrm{x} & \mathbf{e}_\mathrm{y}\\ \partial/\mathrm{i}ct & \partial/\partial x & \partial/\partial y\\ \mathrm{i}\Phi/m_0c^2 & 0 & 0\end{bmatrix}=-\frac{\partial}{\partial y}\mathrm{i}\frac{\Phi}{m_0c^2}\mathbf{e}_\mathrm{x} \tag{22}$$

where $\mathbf{e}_\mathrm{x}$,$\mathbf{e}_\mathrm{y}$ and $\mathbf{e}_\mathrm{t}$, respectively , are unit vectors along the two spatial axes and the temporal axis. and the spatial axis.

Note: The i factor in the scalar component is due to the (Hawking) metric choice (+,+,+,+) / (ict,x,y,z). It can be easily seen from the Lorenz gauge

$$\nabla\cdot\mathbf{A}+\frac{1}{c^2}\frac{\partial\Phi}{\partial t}=0\rightarrow\nabla\cdot\mathbf{A}+\mathrm{i}\frac{\partial\Phi/c}{\partial\mathrm{i}ct}=0. \tag{23}$$

Note also that Φ/m_0c^2 is a dimensionless quantity and that the gravitational potential is an energy per unit of mass. Hence

$$\Phi_G(r)=\frac{MG}{r}=\frac{\Phi}{m_0}. \tag{24}$$

Consequently, (21) evolves as

$$(p'_0+\frac{\mathrm{i}\Phi}{m_0c^2})^2+p'^2_1-\frac{\hbar}{m_0c}\frac{\partial}{\partial y}\frac{\Phi}{m_0c^2}+1=0. \tag{25}$$

After denormalization,

$$(\frac{p_0}{m_0c}+\frac{\mathrm{i}\Phi}{m_0c^2})^2+(\frac{m_0v}{m_0c})^2-\frac{\hbar}{m_0c}\frac{\partial}{\partial y}\frac{\Phi}{m_0c^2}+1=0\,. \tag{26}$$

Note that p_0 is imaginary, as can be seen from (9).

Hence, under consideration of (9),

$$(\frac{E_W}{m_0c^2})^2=-(\frac{p_0}{m_0c}+\frac{\mathrm{i}\Phi}{m_0c^2})^2=(\frac{m_0v}{m_0c})^2-\frac{\hbar}{m_0c}\frac{\partial}{\partial y}\frac{\Phi}{m_0c^2}+1$$

Supposing that the first two terms in the most right hand part are much smaller than 1,

$$E_W\approx m_0c^2(1+\frac{1}{2}\frac{v^2}{c^2}+\frac{\hbar}{2m_0c}\frac{\partial}{\partial y}\frac{\Phi}{m_0c^2})=m_0c^2(1+\frac{1}{2}\frac{v^2}{c^2})-\frac{\hbar}{2c}\frac{1}{m_0}\frac{\partial}{\partial y}\Phi \tag{27}$$

The last term in the right hand part of (27) is the influence of a torque from a scalar field perpendicular on the direction of motion.

The energy dimension of Φ makes $\hbar/2c$ an elementary dipole moment. Curiously, whatever the mass of the particle, this elementary dipole moment always has the same value. It is just a consequence of the particle/wave duality. The small value condition in (27) is not a prerequisite. It is adopted here to reveal the physical interpretation of $\hbar/2c$ as a virtual dipole moment $\hbar/2c$, because eventually, in the static condition, the torque disappears and the condition is true for tiny mass as well.

Curiously, unlike Dirac's conclusion, this dipole moment shows up as a real quantity. Let us now verify that inclusion of the vector components, would deliver an additional momentum that is real as well. To do so, we expand (22) to

$$\nabla\times\boldsymbol{A}'=\begin{bmatrix}\mathbf{e}_t & \mathbf{e}_x & \mathbf{e}_y\\ \partial/\mathrm{i}ct & \partial/\partial x & \partial/\partial y\\ \mathrm{i}\Phi/m_0c^2 & A'_x & A'_y\end{bmatrix}=(-\frac{\partial}{\partial y}\mathrm{i}\frac{\Phi}{m_0c^2}+\frac{1}{m_0c^2}\frac{\partial}{\partial\mathrm{i}ct}A_y)\mathbf{e}_x+\ldots\ldots \tag{28}$$

Note that both components are torque forces, which can be understood by supposing that the vectorial field behaves as a Maxwell's law, where

$$\mathbf{E}=-\nabla\Phi-\partial\mathbf{A}/\partial t. \tag{29}$$

Both contributions in (28) are imaginary, thereby making a real contribution in (21). In spite of Dirac's statement, there is no reason why one of the dipole moments would be imaginary while the other would be real.

4. The potential field of a quark

Let us proceed by considering the field potential of a Dirac particle. First, from the linear momentum. Second, from the angular momentum. As can be expected, the most simple expression for the field from the linear momentum will show up on the perpendicular axis from the center of the dipole. Under consideration of a generic dipole moment $m_0 d$, this potential field can be readily derived as,

$$\frac{\Phi_N(r)}{m_0} = \frac{Gm_0 d}{r^2} \rightarrow \frac{\Phi_N(r)}{m_0} = \frac{\hbar}{2c}\frac{\lambda^2 G}{(\lambda r)^2} \rightarrow \frac{\Phi_N(r)}{m_0} = \frac{\Phi_0}{m_0}\frac{1}{(\lambda r)^2}; \quad \frac{\Phi_0}{m_0} = \frac{\hbar}{2c} G\lambda^2 . \tag{30}$$

This field from the linear moment of the Dirac particle is a candidate for the near field of the quark as proposed by (7).

The far field is the result of an effective mass from the elementary angular moment. From (28) and (29) we may conclude that the elementary angular moment amounts to $\hbar/2$. Interpreting the angular momentum as a rotation with light speed at a fictitious radius $r_0 = \beta/\lambda$, we have

$$\frac{\hbar}{2} = m_0 c \frac{\beta}{\lambda} \rightarrow m_0 = \frac{\hbar}{2}\frac{\lambda}{\beta c} . \tag{32}$$

Hence,

$$\frac{\Phi_F(r)}{m_0} = \frac{m_0 G}{r} = \frac{\hbar}{2}\frac{\lambda}{\beta c}\frac{G}{r} = \frac{\hbar}{2}\frac{G\lambda^2}{\beta c}\frac{1}{\lambda r}, \tag{33}$$

and, under consideration of Φ_0 as defined in (30),

$$\frac{\Phi_F(r)}{m_0} = \frac{\hbar}{2}\frac{G\lambda^2}{\beta c}\frac{1}{\lambda r} = \frac{\Phi_0}{m_0}\frac{1}{\beta}\frac{1}{(\lambda r)} . \tag{34}$$

These two potential fields, $\Phi_N(r)$ in (30 and $\Phi_F(r)$ in (34), are the results of the energetic flow from the Dirac particle-type source. It can be influenced by a background field, if such a background field would be present. Assuming such influence and assuming that the near field is attracting and that the far field is repulsive,

$$\Phi(\lambda r) = \Phi_0 \exp(-\lambda r)\{\frac{1}{(\lambda r)^2} - \frac{1}{\beta}\frac{1}{\lambda r}\} . \tag{35}$$

This is a correction on the profiled format (5) that I derived before from the heuristic Higgs potential (1). The new format gives an almost perfect with the heuristic format for $\beta = 0.55$. It now has a firm theoretical basis. All owing to the overlooked second dipole moment of a Dirac particle. It has only a minor influence on my previous studies, such as for instance the developed theory of the mass spectrum of hadrons and for the article in which the gravitational constant has been expressed in quantum mechanical quantities.

An additional support for this view is obtained from an interpretation for the 80.4 GeV weak interaction bosons $\hbar\omega_W$ and the 127 GeV boson, known as the Higgs particle. The Higgs particle is just the boson of the far field. The weak interaction boson keeps the two quarks in the archetype meson (pion) spaced. It is the result of the combined effect from the attracting near field and the repelling far field. The far field resonance can be established from the pulse response of the far field's wave equation, which has been derived as [12],

$$r\Phi_F(r,t) \leftrightarrow \frac{\Phi_0}{\lambda}\frac{1}{s}\exp(-\lambda r\sqrt{s^2/(\lambda c)^2+1})\,. \tag{36}$$

The right hand part is its Laplace transform. Hence, the resonance ω_0 is,

$$\omega_0 = \lambda c \tag{37}$$

It is tempting to directly associate this resonance frequency with the energy of the Higgs boson as

$$m'_H = \hbar\omega_0\,.$$

Actually, the massive energy of the Higgs boson has to be equated as,

$$m'_H = \hbar\omega_H = 2\lambda(\hbar c)\,. \tag{38}$$

The reason is that in the Standard Model the Higgs boson is defined as the quantum of a single scalar field. It is measured as the total fermionic energy of a decay path. This decay path consists of two far field bosons of the type shown by (36). Hence, the total energy of the Higgs boson is made up by two of these bosons rather than by a single one. Where the weak interaction boson easily shows up in the decay processes of nuclear particles, the Higgs boson only shows up after the confinement break between quarks. That is the reason for the late discovery of the Higgs boson.

The weak interaction boson $\hbar\omega_W$ can be found by relating is half wave length with the spacing $2d_{\min}$ between the two quarks. Hence,

$$2d_{\min} = \frac{1}{2}\alpha cT\,,$$

where α is a dimensionless quantity of order 1. Evaluation gives,

$$2d_{\min} = \frac{1}{2}\alpha cT = \frac{1}{2}c\alpha\frac{2\pi}{\omega_W} \rightarrow \hbar\omega_W = \frac{\pi\hbar c}{2d_{\min}} = \frac{\lambda\alpha\pi\hbar c}{2d'_{\min}} \rightarrow \lambda = \frac{2d'_{\min}m'_W}{\alpha\pi\hbar c}\,. \tag{39}$$

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Hence, from (38) and (39),

$$d'_{\min} = \frac{\alpha \pi m'_H}{4 m'_W} \tag{40}$$

The known numerical values of the weak interaction boson and the Higgs boson settle a condition for the ratio $d'_{\min} / \alpha$. If $d'_{\min} \approx$ 0.856 as will be expected, α amounts to $\alpha \approx$ 0.69.

The next issue to be discussed is the viability of the (unbroken!) energetic background field.

5. The energetic background field

As we have discussed, the omnipresent background energy is a major constituent of the Higgs field. The presence of such an omnipresent background field is imposed by the vacuum solution of Einstein's Field Equation with Cosmological Constant Λ. It is therefore a prerequisite in cosmology. It is a reasonable conjecture to assume that the omnipresent field of nuclear energy is the same as the omnipresent cosmological background field. The Debije effect that would evoke the exponential decay consists of polarizable constituents. Supposing that that the nuclear background field indeed is the same as the cosmological background field, I invoke some recent documented results, available as yet in preprints [16,17]. In these articles, the background field shows up as uniformly distributed Dirac/Majorana particles (with dipoles $\hbar / 2c$). The particle density (hence dipole density) P_{g0} has been calculated as [16] ,

$$P_{g0} = \frac{a_0}{20 \pi G}, \tag{41}$$

where a_0 is Milgrom's acceleration constant. This constant has been originally been introduced defined as an empirical quantity that describes the effect of dark matter in the universe [18,19]. In the referenced preprints, this constant appears being a second constant of nature for gravity, next to the gravitational constant G, related with Einstein's Λ. The latter one is, unlike what cosmologists believe, not a constant of nature, but just an integration constant in Einstein's Field Equation.

A relatively small part of these constituents are clustered as baryonic particles. Another part is locally polarized by the clusters and the polarization of the remaining part remains randomly oriented. This is just the overall picture. The clusters can be locally described as gravitational systems with a central mass. Their gravitational fields are influenced by the surrounding background field. The polarization of the background field dipoles is inwardly oriented. This is different from the outward orientation that occurs in an ionized plasma. Nevertheless, the mechanism is essentially the same. It can be captured by a (n anti) decay parameter λ for the potential of the local center of energy (the central mass). Quantitatively, the square of the anti-decay parameter appears being,

$$\lambda^2 = \frac{2 a_0}{5 M G}, \tag{42}$$

 doi:10.20944/preprints201902.0197.v1

where M is the mass of a gravitational system with a centric baryonic source, such as valid for solar systems and galaxies.

If we wish to unify gravity with quantum mechanical particle physics, it is a logic step to apply the very same underlying polarization mechanism at the microscopic level of quarks as the one that explains dark matter by Milgrom's law. Hence, the decay parameter of the nuclear energetic background field for nuclear sources with mass m_0 can be established from (42) as

$$\lambda^2 = \frac{2a_0}{5m_0 G}, \tag{43}$$

where m_0 is the mass equivalent of the quark's energy. It will be clear that the identification of the nuclear background field as being the same as the cosmological background yields the instrument for unifying gravity with quantum physics. This will be made explicit in the next paragraph.

6. The unification of gravity with quantum mechanical physics

The force F of a nuclear particle experienced from the potential field of the quark can be expressed by

$$F = g\frac{d\Phi_N}{dr} + g\frac{d\Phi_F}{dr}, \tag{44}$$

where where g is the generic quantum mechanical coupling factor, defined by $g^2 = 4\pi\varepsilon_0\hbar c$ (= 1/137).

From the format of Φ_F as shown in (34) it is obvious that it shows the same behavior as a gravitational potential. The factor β^{-1} can be interpreted as a gyrometric factor, more or less similar to the gyromagnetic factor that shows up the relationship between the magnetic moment of an electron with its angular moment. Interpreting the far field force as a gravitational force indeed, justifies the equivalence,

$$g\frac{d\Phi_F}{dr} = \beta^{-1} m_0 \frac{d}{dr}\frac{m_0 G}{r}. \tag{45}$$

Hence from (33),

$$g m_0 G \frac{\hbar}{2c}\lambda^3 = m_0^2 G \lambda^2 \rightarrow m_0 = g\frac{\hbar}{2c}\lambda . \tag{46}$$

Hence from (46) and (43)

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

This is the basic unification formula. The remaining issue is establishing an expression for λ. This is possible by considering that the spacing between the quarks in the center of frame is just the half wavelength of a boson $\hbar\omega_W$. Considered, however, in the inertial frame, the energy of the boson is the rest mass of the meson $\hbar\omega_\pi$. Hence

$$2d_{\min}=\frac{1}{2}cT=\frac{1}{2}\hbar c\frac{2\pi}{\hbar\omega_W}=2\frac{d'_{\min}}{\lambda}\rightarrow\lambda=\frac{1}{\pi}\frac{\hbar\omega_\pi}{\hbar c}2d'_{\min}. \tag{48}$$

Hence, from (40),

$$\lambda=\frac{\hbar\omega_\pi}{\hbar c}(\frac{\alpha m'_H}{2m'_W}). \tag{49}$$

The two expressions (47) and (49) express a unification between gravity (47) and (49). Similarly, as in the expression of the gravitational constant in terms of quantum mechanical quantities as derived by me before from quite another perspective [11], the parameter α plays a crucial role. For a_0 = 1.25 10^{-10} m/s^2 (present known value of Milgrom's acceleration constant), G = 6.67 10^{-11} kg^{-1} m^3 s^{-2}, $\hbar\omega_\pi\approx$ 140 MeV (pion), $m'_W\approx$80.4 GeV (weak interaction boson) and $m'_H\approx$127 GeV (Higgs boson), the fit is obtained for $\alpha\approx$0.66. This surprisingly close to the $\alpha\approx$0.69 value obtained in [11].

7. Conclusion

In this article, quarks have been described as Dirac particles subject to gravitational laws. This has been possible by recognizing that Dirac particles show a second elementary dipole moment next to the well known angular moment $\hbar/2$, usually dubbed as spin. It has been shown that this second elementary dipole moment, dubbed in this text as isospin, has a real valued magnitude $\hbar/2c$. This in spite of Dirac's conclusion that it would be imaginary. The theory, based upon this view, has resulted in the view that the quark is an elementary gravitational particle. As a result, gravity and quantum physics can be unified. The unification has been explicitly been expressed in the relationship between the two major gravitational constants of nature G (gravitational constant) and a_0 (Milgrom's constant, related with Einstein's Cosmological Constant [14]) and the two major nuclear field constants embodied by the weak interaction boson $m'_W=\hbar\omega_W$ and the Higgs boson $m'_H=\hbar\omega_H$. In explicit terms,

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

Apart from the constants of nature, g,c and $\hbar$, this expression contains the energetic value of the rest mass of the archetype meson (pion) and a dimensionless quantity α. The latter value is a quantity of order 1 that relates the quark spacing in the pion with the half wave length of the weak interaction boson. It may seem that it is used as a "fudge" parameter for fitting the left hand part with the right hand part of the derived expression (50). Actually, it is much better than that. The same parameter shows up in the gravitational constant that has been expressed in quantum mechanical quantities before [11], which has been derived from quite another perspective. The two values $\alpha \approx 0.66$ (this theory) and $\alpha \approx 0.69$ [11] are so close, that it justified to conclude that both theories confirm each other. The difference between the two theories, though, is quite substantial. First, in [11], the pion structure has been derived by accepting the heuristics of the Higgs potential and by assuming some unknown gluing force between the quarks in a pion. In the present article, the gluing force between the quarks has been derived from the second elementary dipole moment of the quark conceived as a Dirac particle. Second, in [11] the broken field format of the Higgs field has been accepted as an axiom from the Standard Model. In the present article, though, it has been shown that the format of this field is the result of the interaction of the energy flow from the quark with the (unbroken) cosmological background field. Both theories have in common that they describe the archetype meson as a quantum mechanical oscillator. It justifies the excitation mechanism of mesons that explains the systematic relationships, not only between hadrons, but even between the quarks themselves, such that the number of elementary particles can be significantly reduced [12].

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