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The impact of the quark's monopole properties on the unification of the fundamental physical forces

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Summary
It is shown that the four fundamental physical forces, i.e. weak interaction, strong interaction, electromagnetism and gravity, all have their origin in the quark as the single true elementary particle. This requires conceiving the quark as a Dirac particle in a pseudo-tachyon mode, which possesses two real dipole moments: the common one associated with its angular momentum and a second one that is polarisable in a scalar field. This Dirac particle carries a regular charge magnetic monopole without Dirac's string, theorized by Comay. The boson carrier of its field of energy is the gluon showing an exponential decay of its spatial range because of the influence of an omni-present energetic background field, known as the Higgs field, in this article interpreted as the Lambda in Einstein's Field Equation.

Keywords: grand unification; magnetic monopole; pseudo-tachyon; Higgs field

1. Introduction

The work to be described in this document is meant as an extension on earlier work, in which hadrons have been described in terms of quarks that are conceived as Dirac particles of a particular type that possess the unique property of having a polarisable dipole moment in scalar potential field [1,2]. It has been shown and justified that the quark can be modelled as an energetic pointlike particle that erupts an energetic field $\Phi(r)$, which can generically be expressed as,

$$\Phi_F(r) = \frac{\Phi_{F0}}{\lambda r}, \tag{1}$$

in which Φ_{F0} is a strength parameter in units of energy and in which λ is a normalization parameter with dimension [m^{-1}]. The polarisable dipole moment is responsible for an additional near field that along the direction of the dipole axis has the format $\Phi_N(x)$, which can be generically be expressed as,

$$\Phi_N(x) = \frac{\Phi_{N0}}{(\lambda x)^2}. \tag{2}$$

The two fields can be combined into a single field expression. To explain the short spatial range of nuclear forces, it has been assumed that the fields are shielded by an energetic background field in a similar way as the Coulomb field of a charged particle in an ionic plasma is shielded by the Debije effect. As a result from these two contributions, the

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potential field of a quark in this background field can be generically expressed along the axis of the dipole moment as,

$$\Phi(x) = \Phi_0 \exp(-\lambda x)\{\frac{1}{(\lambda x)^2} - w\frac{1}{\lambda x}\}, \tag{3}$$

in which w is a dimensionless weighing factor that relates the far field with the near field. The identification of the background field with the Higgs field as defined in the Standard Model has enabled the assessment of a numerical value $w \approx 1/0.55$. The shape of the potential function, shown by figure 1a, is known as "the liquid drop model" [3]. This model, conceived in 1928 by Ganov [3] for the internucleon potential, has been adopted, apart from me [4], by Comay for the interaction between the two quarks in a pion [5]. As proven in [4], It can be retrieved from the Higgs Lagrangian [6],

$$U(\Phi) = -\frac{\mu_H^2}{2}\Phi^2 + \frac{\lambda_H^2}{4}\Phi^4, \tag{4}$$

shown in figure 1b, nicknamed as the "Mexican hat model", owing to its shape if rotated around the vertical axis.

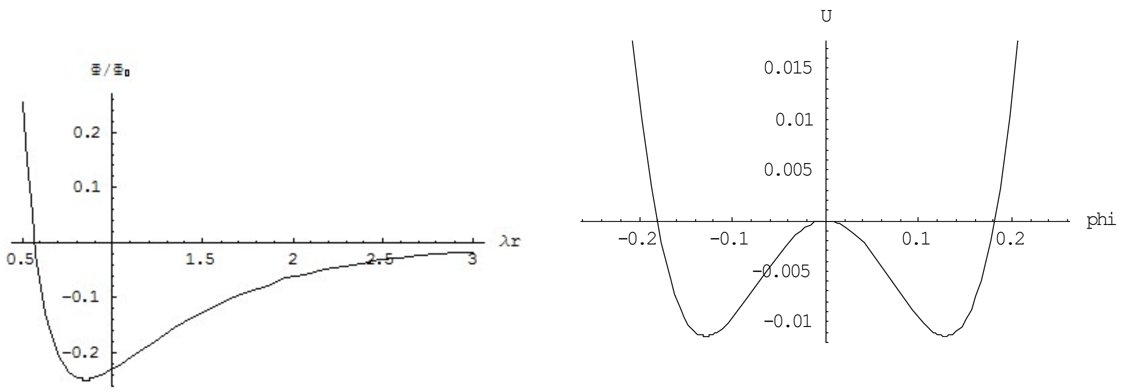

Fig. 1. (Left) The quark's scalar field Φ/Φ_0 as a function of the normalized radius λx ; (Right) The field's Lagrangian $U_H(\Phi) = -U(\Phi)$ retrieved from the spatial expression. .

This quark model enables to conceive the archetype meson (pion) as a structure shown in figure 2. In this structure, the quark is coupled by a dimensionless coupling factor to the field of the antiquark. In the center-of-mass frame, the *relativistic* two-body structure can be modelled as a *non-relativistic* one-body a(n) harmonic oscillator that can be described by a Schrödinger type wave function ψ of the center-of-mass in the wave function equation,

$$-\frac{\hbar^2}{2m_m}\frac{d^2\psi}{dx^2} + g\Phi_0\{k_0 + k_2\lambda^2x^2 + ...\}\psi = E\psi, \tag{5}$$

in which g is a dimensionless coupling factor. This represents an anharmonic quantum mechanical oscillator characterized by quantum steps $\hbar\omega$ related with the effective mass m_m, such that

$$\frac{1}{2}m_m\omega^2 = g\Phi_0 k_2\lambda^2 \rightarrow \frac{m'_m(\hbar\omega)^2}{(\hbar c)^2} = 2g\Phi_0 k_2\lambda^2 . \tag{6}$$

Conventionally, $m'_m = m_m c^2$ is the energy of the central mass of the oscillator. In this case, the mass does not represent the individual masses of the two bodies, but it is an equivalent mass that captures the energy of the field. As usual, ω is related with the vibration energy $E_n = (n+1/2)\hbar\omega$. The dimensionless constant k_0 is a measure for the binding energy between the two bodies. The dimensionless constant k_2 is determined by the curvature of the potential in the center of mass. These values can be straightforwardly calculated from (3) as $k_0 = -1/2$ and $k_2 = 2.36$ [1].

Considering that the pion decays into a fermion via the weak interaction boson, the boson $\hbar\omega$ can be equated with the weak interaction boson. Hence,

$$\hbar\omega = \hbar\omega_W . \tag{7}$$

Its value $\hbar\omega_W$ = 80.4 GeV represents the relativistic value of the non-relativistic lab frame rest mass of the pion ($m'_\pi = m_\pi c^2 \approx$ 140 MeV).

The oscillator settles itself into minimum energy condition. This is established under a particular spacing $2d$ between the two quarks, such that $d'_{\min} = d\lambda =$ 0.853. In this condition two important relationships can be derived. These are, respectively

$$\hbar\omega_W = 2|k_0|g\Phi_0 = g\Phi_0 \tag{8}$$

$$\frac{g\Phi_0}{\lambda} = \frac{\alpha\pi(\hbar c)}{2d'_{\min}} , \tag{9}$$

in which α is a dimensionless constant of order 1, the value of which has been calculated as $\alpha \approx$ 0.69 [2].

The simple anharmonic oscillator model described by (5) enables the mass spectrum calculation of the pseudoscalar mesons as excitations from the pion state. The excitation mechanism stops beyond the bottom quark due to the loss of binding energy. The mass spectrum calculation of the vector mesons requires the inclusion of the impact of the nuclear spin shown in the upper part of figure 2. The massive energy difference ΔE between the pseudoscalar pion and the vector type sisters rho and omega has been calculated as,

$$\Delta E = Bm'_\pi \ ; \ B = \frac{7}{12}\frac{8\gamma^2}{d'_{\min}(\alpha\pi)^2} \approx 4.66 \text{ for } \gamma = 2, \tag{10}$$

in which γ is the nuclear equivalent of the gyromagnetic ratio. This massive energy difference is caused by the interaction of the nuclear spins and comes free mediated by the Z boson under influence of the nuclear spin flip from parallel to anti-parallel. As shown in [1], this expression allows to calculate the Z boson energy as 91.16 MeV.

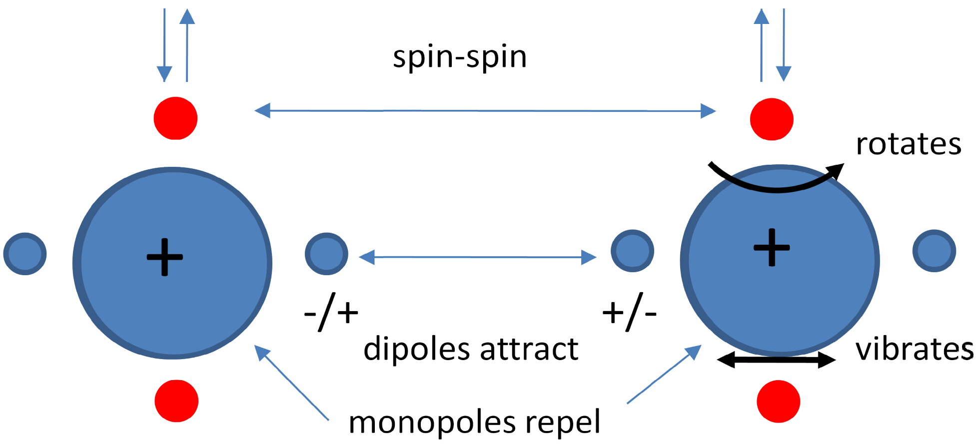

Fig. 2. A quark has two real dipole moments, hence two dipoles. One of these (horizontally visualized) is polarisable in a scalar potential field. The other one (vertically visualized) is not. The dipole moments are subject to spin statistics. However, the polarity of the horizontal one is restrained by the bond: the horizontal dipoles are only oriented in the same direction: either inward to the centre or outward from the centre.

In this model, the role of the Higgs field is represented by the shield parameter λ. A comparison of this structural model with the Standard Model, has revealed the relationship,

$$m'_H = 2\lambda(\hbar c)\,, \tag{11}$$

In fact, the Higgs now shows up as the signature of two gluons rather than as an individual particle. More particularly, the gluon-quark relationship is seen as the nuclear equivalent of the photon-electron relationship. It means that the gluon should be interpreted as the boson associated with the quark's far field (1). Such boson is subject to the Proca-type wave equation,

$$\frac{1}{c^2}\frac{\partial^2 r\Phi}{\partial t^2} - \frac{\partial^2}{\partial r^2} r\Phi + \lambda^2 r\Phi = \rho_H(r,t)\,, \tag{12}$$

in which $\rho_H(r,t)$ is a Dirac-type pointlike source that can be expressed as,

$$\rho_H(r,t) = 4\pi r\frac{\Phi_0}{\lambda}\delta^3(r)H(t)\,, \tag{13}$$

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in which $H(t)$ and $\delta(r)$, respectively, are Heaviside's step function and Dirac's delta function.

Figure 3 shows the solution of the gluon's wave function in a graphical format. Unlike a gamma photon, the gluon is subject to dispersion. The dispersion is due to the λ^2 term in the Proca wave equation (12). This term is a consequence of the energetic ambient field, known as the Higgs field.

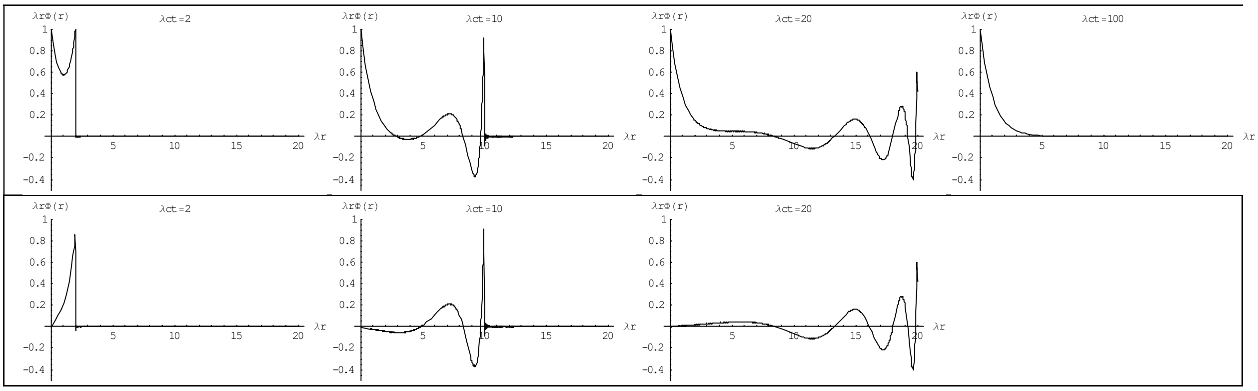

Fig.3. The building of the quark's potential field as a result of a sudden energy eruption from its source. The field is the sum of the steady solution shown at the right and the transient pulse shown in the lower part of the figure. This pulse is the actual gluon. It propagates at light speed and it eventually disappears as a result of dispersion. If λ is zero, the transient is a never disappearing gamma photon and the stationary situation is shown by an unfinished rectangular shape of the upper most right graph. Note that the field is represented by $r\Phi(r)$.

2. The second dipole moment of the quark

The simple model as described in the introduction relies on the presupposed quark's property of showing nuclear equivalents for the magnetic dipole moment and the electric dipole moment of electron-type Dirac particles. Whereas the viability of an equivalent for the magnetic dipole moment, related with the elementary angular momentum ***ħ*** can be readily understood, it is not the case for an equivalent of the electric dipole moment, related with the position momentum ***ħ/c***. While for common Dirac particles the magnetic dipole moment is a real value, the electric dipole moment is an imaginary value, hence non-existing [7]. This implies that if the quark shows two real dipole moments like described in the introduction above, it can't be a common Dirac particle. If it is a Dirac particle indeed, it must be an uncommon one. Let us try finding if such an uncommon type with the desired property would be feasible from a theoretical point of view.

To do so, let us start from the canonic format of Dirac's equation as captured by,

$$(\mathrm{i}\hbar\gamma^{\mu}\partial_{\mu}\psi - m_0 c\psi) = 0 \rightarrow (\hbar\gamma^{\mu}\frac{\partial_{\mu}\psi}{\mathrm{i}} - \frac{1}{\mathrm{i}^2}m_0 c\psi) = 0, \qquad (14)$$

It can be rewritten after division by $m_0 c$, in terms of wave function operators as,

$$[\gamma_0 \hat{p}'_0 + (\bar{\gamma} \cdot \hat{\mathbf{p}}') + I_4]\psi = 0, \tag{15}$$

in which $\hat{\mathbf{p}}' = \hat{\mathbf{p}}'(\hat{p}_1, \hat{p}_2, \hat{p}_3)$ with

$$\hat{p}'_i = \frac{1}{m_0 c} \frac{\hbar}{\mathrm{i}} \frac{\partial}{\partial x_i} \quad \text{and} \quad \hat{p}'_0 = \frac{1}{m_0 c} \frac{\hbar}{\mathrm{i}} \frac{\partial}{\partial c\tau}, \tag{16}$$

and in which I_4 is the 4 x 4 identity matrix.

Note that the variables are signed by ' to emphasize their normalization on $m_0 c$. Note also that the temporal parameter is written as proper time τ to emphasize the (special) relativistic nature of Dirac's equation in free space. Rewriting (15) in the Weyl format gives,

$$\begin{bmatrix} I & 0 \\ 0 & -I \end{bmatrix} \begin{bmatrix} \hat{p}'_0 \psi \\ \hat{p}'_0 \chi \end{bmatrix} + \begin{bmatrix} 0 & \bar{\sigma} \\ -\bar{\sigma} & 0 \end{bmatrix} \begin{bmatrix} \hat{\mathbf{p}}' \psi \\ \hat{\mathbf{p}}' \chi \end{bmatrix} + \begin{bmatrix} I & 0 \\ 0 & I \end{bmatrix} \begin{bmatrix} \psi \\ \chi \end{bmatrix} = 0. \tag{17}$$

As known, Dirac's equation is based upon a heuristic elaboration of the Einsteinean energy expression under use of particular properties of the γ matrices. These properties can be summarized as,

$$\gamma_\mu \gamma_\nu + \gamma_\nu \gamma_\mu = 0 \text{ if } \mu \neq \nu; \text{ and } \gamma_0^2 = 1; \gamma_i^2 = -1; \beta^2 = 1, \tag{18a}$$

in which β is the last matrix term in (17). Recognizing that the last term in the left hand part of (16) represent a matrix β and that (14) is valid for a plus sign in front of m_0 as well, one should add in fact,

$$\gamma_\mu \beta \mp \beta \gamma_\mu = 0; \ \beta = \pm 1, \tag{18b}$$

which is trivial as long as β is an Identity matrix. The very same properties are met if (17) is modified into,

$$\begin{bmatrix} I & 0 \\ 0 & -I \end{bmatrix} \begin{bmatrix} \hat{p}'_0 \psi \\ \hat{p}'_0 \chi \end{bmatrix} + \begin{bmatrix} 0 & \bar{\sigma} \\ -\bar{\sigma} & 0 \end{bmatrix} \begin{bmatrix} \hat{\mathbf{p}}' \psi \\ \hat{\mathbf{p}}' \chi \end{bmatrix} + \mathrm{i} \begin{bmatrix} 0 & I \\ I & 0 \end{bmatrix} \begin{bmatrix} \psi \\ \chi \end{bmatrix} = 0. \tag{19}$$

Note that the β is modified from the 4 x 4 identity matrix into the imaginary value of the "fifth" gamma matrix γ_5. The two representations (17) and (19) are equivalent. Both represent the common electron-type Dirac particle with a real magnetic dipole moment and an imaginary electric dipole moment. If β would have been modified into the real value of γ_5, we would have obtained the tachyon format, which reads as,

$$\begin{bmatrix} I & 0 \\ 0 & -I \end{bmatrix} \begin{bmatrix} \hat{p}'_0 \psi \\ \hat{p}'_0 \chi \end{bmatrix} + \begin{bmatrix} 0 & \bar{\sigma} \\ -\bar{\sigma} & 0 \end{bmatrix} \begin{bmatrix} \hat{\mathbf{p}}' \psi \\ \hat{\mathbf{p}}' \chi \end{bmatrix} + \begin{bmatrix} 0 & I \\ I & 0 \end{bmatrix} \begin{bmatrix} \psi \\ \chi \end{bmatrix} = 0. \tag{20}$$

This tachyon format is studied in the context of the hypothetical existence of superluminal particles [8]. It does meet the constraint (18a), but it violates constraint (18b). Instead it meets,

$$\gamma_\mu\beta + \beta\gamma_\mu = 0;\ \ \beta^2 = -1. \tag{21}$$

Note the subtle difference between (18b) and (21). The dipole moments of the tachyon are similar to those of the electron-type: the equivalent magnetic one is real and the equivalent electric one is imaginary.

Both dipole moments are real for a *third* modification of Dirac's particle [9,10]. This modification reads as,

$$\mathrm{i}\begin{bmatrix} I & 0 \\ 0 & -I \end{bmatrix}\begin{bmatrix} \hat{p}'_0\psi \\ \hat{p}'_0\chi \end{bmatrix} + \begin{bmatrix} 0 & \overline{\sigma} \\ -\overline{\sigma} & 0 \end{bmatrix}\begin{bmatrix} \hat{\mathbf{p}}'\psi \\ \hat{\mathbf{p}}'\chi \end{bmatrix} + \begin{bmatrix} 0 & I \\ I & 0 \end{bmatrix}\begin{bmatrix} \psi \\ \chi \end{bmatrix} = 0. \tag{22}$$

As compared with the electron-type (19), the γ_0 matrix is made imaginary. It meets the constraints,

$$\gamma_\mu\gamma_\nu + \gamma_\nu\gamma_\mu = 0 \text{ if } \mu \neq \nu;\ \ \gamma_\mu\beta + \beta\gamma_\mu = 0;\ \gamma_0^2 = -1; \gamma_i^2 = -1;\ \beta^2 = -1. \tag{23}$$

To understand the violations of the constraints (18) and the modifications into (21) and (23), it is instructive to solve the various formats (19), (20) and (22) of Dirac's equation. In full expansion mode, (22) reads as

$$\mathrm{i}\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix}\begin{bmatrix} \hat{p}'_0\psi_0 \\ \hat{p}'_0\psi_1 \\ \hat{p}'_0\psi_2 \\ \hat{p}'_0\psi_3 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & 0 \\ -1 & 0 & 0 & 0 \end{bmatrix}\begin{bmatrix} \hat{p}'_1\psi_0 \\ \hat{p}'_1\psi_1 \\ \hat{p}'_1\psi_2 \\ \hat{p}'_1\psi_3 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 0 & -\mathrm{i} \\ 0 & 0 & \mathrm{i} & 0 \\ 0 & \mathrm{i} & 0 & 0 \\ -\mathrm{i} & 0 & 0 & 0 \end{bmatrix}\begin{bmatrix} \hat{p}'_2\psi_0 \\ \hat{p}'_2\psi_1 \\ \hat{p}'_2\psi_2 \\ \hat{p}'_2\psi_3 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 \\ -1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}\begin{bmatrix} \hat{p}'_3\psi_0 \\ \hat{p}'_3\psi_1 \\ \hat{p}'_3\psi_2 \\ \hat{p}'_3\psi_3 \end{bmatrix} + \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}\begin{bmatrix} \psi_0 \\ \psi_1 \\ \psi_2 \\ \psi_3 \end{bmatrix} = 0$$

and written differently,

$$\begin{bmatrix} \mathrm{i}\hat{p}'_0 & 0 & \hat{p}'_3 + 1 & (\hat{p}'_1 - \mathrm{i}\hat{p}'_2) \\ 0 & \mathrm{i}\hat{p}'_0 & (\hat{p}'_1 + \mathrm{i}\hat{p}'_2) & -\hat{p}' + 1_3 \\ -\hat{p}'_3 + 1 & (\hat{p}'_1 - \mathrm{i}\hat{p}'_2) & -\mathrm{i}\hat{p}'_0 & 0 \\ -(\hat{p}'_1 + \mathrm{i}\hat{p}'_2) & \hat{p}' + 1_3 & 0 & -\mathrm{i}\hat{p}'_0 \end{bmatrix}\begin{bmatrix} \psi_0 \\ \psi_1 \\ \psi_2 \\ \psi_3 \end{bmatrix} = 0. \tag{24}$$

Let $\psi = u_\mu \exp\{\mathrm{i}(\mathbf{k}\cdot\mathbf{r} - \omega t)\}$; $\mathbf{k} = \mathbf{p}/\hbar$; $\omega = W/\hbar$. (25)

Applying (25) on (24) gives after some elaboration,

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$$\begin{bmatrix} -\mathrm{i}W & 0 & cp_3+m_0c^2 & c(p_1-\mathrm{i}p_2) \\ 0 & -\mathrm{i}W & c(p_1+\mathrm{i}p_2) & -cp_3+m_0c^2 \\ -cp_3+m_0c^2 & -c(p_1-\mathrm{i}p_2) & \mathrm{i}W & 0 \\ -c(p_1+\mathrm{i}p_2) & cp_3+m_0c^2 & 0 & \mathrm{i}W \end{bmatrix}\begin{bmatrix} u_0 \\ u_1 \\ u_2 \\ u_3 \end{bmatrix}=0. \tag{26}$$

This homogeneous set of equations has the solution (25) indeed under the constraint of the determinant value

$$W^2=(m_0c^2)^2-c^2|\mathbf{p}|^2. \tag{27}$$

The canonical equations (17) or (19) show the same solution (25), but different from (27), under the constraint,

$$W^2=E_W^2=c^2|\mathbf{p}|^2+(m_0c)^2.. \tag{28}$$

The tachyon equation (20) shows solution (25) for

$$W^2=c^2|\mathbf{p}|^2-(m_0c^2)^2. \tag{29}$$

For a meaningful wave function, ω and $\mathbf{k}$, hence W and $\mathbf{p}$, must be real. Hence, let us consider the condition (27) more closely. It can be rewritten as,

$$\frac{W^2}{(m_0c^2)^2}=\frac{(v/c)^2}{(v/c)^2-1}+1=0\rightarrow\frac{W^2}{(m_0c^2)^2}=\frac{1-2(v/c)^2}{1-(v/c)^2}. \tag{30}$$

The condition for the momentum $\mathbf{p}$ evolves as,

$$\frac{c^2|\mathbf{p}|^2}{(m_0c^2)^2}=-\frac{W^2}{(m_0c^2)^2}+1=1-\frac{1-2(v/c)^2}{1-(v/c)^2}\rightarrow\frac{\mathbf{p}}{m_0c}=\pm\sqrt{\frac{(v/c)^2}{1-(v/c)^2}}. \tag{31}$$

Hence,

$$W=\pm m_0c^2\sqrt{\frac{1-2(v/c)^2}{1-(v/c)^2}};\quad \mathbf{p}=\pm\frac{m_0v}{\sqrt{1-(v/c)^2}}. \tag{32}$$

The similar elaboration for the tachyon format results into,

$$W=\pm\frac{m_0c^2}{\sqrt{(v/c)^2-1}};\ \frac{\mathbf{p}}{m_0c}=\pm\frac{m_0v}{\sqrt{(v/c)^2-1}}. \tag{33}$$

The tachyon format shows real values for W and $\mathbf{p}$ under superluminal conditions. It is a reason for speculations on the potential existence of superluminal particles. It is not meaningful under subluminal conditions, because the real values turn into imaginary ones.

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The properties of the "third" format, though, as shown by (32) are real under subluminal conditions. The real value of its second dipole moment makes it of interest.

For better understanding the origin of the difference between the canonical format (19), the tachyon format (20) and the "third" format (22), it is instructive reconsidering Dirac's transformation of the momenta $\boldsymbol{p}(p_0, \mathbf{p})$ of a particle in motion into wave function operators p_0 and $\hat{\mathbf{p}}$, like shown in (15), in which p_0 represents the temporal momentum $p_0 = m_0 \mathrm{d}(ct)/\mathrm{d}\tau$. In fact, the expression is incomplete, because the transform of a scalar constant like, for instance rest mass $m_0 c^2$, is missing. Implicitly, Dirac has included the transformation of a generic scalar k as,

$$k \to \hat{k} = k\psi . \tag{34a}$$

A similar set, different from (15) and (33) would have resulted into an equation different from the canonical format (19). Considering that in this respect Dirac's choice is heuristic, one might suppose that adopting

$$k \to \hat{k} = \pm \mathrm{i} k\psi , \tag{34b}$$

Is theoretically viable as well. It is easy to see that this simple change of rule transforms the canonical format (18) into the tachyon format. Hence, although up to now, there is no experimental physical evidence, tachyons are considered as potentially existing [11].

Apart from considering a different transformation for scalar constants, one might consider a change of Dirac's heuristic choice (15) into,

$$\hat{p}'_i = \frac{1}{m_0 c}\frac{\hbar}{\mathrm{i}}\frac{\partial}{\partial x_i} \;;\; \hat{p}'_0 = \frac{1}{m_0 c}\frac{\hbar}{\mathrm{i}}\frac{\partial}{\partial(\mathrm{i}c\tau)} ;\; \hat{k} = \pm \mathrm{i} k\psi \tag{35}$$

This changes the tachyon format into the "third" format, shown by (22), which is subject to the constraint (27). The interpretation of its W as energy, shown by (27) implies that the particle's energy decreases if it goes from rest into motion. This is contra-intuitive, because In true empty space one would expect the opposite, such as expressed by the Einsteinean energy expression (28) that holds for the canonical case. Apparently, the discrepancy is due to the difference between the constraints shown by (23) with the constraints shown by (18). While the latter ones hold for empty space indeed, eq. (22) holds for a space with a different metric of space-time as may occur from the presence of background energy. While such a background field in free space is clearly absent in electromagnetism, it is not excluded that it may exist for non-electromagnetic energy. One might speculate that in particle physics the presupposed Higgs field might give a pedestal such that the binding energy of the particle with space decreases as soon as the particle starts moving. Later in this article we shall come back on the issue. For the moment we shall adopt the view that the quark can be described by a Dirac equation of the format shown by (22). Like proven in [9,10], such a quark has a polarisable dipole moment in a scalar field. The existence of such a dipole moment validates the structural quark model shown in figure 2.

3. The monopole properties of the quark

So far in this description, a generic energetic potential Φ has been assigned to the quark, to which an identical other one couples with a dimensionless coupling factor g, such that the interaction force F is expressed as,

$$F = g\frac{\partial}{\partial r}\frac{\Phi_0}{r'}; \quad r' = r\lambda, \tag{36}$$

in which λ is a normalization quantity that makes r' dimensionless. Because of the degree of freedom in the invariant product $g\Phi_0$, the coupling factor g has been set to the square root of the electromagnetic fine structure constant α_e, such that $g = \sqrt{\alpha_e} = 1/\sqrt{137}$.

Doing so similarly for the interaction between two electrons, we would have,

$$F = g\frac{\partial}{\partial r}\frac{\Phi'_0}{r'} = \frac{e^2}{4\pi\varepsilon_0}\frac{\partial}{\partial r}\frac{1}{r} = \frac{e^2}{4\pi\varepsilon_0}\frac{\partial}{\partial r}\frac{\lambda}{r'} = \alpha_e\hbar c\lambda \rightarrow \Phi'_0 = g(\hbar c)\lambda. \tag{37}$$

Doing so for the interaction between two unknown nuclear charges u, we would have,

$$F = g\frac{\partial}{\partial r}\frac{\Phi_0}{r'} = u^2 G_{qu}\frac{\partial}{\partial r}\frac{1}{r} = u^2 G_{qu}\frac{\partial}{\partial r}\frac{\lambda}{r'} \rightarrow \Phi_0 = N_{qu} g(\hbar c)\lambda; \; N_{qu} = \frac{u^2 G_{qu}}{g(\hbar c)}. \tag{38}$$

In this picture, the quantity N_{qu} is the factor that expresses the excess strength over the electrical strength. It can be calculated by comparing the far field force F_F evoked by a quark with the electromagnetic force F_e evoked by an electron e. Generally,

$$F_e = -e\frac{\partial}{\partial r}\frac{e}{4\pi\varepsilon_0 r} \quad \text{and} \quad F_F = -g\frac{\partial}{\partial r}\Phi_0\frac{\exp(-\lambda r)}{\lambda r}. \tag{39}$$

There is no reason why these forces would be the same. What is clear, however, is, that $g\Phi_0/\lambda$ plays a similar role as $e^2/(4\pi\varepsilon_0)$, i.e.,

$$\frac{e^2}{4\pi\varepsilon_0} \leftrightarrow \frac{g\Phi_0}{\lambda}. \tag{40}$$

It means that the electric force from certain electric charge q_e is equivalent with a nuclear force such that

$$\frac{q_e^2}{4\pi\varepsilon_0} = \frac{g\Phi_0}{\lambda}. \tag{41}$$

Hence, from (9) and (41),

$$q_e^2 = 4\pi\varepsilon_0 \frac{\alpha\pi\hbar c}{2d'_{\min}} = \frac{4\pi}{c^2\mu_0}\frac{\alpha\pi\hbar c}{2d'_{\min}}. \tag{42}$$

A numerical evaluation of this expression ($\alpha \approx 0.69; d'_{\min} \approx 0.856, \mu_0 = 4\pi$ x 10-7 N/A^2 , $e =$ 1.6 x 10^{-19} A s^{-1}) reveals that the far field nuclear force between two archetype quarks is about equivalent with the electric force between 13 electrons.

The parallel between the nuclear charge u and the electric charge q_e as shown by (37-38) evokes the suggestion that the nuclear energy might have an electromagnetic origin. A bold hypothesis is supposing that the quark might be a magnetic monopole q_u with an equivalent strength of 13 electrons. Considering the quark as a Dirac particle with magnetic monopole properties instead of electric monopole properties (like an electron), it must have a real electrical dipole moment, similarly as the electron has a real magnetic one.

4. Comay's monopole versus Dirac's monopole

Hence, let us proceed with the hypothesis that the quark is a magnetic monopole. As is well known, the magnetic monopole concept is based upon a generalization of Maxwell's equations. Let us consider the Gaussian part,

$$\nabla \cdot \mathbf{E} = \frac{\rho_e}{\varepsilon_0}; \quad \nabla \cdot \mathbf{B} = \mu_0 \rho_m, \tag{43}$$

in which ρ_e is electrical space charge and ρ_m is hypothetical magnetic space charge. Solving these equations under pointlike conditions q_e and q_m for the space charges ,

$$\rho_e = 4\pi\varepsilon_0 q_e \delta^3(r); \quad \rho_m = \frac{4\pi}{\mu_0} q_\mu \delta^3(r, \tag{44}$$

the resulting field strength expressions have the formats,

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q_e}{r^2}; \quad B = \frac{\mu_0}{4\pi}\frac{q_m}{r^2}. \tag{45}$$

Whereas an "electron-type" Dirac particle with pointlike electric charge q_e has a real magnetic dipole moment $\boldsymbol{\mu}_\mathbf{m}$ and an imaginary electric dipole moment, an "electron-type" Dirac particle with pointlike magnetic charge q_m has a real electric dipole moment $\boldsymbol{\mu}_\mathbf{e}$ and an imaginary magnetic dipole moment. A (non-electron) quark-type Dirac particle, with its two real dipole moments and a nuclear charge interpreted as magnetic charge, has a real electric moment as well as a real magnetic moment. Inherited from electromagnetism, the eigen values are, respectively,

$$\mu_e = \frac{q_m}{2m_0}\hbar\,;\ \mu_m = \frac{q_m}{2m_0}\frac{\hbar}{c}. \tag{46}$$

From (41) and (42), the magnetic charge is calculated as,

$$q_m^2 = \frac{4\pi}{\mu_0}\frac{\alpha\pi\hbar c}{2d'_{\min}}. \tag{47}$$

This allows the assessment of its numerical value as q_m = 6.34 x 10^{-10} A s. This value is well below the minimum value of the magnetic monopole as derived in Dirac's classic paper [15]. Dirac's monopole is constrained by the condition,

$$q_m e = n(\frac{2\pi\hbar}{\mu_0}), \tag{48}$$

in which n is a natural number. This gives a minimum value for the magnetic monopole as 3.29 x 10^{-9} A s, which is significantly larger than the calculated value for the quark. This seems to exclude the possibility that the quark is a magnetic monopole. However, it has to be taken into account that Dirac's monopole is driven by the wish to prove the quantized nature of electric charge. As pointed out by Comay [5,12,13,14] in his Regular Charge Monopole Theory (RCMT), this wish has spoiled the symmetry of Dirac's monopole theory. Dirac's theory as well as Comay's theory is fully symmetrical under the substitutions $\mathbf{E} \to \mathbf{B}; \mathbf{B} \to -\mathbf{E}$ and $q_e \to q_m; q_m \to -q_e$. However, whereas full symmetry would require a vector potential $\mathbf{A}$ such that $\mathbf{E} = \nabla \times \mathbf{A}$, Dirac maintained $\mathbf{B} = \nabla \times \mathbf{A}$, under allowance of a string singularity. This difference makes Dirac's monopole theory asymmetrical, while Comay's monopole theory is fully symmetrical. As long as magnetic monopoles and electric monopoles (i.e. electric pointlike charges) are mutually exclusive, Comay's theory is the true equivalent of the canonical Maxwell theory. Its strength comes forward in conditions of simultaneous presence of magnetic monopoles and electric monopoles. While Dirac's monopole theory is based upon a hypothetical interaction between the two, Comay has proven that such interaction is an inconsistency by theory in the case that the interaction is supposed being taking place in static or quasi static (i.e non-accelerating) conditions. The boson fields (i.e. the radiated fields) of magnetic monopoles and electric monopoles are indistinguishable, but their fermion fields cannot interact. Because Dirac's constraint is based upon a fermionic interaction between an electron and a magnetic monopole and because such an interaction, like proven by Comay and confirmed by Mc.Donald [13], is inconsistent by theory, a magnetic monopole may still exist without being constrained by condition (48).

Let us proceed by interpreting the potential field of the quark in terms of a magnetic monopole field $\mathbf{B}(r)$ associated with, respectively, a magnetic dipole field $\mathbf{B}_d(r)$ and an electric dipole field $\mathbf{E}_d(r)$, such that,

$$\mathbf{B}(r) = \frac{\mu_0}{4\pi} q_m \frac{\hat{\mathbf{r}}}{r^2}, \tag{49a}$$

$$\mathbf{B}_d(r) = \frac{\mu_0}{4\pi}\{\frac{1}{r^3}[3(\boldsymbol{\mu}_m \cdot \hat{\mathbf{r}}) - \boldsymbol{\mu}_m] + \frac{8\pi}{3}\boldsymbol{\mu}_m \delta^3(r)\} \, , \tag{49b}$$

$$\mathbf{E}_d(r) = \frac{1}{4\pi\varepsilon_0}\{\frac{1}{r^3}[3(\boldsymbol{\mu}_e \cdot \hat{\mathbf{r}}) - \boldsymbol{\mu}_e] + \frac{8\pi}{3}\boldsymbol{\mu}_e \delta^3(r)\} , \tag{49c}$$

in which $\hat{\mathbf{r}}$ is the unit vector in r direction.

One may expect that the magnetic dipoles will align along the direction of the field between the two monopoles. If the quarks are magnetic monopoles, the quarks will attract, because if the quark has a positive magnetic charge, the antiquark has a negative charge. Hence, figure 2 requires a somewhat different interpretation, like shown in figure 4. This interpretation has no effect on the theory developed in [1].

The magnetic potential $\Phi_m(x)$ along the dipole axis can be expanded as,

$$\Phi_m(x) = -\frac{\mu_0}{4\pi}\frac{q_m}{x} + \frac{\mu_0}{4\pi}(\frac{q_m}{2m_0}\frac{\hbar}{c})(\frac{1}{x^2} + ...) \, . \tag{50}$$

The first right-hand term is the magnetic monopole potential and the second right-hand term is the magnetic dipole potential. The potential can be rewritten by approximation as,

$$\Phi_m(x) = \Phi_0^m \{\frac{1}{(\lambda x)^2} - w\frac{1}{\lambda x}\}, \text{ with} \tag{51}$$

$$\Phi_0^m = \frac{\mu_0}{4\pi}(\frac{q_m}{2m_0}\frac{\hbar}{c})\lambda^2 \text{ and } w = \frac{2m_0 c^2}{\hbar c\lambda} \, . \tag{52}$$

Equating

$$g\Phi_0 = q_m \Phi_0^m \, , \tag{53}$$

allows to obtain an expression for the generic potential Φ_0, such that the potential field of the quark can be read as (3), in which

$$\Phi_0 = \frac{1}{g}\frac{\mu_0}{4\pi}\frac{q_m^2\lambda}{w}; \quad w = \frac{2m_0 c^2}{\hbar c\lambda} \, . \tag{54}$$

Under consideration of (9), the magnetic charge is calculated as,

$$q_m^2 = w\frac{4\pi}{\mu_0}(\frac{g\Phi_0}{\lambda}) = w\frac{4\pi}{\mu_0}\frac{\alpha\pi\hbar c}{2d'_{\min}} \, . \tag{55}$$

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This is slightly different from (47). This difference is due to the ignorance of the factor $\exp(-\lambda r)$ in the comparison (40). Hence, the more precise value for the magnetic charge is given by (55) instead of (47). From (55), we now have $q_m = 8.54\ 10^{-10}$ A s.

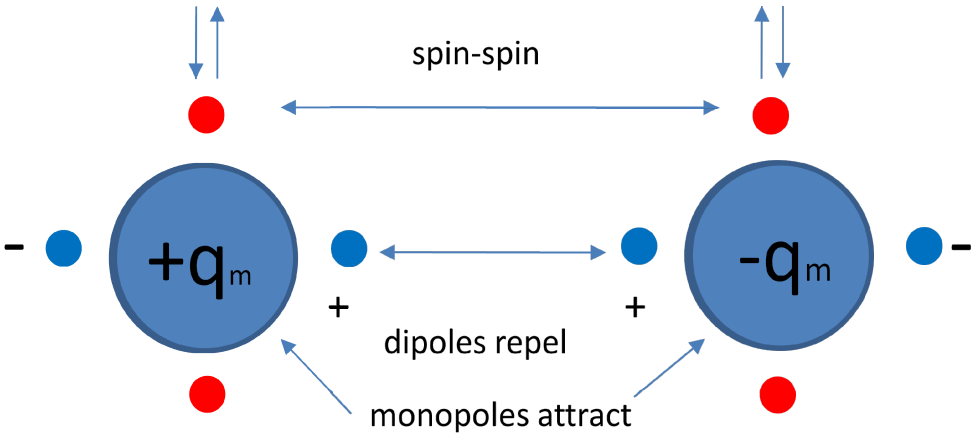

Fig. 4. Electromagnetic interpretation of figure 1.

5. Electric charge

It has been shown in [1,2] that the bond between two and three Dirac particles with polarizable dipole moments in a scalar field is the cradle of baryonic energy, because the center-of-energy of the two-particle and three-particle bonds shows the characteristics of the energy-stress tensor in Einstein's Field Equation for gravity. It is an empirical fact that these bonds are electrically charged. We have also concluded that the nuclear energy from a quark can be interpreted in terms of a nuclear charge and that this nuclear charge can be hypothesized as magnetic charge in (Comay's RCMT) monopole format. Recognizing the correlation between isospin and electric charge and recognizing isospin as the state of the quark's anomalous polarizable dipole moment, evokes the suggestion that the *abnormal* (i.e. polarizable in a scalar field) magnetic dipole moment of the quark, conceived as a magnetic monopole, must coincide with the *normal* (also known as anomalous) magnetic dipole moment of an elementary amount of electric charge. If so, the bond between the quark and the antiquark not only generates a center-of baryonic energy, but it also generates the electric charge that takes part of this baryonic energy. Figure 5 shows the concept.

To investigate the hypothesis, let us equate the magnetic dipole momentum μ_m^m of a monopole q_m with unknown mass m_0 with the magnetic dipole μ_m^e of an electric charge q_e with unknown mass m_e. Hence,

$$\frac{q_m}{2m_0}\frac{\hbar}{c} = \frac{q_e}{2m_e}\hbar \rightarrow q_m = \frac{m_0}{m_e} q_e c\,. \tag{56}$$

Invoking (55) and applying it to (56) gives a relationship between m_0 and m_e

$$q_m = \frac{m_0}{m_e} q_e c = \{w \frac{4\pi}{\mu_0} \frac{\alpha\pi\hbar c}{2d'_{\min}}\}^{1/2} \rightarrow$$
$$\frac{m_0}{m_e} = \frac{1}{c}\{\frac{w}{q_e^2} \frac{4\pi\varepsilon_0}{\mu_0\varepsilon_0} \frac{\alpha\pi\hbar c}{2d'_{\min}}\}^{1/2} = \frac{e}{gq_e}(w\frac{\alpha\pi}{2d'_{\min}})^{1/2} \approx \frac{1.52}{g}\frac{e}{q_e}. \quad (57)$$

Because the electric charge of the pion equals the elementary charge e and because this charge is composed by two contributions q_e, one might suppose that for symmetry reasons $q_e = e/2$. Under consideration of $g = 1/\sqrt{137}$ and $q_e = e/2$, the ratio $m_0/m_e \approx$ 35.6. Although calculated in the center-of-energy frame, this ratio will hold in the lab frame as well. It corresponds fairly with the ratio of the pion mass over the mass difference between the charged pion and the neutral pion, which amounts to 140/4.6 = 30.4.

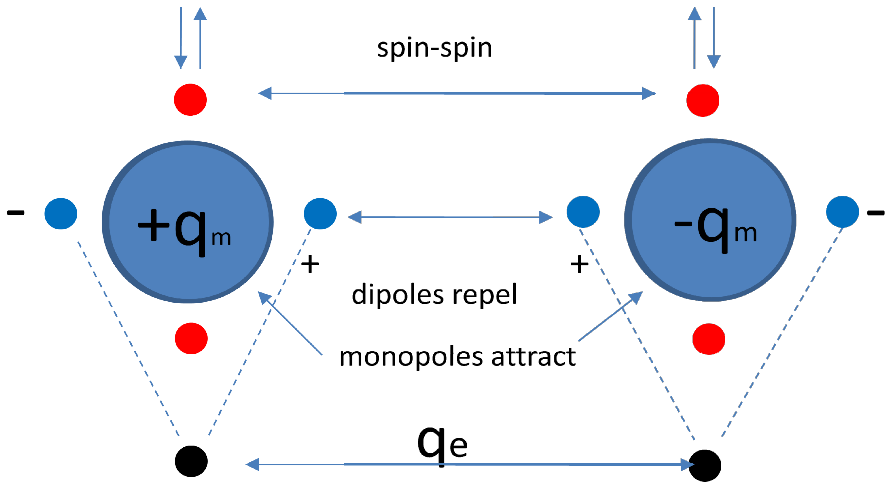

Fig.5: Hypothetical equivalence of the quark's polarisable linear dipole moment with the magnetic dipole moment of its electric charge attribute.

The empirical evidence of the existence of neutral pions (supported by spin statistics [1]) gives reason for reconsideration of the assignment $q_e = e/2$. The more because this assignment would suggest that broken entities of electric charge may exist. If we don't wish to accept such broken entities, one might consider the possibility that the electric charge is the result of some density distribution at the ultimate low spatial scale. In a minimum state of energy, the spatial distance between the quarks is at maximum. Under this condition the spatial distribution of charge would evoke a repulsive effect under the creation of two kernels of equal charge, thereby making a charged pion, whereas a slightly higher state of energy would occur under a distribution into two kernels with opposite charge, thereby making a neutral pion. It has been proven in [1] that under this model a very accurate calculation of the mass difference between charged mesons and neutral mesons is possible. In baryons, such a view is probably even more powerful.

It is fair to conclude that the magnetic monopoles in the pion have ("Gilbertian") magnetic dipole moments that create magnetic fields in a force balanced structure with the magnetic monopole fields, while being at the same time the "Amperian" dipole moment of kernels of electric charge. The classification "Gilbertian" and "Amperian" is from Mc. Donald [13].

6. Baryons

The baryon structure is more complicated than the meson structure. Nevertheless, under proper orientation of the Gilbertian dipoles a stable structure may arise, because the magnetic fields from the monopoles and the dipoles just cancel in the center-of-mass. The structure can be described as the one-body equivalent of a three-body harmonic oscillator in which the center-of-mass models the vibra-roations of the three constituting quarks. Similarly as in the case of the pion, the Gilbertian dipole moments coincide with equivalent Amperian ones that are associated with an amount of electric charge. Because the polarity of the Amperian dipole moments may assume different signs within the Pauli spin constraints, the baryon structure shown in figure 6 may assume different electric charges.

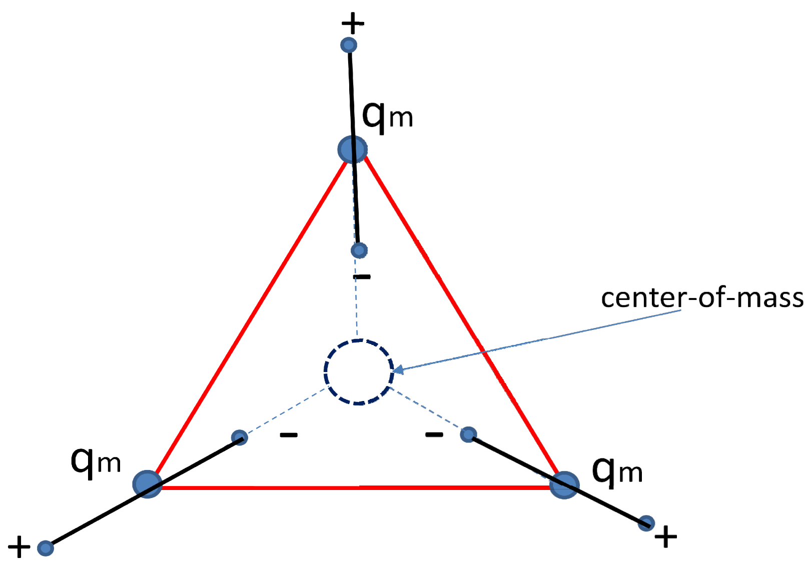

Fig.6: Basic baryon structure. The polarisable ("Gilbertian") magnetic dipole moments balance the magnetic fields of the monopoles. The vibra-rotations of the monopoles have an equivalent in the behavior of the center-of-mass. The GIlbertian dipole moments have equivalent Amperian magnetic dipole moments associated with electric charges that determine the electric behavior of the center-of-mass.

Figure 7 shows how the Gilbertian dipole moments with their fixed orientation may have different polarity Amperian manifestations. Under *nuclear* spin 1/2 condition two modes show up. These are shown in the upper part, which makes clear that the isospin condition is half spin as well. In the nuclear spin 3/2 condition four modes are possible, two of these with isospin 1/2 and two of these with isospin 3/2.

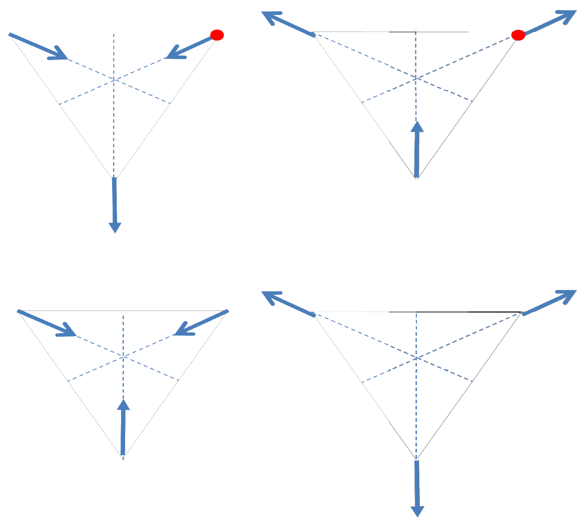

Fig.7: The basic baryon configurations. The arrows represent the isospins. The upper part holds for nuclear spin 1/2 (with dot) and for nuclear spin 3/2 (without dot). The nuclear spin 3/2 condition has two additional modes, shown in the lower part. The isospins oriented toward or outward the center-of-mass are regarded as, respectively, up spins (u) or down spins (d).

Table I

baryon	Isospin modes	code	total isospin	bias	charge	symb
$(uu)\underline{u}$	$(\uparrow\downarrow)\uparrow$	$(ud)\underline{u}$	+1/2	+1/2	1	p
	$(\uparrow\downarrow)\downarrow$	$(ud)\underline{d}$	-1/2	+1/2	0	n

baryon	isospin modes	code	total isospin	bias	charge	symb
$(uu)u$	$(\uparrow\downarrow)\uparrow$	$(ud)u$	+1/2	+1/2	1	Δ^+
	$(\uparrow\downarrow)\downarrow$	$(ud)d$	-1/2	+1/2	0	Δ^0
	$(\uparrow\uparrow)\uparrow$	$(uu)u$	+3/2	+1/2	2	Δ^{++}
	$(\downarrow\downarrow)\downarrow$	$(dd)d$	-3/2	+1/2	-1	Δ^-

Table I. The table shows the basic possible baryon configurations, composed by three archetype quarks u . The subscript bar in the upper part (1/2 nuclear spin) denotes the opposite nuclear spin condition of the third quark as compared to the other two. These other two are in different isospin condition.

These modes can be captured in table format as shown in the table. While the 1/2 spin configurations shown in the upper part of the table are clearly free from violations of Pauli's spin theorem, it is less clear for the 3/2 spin configurations in the lower part of the table. In the Standard Model, the perceived Pauli conflict in the 3/2 spin uuu and ddd configurations is solved by an additional theorem next to the isospin one. This additional axiomatic theorem is known as color charge. Comay [16], though, has proven that the $\Delta^-,\Delta^0,\Delta^+,\Delta^{++}$ is free from spin violations. This can be understood by considering that the Pauli constraint holds in the minimum state of energy in which the spin-spin interaction energy between the quarks is minimum. However, in the 3/2 spin condition the spin-spin interaction energy adds additional levels of energy.

As discussed in [1], the baryon can be modeled as a three-body harmonic oscillator. Its wave function under ignorance of the spin-spin interaction, has the format [17],

$$-\alpha_0\{\frac{d^2\psi}{d\rho'^2}+\frac{5}{\rho'}\frac{d\psi}{d\rho'}+\frac{R(m,v,k)}{\rho'^2}\psi\}+V'(\rho')=E'\psi\,,$$

in which

$$\alpha_0=\frac{\hbar^2\lambda^2}{6m_{eff}\,g\Phi_0}\,;\;E'=\frac{E}{3g\Phi_0}\,;\;V'=\frac{V}{3g\Phi_0}\,;\;\rho'=\rho\lambda\,,\text{ and}$$

$$V(\rho')=3g\Phi_0(k_0+k_2\rho'^2+.......) \qquad (58)$$

$$R(m,v,k)=4m+|v-k|(4m+|v-k|+4)$$

In the ground state $m=0$. Hence,

$$R=R(0,v,k)=l(l+4)\,;\;l=|v-k|\,. \qquad (59)$$

The radial variable ρ is the already mentioned hyper radius, the square of which is the sum of the squared spaces between the three bodies. The potential field is just the threefold of the potential field in the wave equation of the pion. There are three quantum numbers involved. Two of those are left in the ground state, effectively bundled into a single one. The quantum number k allows a visual interpretation, while v is difficult to visualize. The impact of k is shown in figure 8. It illustrates the motion of the center of mass under influence of k . Note that this rotation is quite different from a rotation of the triangular frame around the center of mass. It is the center of mass itself that rotates, while the frame does not.

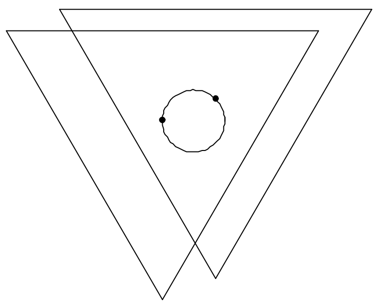

Fig. 8: . Physical interpretation of the proton's motion associated with the angular quantum number k . It illustrates the angular momentum associated with a baryon, thereby removing the "proton spin crisis".

The figure illustrates that the archetype baryon (proton) has an orbital angular momentum, Awareness of this property gives an adequate explanation for the well-known "proton spin crisis" in particle physics theory, identified in 1988 [18]. Apart from rather complicated heuristic theories, so far, no other simple adequate explanation has been found for an orbital angular momentum contribution to spin of the proton next to a minor contribution from the constituting quarks.

The state $(m=0, l=0)$ is the ground state, which splits into nucleons and delta's under influence of the spin-spin interactions [17]. The state $(m=0, l=1)$ is the Σ state, etc. This model allows a pretty accurate calculation of the mass spectrum of baryons including higher excitations [17]. The heuristic format of the quark potential field, adopted in [17] has got a support by theory since the discovery of the polarisable linear dipole moment in a scalar field [1].

Curiously, the difference in state between the two nucleons (proton and neutron) is asymmetrical in the sense of electric charge. Why is the one positive and the other neutral, rather than positive and negative? It can be understood by considering the (very slight) additional effect of electric charge on the spacing between the quarks. Similarly as in the case of mesons, the larger the spacing between the quarks, the lower the state of energy [1]. An equally signed distribution of the charge between the center-of-mass and the outer shell has a repulsive effect on the quarks, bringing the baryon into a lower state of energy, an opposite signed distribution has an attractive effect, bringing the baryon into a higher state of energy. The latter condition makes the baryon neutral (neutron), the former condition makes the baryon positive (proton) or negative (antiproton).

7. The Higgs field: its impact on the quark's potential field

An essential element in the theory developed so far is the presupposed existence of an energetic background field. In the first place as a cause for the spatial exponential decay of the quark's potential field. But also as a potential justification for the origin of the quark's polarisable dipole moment in a scalar field. As we have concluded before, such a dipole moment shows up if Dirac's equation for quarks is slightly different from the canonical electron-type format. This, however, requires a justification for the difference of the underlying space-time metric between the electron-type format and the quark format. Such a difference can only be justified if some background energy curves space-time from the Minowski metric toward an adapted one with different metric. Before discussing this, let us first address the quark's potential field.

Here, we meet a parallel with cosmology, in which the existence of an energetic background field is required to explain some cosmological phenomena, such as, for instance, the accelerated expansion of the universe by "dark energy". To understand this phenomenon within Einstein's framework for gravity, established by his theory of General Relativity, the dark energy is considered as being embodied by the Lambda parameter in his Field Equation. This Lambda parameter influences the space-time curving of the universe and modifies Newton's gravity law on top of the Schwarzschild solution for $\Lambda = 0$. Although far from trivial, it appears possible under particular constraints to derive from Einstein's Field Equation a meaningful wave function for the bosonic central force, such that,

$$-\frac{\partial^2}{c^2\partial t^2}(r\Phi) + \frac{\partial^2}{\partial r^2}(r\Phi) + \lambda^2(r\Phi) = -r(4\pi GM)\delta^3(r)U(t), \quad (60)$$

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

The constraints are twofold. The first one has to with the recognition that space is not empty, but, instead behaves as a molecular fluidum in thermodynamic equilibrium. This allows removing an irrelevant bias, which, in fact, is an equivalent for renormalization as known within the context of the Standard Model of particle physics. As discussed in [20], this awareness explains why the well-known "Cosmology Constant catastrophe" [does not exist. The second element is the restriction to a spatial range of validity between a low spatial limit r_L and a high spatial limit $r_H\lambda \approx 6$. The derivation of (60) can be found in [20].

Recognizing this parallel and the correspondence between (60) and (12), there is no reason why space-time curving would be restricted to common massive energy. Accepting the RCMT magnetic monopole as the ultimate energetic source, it is fair to suppose that this source curves space-time similarly as a gravitational pointlike source does. There is a difference, though, in the sign of λ^2. In fact, the theoretical derivation leaves the sign open to the physical interpretation for the origin of Λ, on which Einstein's theory does not give the answer. The physical interpretation has to do with the nature of the energetic constituents that assemble the energetic background fluid. Applying in both cases Debije's model of polarisable almost mass less dipoles, the bosonic field is either enhanced or shielded. There is reason to suppose that in the gravity case the bosonic field is enhanced, because this would explain the dark matter effect in the gravitational objects orbiting in galaxies, while there is reason to suppose that in the nuclear case the bosonic field is shielded. In other words: whereas baryonic kernels are attracting on the background dipoles, the RCMT monopoles are repelling on the background dipoles.

Hence, applying (60) to the field of a Gilbertian magnetic monopole, we have in static condition in terms of Poisson's equation,

$$\nabla^2\Phi - \lambda^2\Phi = -\mu_0\rho(r);\ \rho(r) = Q_m\delta^3(r), \tag{61}$$

in which Q_m is the magnetic charge of the monopole. Let us rewrite (61) as,

$$\nabla^2\Phi = -\mu_0\rho(r);\ \rho(r) = Q_m\delta^3(r) - \rho_D(r);\ \rho_D(r) = \frac{\lambda^2}{\mu_0}\Phi(r) \tag{62}$$

In Debije's theory of electric dipoles [21,22,23,24],

$$\rho_D(r) = -\nabla\cdot\mathbf{P_g}. \tag{63}$$

The vector $\mathbf{P_g}$ is the dipole density. From (62),

$$\rho_D = \frac{1}{r^2}\frac{\mathrm{d}}{\mathrm{d}r}\{r^2 P_g(r)\}. \tag{64}$$

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 (64),

$$\rho_D(r) = 2\frac{P_{g0}}{r}. \quad (65)$$

Taking into account that to first order,

$$\Phi(r) = \frac{\mu_0}{4\pi}\frac{Q_m}{r} \to \rho_D(r) = -\frac{\lambda^2}{\mu_0}\frac{\mu_0}{4\pi}\frac{Q_m}{r} = \frac{2P_{g0}}{r} \to 2P_{g0} = -\frac{\lambda^2}{4\pi}Q_m. \quad (66)$$

Supposing that the Higgs field is built up by elementary Gilbertian dipoles with dipole moments,

$$p_m = q_m\hbar/2m_d c, \quad (67)$$

and that N is the number N of dipole moment carrying particles per unit of volume, we have from (66) and (67), ,

$$\lambda^2\frac{Q_m}{4\pi} = 2Np_m = 2N\frac{q_m\hbar}{2m_d c} \to \frac{q_m}{Q_m} = \frac{\lambda^2}{4\pi N}\frac{m_d c^2}{\hbar c}. \quad (68)$$

Considering that

$$\frac{q_m}{Q_m} = \frac{m_d}{m_{qu}}, \quad (69)$$

in which m_{qu} is the bare mass of the quark, we have from (68) and (69),

$$m_{qu}c^2 = m'_{qu} = 4\pi N\frac{\hbar c}{\lambda^2}. \quad (70)$$

From (11), we have $\lambda = m'_H/2\hbar c$, in which m'_H is the energy of the Higgs boson. This relationship has been established in the center-of-mass frame of the pion. The λ in (70), though, is a lab frame value. Considering that pion with its lab frame rest mass $m_\pi \approx 140$ MeV/c^2, decays by the weak interaction $m_W \approx$ 80.4 GeV/c^2, such that we may consider the mass of the pion as the non-relativistic correction of the weak interaction boson, we have from λ in the pion's center-of-mass frame to the λ in the lab frame,

$$\lambda = \frac{m'_H}{2\hbar c} = \frac{m'_H}{m'_W}\frac{m'_W}{2\hbar c} \to \lambda = \frac{m'_H}{m'_W}\frac{m'_\pi}{2\hbar c}. \quad (71)$$

Hence from (70) and (71)

$$m'_{qu} = 4\pi N\hbar c(\frac{2\hbar c}{m'_\pi}\frac{m'_W}{m'_H})^2 . \tag{72}$$

It is well-known that the semantics of the mass values of quarks should be interpreted with care. There is a difference between the bare mass of a quark and the constituent mass. The latter one is a result of the mass model that is used for the calculation of quark-composites such as mesons and baryons. In the underlying theory of this article, as described in [1], the quark gains its mass predominantly from its energetic bond with an antiparticle. In fact, the quark and the antiquark in a pion composes a quantum mechanical oscillator. Its state of energy determines the pion mass from which the masses of the quark are derived as constituent values. In that model the bare mass of the quark as carrier of the magnetic monopole has a negligible influence of the state of energy and therefore on the constituent mass of the quark. In the expression (50) for the quark's potential function the quoted mass value m_0 is related with the constituent mass in the quark model for the pion, in which the dimensionless relational quantity w has got the value $w =$ 1/0.55 [1]. Different from m_0 in (50), the derived expression for the quark's mass m_{qu} does not depend on an energetic bond (binding energy) with an antiquark. Hence, it is unrelated with the quark's constituent mass. It is the quark's bare mass. As shown by (72) Its assessment requires a quantitative value for the quantity N as the number per unit of volume of the elementary carriers of the energetic background field, known as the Higgs field.

8. Relationship with gravity

Curiously, in gravity, ever since 1988 the existence of an energetic background field in vacuum has been identified as well. Its existence is required to explain the accelerated expansion of the universe [25]. This cosmological background field has been defined on the basis of Einstein's Cosmological Constant [26]. 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 [27]. 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. For gravity, this concept has resulted into the identification of an energetic background energy consisting of elementary constituents of Dirac's "third" type, with a particle density to the amount of [20],

$$\text{N/m}^3 = (a_0/20\pi G)/(\hbar/2c) \approx 1.7\ 10^{14} \text{ particles per cubic nanometer,} \tag{73}$$

in which a_0 (≈ 1.25 10^{-10} m/s^2) is Milgrom's empirical acceleration constant for dark matter. It is probably more than hypothetical to suppose that the very same particles are the carriers of the Higgs field. As a consequence from this conclusion, the bare mass of the archetype quark follows from (72) and (73) as,

$$m'_{qu} = 4\pi\hbar c \frac{a_0}{20\pi G}\frac{2c}{\hbar}\left(\frac{2\hbar c}{m'_\pi}\frac{m'_W}{m'_H}\right)^2 = \frac{8}{5}\frac{a_0 c^2}{G}\left(\frac{\hbar c}{m'_\pi}\frac{m'_W}{m'_H}\right)^2 \approx 1.34 \text{ MeV} \quad (74)$$

Unfortunately, no experimental evidence is available for the quark's bare mass. Anyhow, its order of magnitude corresponds with the one estimated by the Particle Data Group (PDG), [28]. It has to be emphasized that for the explanation of the dark matter effect it is not particularly required to identify the energy carrier of the dark as magnetic charge. The only property that matters is their polarization sensitivity to a scalar gravitational field. On the other hand, this property does not exclude that the dark is a magnetic monopole indeed. However, while these darks can be polarized by a scalar field from a baryonic kernel (gravitational monopoles don't exist) as well as by a scalar field from a magnetic monopole, the darks cannot be polarized by the electric field from an electric monopole. This is in agreement with Comay's monopole theory. Whereas classical electromagnetism is not influenced by the energetic background field, the nuclear monopole field of quarks is shielded and the gravitational field of baryonic kernels is slightly enhanced due to vacuum polarization of the darks .

9. Discussion

Gravitational Constant

Back in 2011, the author of this article has derived an expression for the Gravitation Constant G in terms of quantum mechanical quantities [4]. The expression allows a successful numerical justification. The derivation was based upon a structural model of a quark and an antiquark, more or less similar to figure 2. As explained in this article once more, the structure represents an anharmonic quantum mechanical oscillator. In its center, one recognizes a vibrating amount of baryonic energy that originates from the non-baryonic energy of the composing quark kernels. The awareness that this baryonic amount of energy must be the right-hand term in Einstein's Field Equation, as built up from the potential field of the composing quarks, has led to the quoted expression. The 2011 quark model, though, was quite hypothetical. Not more than a pointlike source of nuclear energy of unknown kind, characterized by a static potential field, similar to eq. (3), with no other justification but a mathematical manipulation on the Lagrangian expression of the Higgs field. Whereas the $1/x$ term in (3) can be readily interpreted as the contribution from a classical field, the $1/x^2$ contribution as well as the exponential decay term $\exp(-\lambda x)$ were just adopted as features of the hypothetical Higgs field, without a clear physical interpretation. In a sequence of articles, although certainly not flawless, the virtue of the model has been demonstrated by successful calculations on the mass spectrum of mesons and baryons. Unfortunately, the model did not gain any credit, because of its hypothetical nature and because it was considered of being in conflict with the well proven Standard Model of particle physics. In spite of its numerical proof, the expression for the Gravitational Constant has been ignored, even so after a later more substantial publication in 2016 [2]. It sadly resulted into a place on Jean de Climont's list of dissident scientists [29].

The liquid drop model

The rather convincing relationship between gravity and quantum physics as shown in the verifiable Gravitational Constant expression challenged me trying to give a better motivation for the quark's model but just the hypothetical one derived from the Higgs field Lagrangian. This required finding an explanation for the field component $1/x^2$ and for the field decay term $\exp(-\lambda x)$. The field component $1/x^2$ evokes the suggestion that it must be due to the presence of a dipole. And the exponential decay must be due to the field shielding of a monopole potential due to some kind of background energy. Even more challenging than finding an explanation for the exponential decay term in the quark's potential field, is finding an explanation for the origin of a polarisable dipole contribution in a scalar field. Considering that a quark is a Dirac particle, such a dipole would be rather curious, because the archetype Dirac particle, like an electron, has a magnetic dipole, which is not polarizable in a scalar potential field. A side remark from Dirac appeared being helpful. Whereas the first real first dipole moment ($e\hbar/2m_0$) of the electron is well known as the magnetic dipole moment, the second dipole moment, i.e., the electric one, is less known because of its imaginary value ($ie\hbar/2m_0c$). The latter is one of the two anomalies of Dirac's theory, pointed out by Dirac himself. He noticed a negative energy solution next to a positive energy solution. And he noticed a real magnetic moment next to an imaginary electrical dipole moment. About the first item he remarked that that the problem would disappear if the electron would change its polarity, but that "this is a phenomenon not yet observed". About the second item he remarked that he doubted about the physical meaning of an imaginary electrical dipole moment. Whereas he welcomed the real magnetic dipole moment as a confirmation of a known physical phenomenon ("the spinning electron"), he suggested that the imaginary electrical dipole moment would be a mathematical artefact as a result of "the artificial multiplication of his wave function to create an Hamiltonian that resembles the one of previous theories". In fact, however, the negative energy solution is a result of this artificial multiplication as well. It gives reason for considering a potential generalization of Dirac's approach, like discussed in paragraph 2 of this article.

The generalization has shown the potential viability that a quark can be conceived as a Dirac particle of a particular kind, denoted as *third*. The most essential property of this particle is the nuclear equivalent of the electric dipole moment. Whereas the electric dipole moment of an electron type Dirac particle is imaginary, it is real for the "third". As a consequence, the quark is polarizable in a scalar potential field. This property gives an adequate explanation for the "gluing" of quarks in hadrons. Like discussed in paragraph 2, the justification for the potential existence of "thirds" is based upon the recognition that Dirac's heuristic transformation rule on rest mass, spatial momenta and temporal momentum into operators on wave function components allows a generalization into three basic types. Whereas a second type next to the electron type, known as tachyon, has been accepted as theoretically feasible (although not yet proven by physical evidence), the "third" with its two real dipole moments has not been proposed by other authors.

Einstein's Λ and the Higgs field

The exponential decay of the quark's potential field must be due to some kind of background energy. And this background energy must be due to elementary constituents. Apparently, these constituents shield the quark's field similarly as the field of an electric charge in an ionic plasma is shielded as the consequence of the Debije effect. This occurs if the elementary constituents are polarizable dipoles. This evokes the suggestion that the constituents are elementary Dirac particles of the third kind. Although quarks and such constituents both are Dirac particles of the third kind, sharing the property of possessing of a polarizable dipole moment in a scalar potential, they must be quite different in size and in bare mass. Curiously, an energetic background field is omni-present in cosmology as well. It must be present to explain the accelerated expansion of the universe. It is embodied by the Lambda in Einstein's Field Equation. This awareness has resulted in my attempt to linearise Einstein's Field Equation with inclusion of Λ. As discussed in paragraph 8, this linearization slightly modifies the Newtonian gravitation law by a very weak exponential term. However, whereas in particle physics the background field is of a suppression nature that limits the effective range of nuclear forces, in cosmology the background field is enhancing, although very slightly, the Newtonian gravity strength such as becomes apparent in the dark matter effect. It gives a physical explanation to the mathematical Λ term in Einstein's equation by proving that it shows up as the result of vacuum polarization due to polarizable dipole moments of elementary energetic constituents, dubbed as *darks*. It is not a big step to suppose that these darks are the same as the energetic constituents of the nuclear background field. This implies that the background field of particle physics, hypothetically defined in the Standard Model as the Higgs field is the same as the cosmological background field embodied by Λ in the ΛCDM standard model of cosmology. The acceptance of this view implies that darks can be polarized by a scalar gravitational field as well as by a scalar nuclear field. While in gravity the polarization is field enhancing, it is field shielding in the nuclear case. Unlike in gravity and in particle physics, the darks don't feel a polarization influence from scalar electric fields. The vacuum is fully transparent for classical electromagnetism. The dark matter theory discussed in paragraph 8 enables to calculate the particle density of darks. Relating this density with the known critical mass density of the universe reveals that the darks are virtually mass less particles with a calculated energy of about $\approx 3\ 10^{-32}$ eV [20]. Like discussed in the paragraph 8, the assumption that the cosmological darks are the same as the constituents of the Higgs field allows to use their particle density for calculating the bare mass (not to be confused with the constituent mass) of the basic u/d quark as 1.34 MeV/c^2.

This explanation of the dark matter phenomenon as a consequence from the dark energy meets criticism because of the denial that Einstein's Λ is a constant of nature, usually identified as the Cosmological Constant. Instead, my analysis has been based upon the view that Λ is a covariant integration constant that may have different values depending on the scope of a cosmological system under consideration. Only at the level of the universe it is justified to identify Λ as the Cosmological Constant indeed. This awareness is based upon Einstein's note in his 1916 article that he equated an integration constant as zero (see footnote on p.804 in ref. [30]). Anyhow, the result of this is an explanation for the far field behavior of classical fields of energy, in which the polarity sign of a non zero Λ is responsible either for a exponential decay or for an initial enhancement of the field. Similarly, I may expect that the concept of a third mode of Dirac's particle, next to the bradyon (= electron type) and tachyon will be subject to serious criticism as well and that a more fundamental analysis but the one put forward in this article, would be required. Let me summarize some of my reasons for its existence instead.

Unsolved problems solved

1. The quark-antiquark model shown in figure 3 has allowed to express the Gravitation Constant G into quantum mechanical quantities with a successful numerical proof [4,2].
2. Different from an theoretical axiomatic concept, isospin is a physical attribute associated with the quark's polarizable dipole moment [1].
3. The number of elementary quarks can be reduced to a single basic archetype [1]
4. The big gap between the rest masses of the $(u/d,s,c,b)$ quarks on the one hand hand and the topquark on the other hand is a consequence of the loss of binding energy between the quarks [1].
5. The massive rest mass energies of the Higgs boson, the W/Z bosons and the topquark can be assessed by theory. Experimental evidence is a confirmation instead of empirical axioms [1].
6. The gluon-quark relationship is the equivalent of the electron-photon relationship [1].
7. The mathematical axiomatic SU(2) and SU(3) gauges of particle physics theory can be replaced by physically based gauges similar to the electromagnetic U(1) gauge [1].
8. It solves the "proton spin crisis" problem.
9. Explains the non-existence of the "Cosmological Constant catastrophe".

Origin of electric charge

This is just a small list from many more. In this theoretical concept, the quark is a classical pointlike monopole spreading a potential field, just akin to the one from a pointlike electric charge in electromagnetism and to the one from a baryonic massive kernel in Newtonian gravity. The physical nature of the quark monopole is a generic kind of nuclear energy expressed in terms of a potential Φ with the dimension of energy. As discussed in paragraph 3, rather than defining the monopole strength in terms of energy, one might equivalently define its strength in terms of a nuclear charge, similarly as done in electromagnetism. This consideration evokes the challenge to search for a possible relationship between electric charge and nuclear charge. Whereas the origin of baryon charge (= gravitational mass) is clearly the result from the conversion of nuclear energy (nuclear charge) in the (an)harmonic oscillator structure composed by the quark-antiquark bond, the origin of electric charge different from just axiomatic, is not clear. As discussed in paragraph 5, the identification of nuclear charge as the charge of Comay's magnetic monopole, reveals the origin of electric charge. It can be traced back to the different magnetic monopole (quark) characteristics as compared with those of an electric one (electron). Whereas the magnetic monopole has two real dipole moments, the electron monopole has a single real one, because the second one is imaginary. The origin of electric charge can now be explained as the source of the magnetic dipole moment of the quark. The analysis in paragraph has shown that such fits numerically well. The model denies a asymmetrical split of the elementary charge. This is in agreement with the view that electric charge should be considered as an holistic attribute of hadrons as a whole, instead of composed by fragmented contributions [1]. Up to now Comay's magnetic monopole model for quarks has not get any credit. Instead, it resulted into Comay's place on Jean de Climont's list of dissident scientists [29].

It may seem as if the theory as summarized in this article is in conflict with the Standard Model of particle physics. This imposes a problem indeed, because the Standard Model is regarded as being well proven by an overwhelming amount of experimental evidence of its correctness. In fact, there might be no conflict if one wishes to accept that there is a need to gain understanding a physical basis for the underlying axioms that are accepted in present theory. It has to do with the basic question "what glues the quarks together?" in relation with the object to construct a covariant theory based on well-defined gauges. This objective has led to the $U(1) \otimes SU(2) \otimes SU(3)$ Standard Model. However, whereas the U(1) gauging as inherited from Dirac's electron theory and Einstein's General Relativistic theory is based upon a well-understood physical mechanism, the SU(2) and SU(3) gauging is purely axiomatic (in fact heuristic), because of the lack of knowledge of a physical mechanism that glues two or three elementary particles together. There is nothing wrong of course with an axiomatic basis. In fact, the more axioms, the more accurate a theory is. But it is true as well that mathematically conceived axioms may hide physical interrelationships. It has been shown in this article that the force that glues two and three elementary particles together is due to a unique property of a quark, namely its polarisable dipole moment in a scalar field next to its angular dipole moment. Whereas the latter is known as nuclear spin, the former should be recognized as isospin. This gives a physical justification for the SU(2) and SU(3) axioms including weak isospin, electroweak unification, gluons and the like. That the quark possesses a polarisable dipole moment in a scalar field is not trivial, because it is commonly accepted that the quark is a Dirac particle. Whereas Dirac's theory of electrons reveals a second dipole moment next to the angular dipole moment or spin indeed, this dipole moment shows up as an imaginary quantity and is therefore physically non-existing. However, as argued in this article, the quark is a Dirac particle of a non-electron type. More particularly, it is a pseudo-tachyon (*xenon* ? = "stranger"), described by a set of gamma-matrices different from the canonical ones.

Anyhow, joining the theories of two dissident scientists, summarized in this discussion, may give a clue to a theory that unifies quantum mechanics, electromagnetism and gravity, such as summarized in the following corollary.

10. Corollary

The four fundamental physical forces can be unified in a single theory. Essential elements of the theory are:

1. The quark is a pseudo-tachyon. i.e., an unrecognized Dirac particle that has, next to the well-known real dipole moment associated with the elementary angular momentum ***h***, a second real dipole moment associated with an elementary linear dipole moment ***h/c***, which, unlike as in the case of electrons, is polarisable in a scalar potential field. Its theory can be found in [1,10]

2. The quark is an RCMT magnetic monopole. This monopole is different from the well-known Dirac monopole, because its Maxwellian definition is different. Its theory can be found in [5].

3. Because the quark is a pseudo-tachyon as well, it has a real magnetic dipole moment. This magnetic dipole moment defines an elementary amount of electric charge associated with the quark, such as described in this article.

4. The quark's RCMT magnetic charge spreads a Coulomb-type nuclear field to which other quarks may couple with a coupling factor equal to their own magnetic charge.

5. The quark's RCMT field is shielded by a background field, known as the Higgs field. It can be conceived as an energetic plasma of tiny magnetic dipoles in a similar way as an electric charge is shielded by the polarization of electric dipoles in an ionic plasma (DeBije effect). The quark's electric field from its elementary charge is unaffected by the polarization of the energetic background field.

6. Bonds of three quarks (baryons) and quark-antiquark (bonds) behave as quantum-mechanical oscillators that convert the RCMT monopole fields of the pseudo-tachyon quarks into baryonic energy. The vibration energy of the center-of-energy is the baryonic manifestation of the non-baryonic energy of the quarks [1,2]

11. Conclusion

Whereas the theory developed in [1] has shown the unification between weak interaction and gravity from the concept of a single archetype quark, the unification is completed with electromagnetism and strong interaction by the hypothesis that the archetype quark is an RCMT monopole [5]. The quark is the energetic source of all four fundamental physical forces.

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