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A Maxwell like theory unifying ordinary fields

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Abstract

The field-particle duality originates the modern physics with the Schrödinger equation since the end of the first quarter of the twentieth century; it yet poses understanding problems to specialists and it seems necessary to revisit the Quantum Mechanics origin. To show this necessity, we considered the simpler case of a moving particle in the vacuum with the Dirac equation. We postulated a de Broglie equation. The former defines a scalar field and the latter a vector field. Considering them as describing the interaction particle-vacuum, we found four possible wave fields associated to any particle; each is defined by a gauge coupling explaining the particles wave nature with any fundamental field. When both gauges of the couple are unified, fundamental bosons behave like phonons in a crystal with celerities lower than that of the light c; two of the fields become local. The phonon concept led us to propose a vacuum elastic structure. We found that this is composed of bosons and antibosons we assumed belonging to the unified field. We showed that the vacuum could become instable during particles or objects interactions we explain from General Relativity. We predicted at last the existence of some fundamental fermions owing to the boson-fermion symmetry.

Keywords: Boson, Fermion, Field unification, Fundamental field, Gauge coupling, Phonon, Quantum mechanics, Vacuum structure.

Introduction

The unification of fields is the greatest enigma in physics even with only ordinary fields. Its resolution relies on the field-particle duality, which is the foundation of modern physics via the quantum theory. If still now this unification is not complete, one can ask if the duality is well complete; otherwise, the interpretation problem would not be so discussed[1,2]. Nowadays, some physicists ask questions on the Quantum Mechanics interpretation or formulation[3,4]. The source of the problem comes from the states meaning describing a system. They are rather abstract and seem not to have any relation with the classic physics nearer to our understanding, more familiar from the Maxwell electromagnetic theory. The lack of such relationships originated the quantum mystery. Succeeding to find out these for all fields seems a necessity to break the unification enigma, as we propose in this work. Hence, we could interpret the quantum states meaning in term of field and the probabilities in terms of field intensity consequently.

The Maxwell theory constitutes besides the Standard Model principles background in particles physics. This Standard Model unifies three fundamental fields but without gravitation[5,6]. Specialists recognize its incompleteness despite of its success. To our knowledge, the asset of its completeness would come from a reinterpretation of Quantum Mechanics foundations in the vacuum, before matter considerations. The Super symmetry theory goes beyond that model[7,8] for its improvement but faces mathematical problems, e.g. with the vacuum structure.

Here, we are going to establish a new theory unifying ordinary fields, which reveals Maxwell theory like characteristics from gauges construction procedure; this will lead to microscopic and macroscopic aspects showing the unity between Quantum Mechanics and General Relativity in the same theory. Then we will discuss about the vacuum enigma and the symmetry between fermions and bosons.

Fields unification theory

One knows that the wave-particle duality comes from de Broglie hypothesis associating a wave bundle to any stable particle with a defined celerity in the vacuum. On the other hand, we have the Dirac equation of a free particle, which allowed predicting the antiparticles existence. In this section, we show that the combination of both concepts leads defining a new duality. This allows understanding rapidly the field unification in the vacuum from gauge couplings. Then, we show the vacuum structure, the quantum solutions for a particle of mass m and charge q as well as the interaction interpretation from General Relativity.

Completing the duality formulation: We consider a particle moving at the velocity $\vec{v}$ in the vacuum where c is the velocity of the light or that of any vacuum fundamental particle. Interpreting the Dirac quantum state: If the four-vector $|D\rangle$ describes the particle state of Hamiltonian $\hat{H}$ and impulse $\hat{P}$ operators, the Dirac equation writes under the form $\hat{H}^2|D\rangle = (c^2\hat{P}^2 + m^2c^4)|D\rangle$. We can rewrite this as

$$(\hat{P}^2 - \frac{1}{c^2}\hat{H}^2)|D\rangle = -m^2c^2|D\rangle \tag{1}$$

By substituting both operators by their classical definitions multiplied by a unit operator, this describes a fundamental field having the celerity c. This field defines the particle behavior in the medium, i.e. the result of the interaction particle-vacuum. We can understand a quantum state in this way since any wave equation represents this phenomenon.

For instance, resolving the Schrödinger equation for a Hydrogen atom comes to find the electron behavior in the proton field, i.e. the result of the interaction electron-proton; taking for granted that the electron is the host particle and the proton is the medium master. In addition, if the hyper-fine structure of this atom reveals the proton properties, the vacuum would have to reveal its properties too. It is then an ideal medium having all wave fields. These manifest themselves in respect to any particle.

Defining the de Broglie quantum state: According to the de Broglie hypothesis, a wave bundle associated to a particle has the celerity $v_B = c^2/v$. In propagation term, we can therefore formulate the corresponding wave equation in respect to a physical quantity; this can be a scalar, a vector or a tensor describing a field. Let us consider a four-vector as before, the case suitable for a stable particle. If $|bB\rangle$ is the corresponding De Broglie four-vector, we can then write

$$\left(\Delta - \frac{1}{v_B^2}\frac{\partial^2}{\partial t^2}\right)1.|bB\rangle = |Source\rangle \tag{2}$$

In Dirac formalism, $|bB\rangle$ is another state representing the particle in the vacuum. We can translate this, as another result of the interaction particle-vacuum. This field is also fundamental of celerity c if we rewrite this equation by substituting v_B so that

$$\left(\frac{1}{v^2}\Delta - \frac{1}{c^2}\frac{\partial^2}{\partial(ct)^2}\right)1|bB\rangle = \frac{1}{v^2}|Source\rangle \;\; \forall\, v \neq 0 \tag{3}$$

This is indeed a vacuum fundamental equation with the variables $(v\vec{r}, ic^2t)$ if $(\vec{r}, ict)$ is the space-time position. These are homogeneous to areolar velocities meaning that something rotates in the vacuum. It is the vector bosons describing surfaces along the motion in respect to its velocity. The De Broglie State reveals the vacuum behavior implying directly the boson spin concept.

Field equations generalization: We have therefore two different states describing the interaction particle-vacuum. We deduct that a complete field-particle duality have to take into account both interaction kinds. In addition, if a given particle is no longer free, both field sources change. Using the initial definition of the de Broglie celerity for a particle having the impulse p and energy E, (3) writes under the general form, valid in General Relativity:

$$\left(\frac{1}{p^2}\Delta - \frac{1}{E^2}\frac{\partial^2}{\partial(ct)^2}\right)1|bB\rangle = \frac{1}{p^2}|Source\rangle \;\; \forall\, p \neq 0 \tag{4}$$

This shows that the vector field also describes with the variables $(p\vec{r}, iEt)$; these are kinetic momentum projections on perpendicular axes to each axis respectively.

Thus, we can represent each interacting field by a four-potential suitable to field description. Let then $\{|A_\alpha\rangle\,;\ \alpha = \parallel, \perp\}$ defines the four-potentials of the longitudinal and transverse states or equivalently of the scalar and vector states. If $|S_\alpha\rangle$ defines each source, the corresponding equations write

$$\Box_\alpha 1|A_\alpha\rangle = |S_\alpha\rangle \tag{5}$$

Where: $\Box_\parallel = \Delta - \partial_t^2$; $\partial_t = \frac{\partial}{c\,\partial t}$; $\Box_\perp = \frac{1}{v^2}\Delta - \frac{1}{c^2}\partial_t^2$

Gauges and fields expressions: Expressing explicitly each four-vector α under the explicit form
$|A_\alpha\rangle = (\vec{A}_\alpha, iV_\alpha/c)\,;\,|S_\alpha\rangle = (\vec{S}_\alpha, iS_{\alpha4}/c)$, we have

$$\begin{cases} \Box_\alpha \vec{A}_\alpha = \vec{S}_\alpha \\ \Box_\alpha V_\alpha = S_{\alpha4} \end{cases} \tag{6}$$

To find each mode gauges, we carry out by transforming each equation to another; this consists on applying the appropriated nabla operator to an equation both members, then integrating in respect to the time-coordinate. With the definitions

$$\vec{\nabla}_\perp = \frac{1}{v}\vec{\nabla};\ \partial_{t\perp} = \frac{1}{c}\partial_t \tag{7}$$

From the scalar potential equation, one gets two gauges for the scalar fields:

$$\Box\int \vec{\nabla}V_\parallel c\,dt = \int \vec{\nabla}S_{\parallel 4} c\,dt \Rightarrow \Box\vec{A}_\parallel = \vec{S}_\parallel$$
$$if\ c\vec{A}_\parallel = \pm\int \vec{\nabla}V_\parallel c\,dt\,;\,c\vec{S}_\parallel = \pm\int \vec{\nabla}S_4\ c\,dt \tag{8}$$

From the vector potential equation, one gets two gauges for the vector fields:

$$\Box_\perp\int \vec{\nabla}_\perp\vec{A}_\perp c^2 dt = \int \vec{\nabla}_\perp\vec{S}_\perp c^2 dt \Rightarrow \Box_\perp V_\perp = S_4$$
$$if\ V_\perp = \pm c\int \vec{\nabla}_\perp\vec{A}_\perp c^2 dt\,;\,S_4 = \pm c\int \vec{\nabla}_\perp\vec{S}_\perp c^2 dt \tag{9}$$

We summarize the result in Table-1 after derivation of conditional expressions.

Each field definition is such as its combination with the gauge relation leads to a wave equation. One can note that the ordinary vector fields gets by multiplying each relation by v. There are four gauge couples for each mode. Each represents a fundamental field. One can expect them to be gravitational, electromagnetic, weak or strong. Usually, one recognizes the two last as fields of short range in matter. By using both adjectives here, we assume their existence in the vacuum as wave fields.

Gauge couplings identification and bosons nature: To identify the four gauge couplings, we can consider the case of fundamental particles, in which both kinds of field are unified; each four-potential $|A\rangle$ satisfies both gauge relations of the couple. These combination lead to motion equations summarized in Table-2. The operator $\square_{\mp} = (\Delta \mp \beta\partial_t^2)$ with $\beta = v/c$ indicates a local equation decreasing in either space (for the strong field) or time (for the weak field), by definition. There is no field source in each case, expressing bosons spontaneous appearance as soon as the particle velocity is non-zero.

We identify the fields as follow: The electromagnetic field recognizes by the Lorentz gauge, which must be that of the weak field in order to justify the electro-weak vector field. Thence, the gravitational and strong vector fields are unified into gravi-strong field; the electromagnetic and strong fields are unified through scalar gauge; the weak and gravitational fields as well. Although these equations allow identifying gauge couplings, the waves velocity $(c/\sqrt{\beta})$ reminds that of de Broglie. Proceeding as before, we can define two possibilities for propagating waves at the celerity c: a space-time of coordinates $(\vec{r}, ict/\sqrt{\beta})$ or a space-time of coordinates $(\sqrt{\beta}\vec{r}, ict)$. In both cases corresponds the velocity $\vec{v}\,' = \sqrt{\beta}\vec{v}$. This leads to the relation $\vec{v}\,'^2 . v_B/c = \vec{v}^2$, which shows that to the de Broglie waves is associated a fundamental boson moving at the energy velocity $\vec{v}\,'^2/c = v^3/c^2$ from the moving particle. This completes the relation $vv_B = c^2$, which shows that to the de Broglie waves is associated a particle of velocity v from the vacuum. That fact expresses the interaction particle-medium so as we have to associate a structure to the vacuum too. Fundamental bosons are then similar to phonons in a crystal. We deduce that the vacuum has a crystal structure. The result with non-wave equations is the same. We dedicate the next section to this topic.

We can now generalize the identification of couplings. Knowing that the local gauges must remain linked to the vector fields for non-fundamental bosons too, we deduct the Table-3 results for any boson kind.

Table-1: Gauges and fields definitions for any particle.

Gauge relation	Field definitions	Field equations
$c\,\partial_t\vec{A}_\parallel - \vec{\nabla}V_\parallel = \vec{0}$	$\Gamma_- = -\vec{\nabla}\vec{A}_\parallel + \partial_t V_\parallel/c$	$\square\vec{A}_\parallel = -\vec{\nabla}\Gamma_-$ $\square V_\parallel = -c\,\partial_t\Gamma_-$;
$c\,\partial_t\vec{A}_\parallel + \vec{\nabla}V_\parallel = \vec{0}$	$\Gamma_+ = \vec{\nabla}\vec{A}_\parallel + \partial_t V_\parallel/c$	$\square\vec{A}_\parallel = \vec{\nabla}\Gamma_+$; $\square V_\parallel = -c\,\partial_t\Gamma_+$
$\vec{\nabla}_\perp\vec{A}_\perp + \frac{\partial_{t\perp}V_\perp}{c} = 0$	$\vec{E}_+ = -\vec{\nabla}_\perp V_\perp - c\,\partial_{t\perp}\vec{A}_\perp$ $\vec{D}_+ = \vec{\nabla}_\perp \wedge \vec{A}_\perp$	$\square_\perp\vec{A}_\perp = \vec{\nabla}_\perp \wedge \vec{D}_1 + \partial_{t\perp}\vec{E}_+/c$ $\square_\perp V_\perp = -\vec{\nabla}_\perp\vec{E}_+$
$\vec{\nabla}_\perp\vec{A}_\perp - \frac{\partial_{t\perp}V_\perp}{c} = 0$	$\vec{E}_- = -\vec{\nabla}_\perp V_\perp + c\,\partial_{t\perp}\vec{A}_\perp$ $\vec{D}_- = \vec{\nabla}_\perp \wedge \vec{A}_\perp$	$\square_\perp\vec{A}_\perp = \vec{\nabla}_\perp \wedge \vec{D}_- - \partial_{t\perp}\vec{E}_-/c$ $\square_\perp V_\perp = -\vec{\nabla}_\perp\vec{E}_-$

Table-2: Field identification with fundamental bosons.

Non-local gauge	Local gauge	Equation	Vector field
$\vec{\nabla}_\perp\vec{A} + \frac{\partial_{t\perp}V}{c} = 0$	$c\,\partial_t\vec{A} + \vec{\nabla}V = \vec{0}$	$\square_-\lvert A\rangle = 0$	Electromagnetic
	$c\,\partial_t\vec{A} - \vec{\nabla}V = \vec{0}$	$\square_+\lvert A\rangle = 0$	Weak
$\vec{\nabla}_\perp\vec{A} - \frac{\partial_{t\perp}V}{c} = 0$	$c\,\partial_t\vec{A} - \vec{\nabla}V = \vec{0}$	$\square_-\lvert A\rangle = 0$	Gravitational
	$c\,\partial_t\vec{A} + \vec{\nabla}V = \vec{0}$	$\square_+\lvert A\rangle = 0$	Strong

Table-3: Gauge couplings identification for any boson.

Vector gauge	Scalar gauge	Vector field
$\vec{\nabla}_\perp\vec{A}_\perp + \frac{\partial_{t\perp}V_\perp}{c} = 0$	$c\,\partial_t\vec{A}_\parallel + \vec{\nabla}V_\parallel = \vec{0}$	Electromagnetic
	$c\,\partial_t\vec{A}_\parallel - \vec{\nabla}V_\parallel = \vec{0}$	Weak
$\vec{\nabla}_\perp\vec{A}_\perp - \frac{\partial_{t\perp}V_\perp}{c} = 0$	$c\,\partial_t\vec{A}_\parallel - \vec{\nabla}V_\parallel = \vec{0}$	Gravitational
	$c\,\partial_t\vec{A}_\parallel + \vec{\nabla}V_\parallel = \vec{0}$	Strong

The vacuum elastic structure: To understand the vacuum structure, it is necessary to know its particle composition. As in any material, we can elastically explain the propagating waves as describing successive elastic shocks between a moving particle and an equivalent vacuum volume. Consider then $\boldsymbol{\hat{p}_1}$and $\boldsymbol{\hat{p}_2}$ as four-impulsesre presenting the particle and its equivalent before the shock and $\boldsymbol{\hat{p}}$, the resulting four-impulse after the shock. The conservation laws of energy and impulse of the system implies that

$$\hat{p}_2\ \hat{p}_1 = \frac{1}{2}(\hat{p}^2 - \hat{p}_1\hat{p}_1 - \hat{p}_2\hat{p}_2) \quad (10)$$

Multiplying both member by $|A_\alpha\rangle$ and comparing with the previous equation, we find $\hat{p}_2\hat{p}_1 = Cst.1\square$. The determination of both operators is impossible, otherwise, to near two constants. Then, due to the d'Alembertian definition, we can choose these following generalized solutions for a state α:

$$\begin{cases}\hat{p}_{1\alpha} = -i\square\hat{a}_{1\alpha}(\vec{\nabla}_\alpha \mp i\vec{\partial}_{t\alpha}) \\ \hat{p}_{2\alpha} = -i\square\hat{a}_{2\alpha}(\vec{\nabla}_\alpha \mp i\vec{\partial}_{t\alpha})\end{cases} \hat{a}_{1\alpha}.\hat{a}_{2\alpha} = -1 \quad (11)$$

In these, we defined the time arrow by the anti-unitary vector $i\vec{\tau}$ ($\vec{\tau}^2 = -1$) so that $\vec{\partial}_{t\alpha} = \vec{\tau}\partial_{t\alpha}$. This definition calls attention on the space and time equivalency. Then, it is opportune to express our operators in the base $\{\vec{r}/r, i\vec{\tau}\}$ so as

$$\hat{a}_{1\alpha}.\hat{a}_{2\alpha} = -\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix} \quad (12)$$

Remembering that only two parameters are necessary, both operators must be proportional to the same matrix ($\hat{\sigma}$) such as

$$\begin{cases}\hat{a}_{1\alpha} = \hat{\sigma}a_{1\alpha}\ ;\ \hat{a}_{2\alpha} = \hat{\sigma}a_{2\alpha} \\ \hat{\sigma}^2 = 1;\ a_{1\alpha}.a_{2\alpha} = -1\end{cases} \quad (13)$$

From a hermitic matrix 2x2, one shows that ($\hat{\sigma}$) is a linear combination of the three Pauli matrixes, i.e. both components are fermions having the spins 1/2 and -1/2; this result is comparable to that of Dirac. One gets to

$$\hat{\sigma}_\alpha = \sqrt{1 - b_\alpha^2}\left[cos(\theta)\,\sigma_x + sin(\theta)\sigma_y\right] + b_\alpha\sigma_z \quad (14)$$

With $\sigma_x = \begin{bmatrix}0 & 1\\ 1 & 0\end{bmatrix}$, $\sigma_y = \begin{bmatrix}0 & i\\ -i & 0\end{bmatrix}$, $\sigma_z = \begin{bmatrix}1 & 0\\ 0 & -1\end{bmatrix}$

Where: θ is an arbitrary angle and $b_\alpha \in [0,1]$ is a real parameter. This last defines the spin polarization in the mode α.

In addition, the evidence $\hat{p}^2 \geq 0$ leads to get $|a_{1\alpha}| \geq 1 or |a_{2\alpha}| \geq 1$ such as both operators are complex. The four-impulse operators become identical to the usual definition in Quantum Mechanics, if $a_{1\alpha} = 1$; otherwise, the parameters are relative to any macroscopic object. Due to the operators opposite signs, the vacuum equivalent object is in reality the virtual anti-object, i.e. each operator represents a virtual entity.

We can now tell that any object disturbing the vacuum is either a fermion or a set of fermions generating its opposite as a mass or charge default. This means that fermions are the primmest particles we can have. As any field describes with phonons or bosons, we deduct that each of them is a fermion-antifermion coupling. Without disturbing object, fundamental particles composed then the vacuum. Consequently, the vacuum is full of bosons and antibosons, which react to any object presence creating a default. Its structure in equilibrium state can only be homogeneous and isotropic. This corresponds to the cubic structure with centered faces.

Figure-1 illustrates the vacuum structure in its equilibrium state. The best scenario is that of locally oscillating couples of scalar and vector bosons or the opposites on faces. The vector component rotates around the scalar component, depending on the particle velocity. The six bosons and six antibosons (scalar or vector) for one cube are justifiable from three fermions (f_1, f_2, f_3) and three antifermions $(\bar{f}_1, \bar{f}_2, \bar{f}_3)$, i.e. the couples $(f_1\bar{f}_2, f_1\bar{f}_3, f_2\bar{f}_1, f_2\bar{f}_3, f_3\bar{f}_1, f_3\bar{f}_2)$ for each state. The two following sections show the steps for the interacting field determination with such a vacuum.

Explicit field equations in the vacuum: To know these, it is necessary to determine explicitly the equation quantities. Thence, we apply the conservation relativistic rule of the scalar product of four-vectors.

For the scalar field, the operators in the couple system write $\tilde{p}_\parallel = i\vec{\tau}mca_\parallel$; $\tilde{p}'_\parallel = -i\vec{\tau}mca'_\parallel$. Then ce$\tilde{p}_\parallel\tilde{p}'_\parallel = m^2c^2$ so that the equation (5) transforms into the familiar form

$$\square_\parallel 1|A_\parallel\rangle = \left(\frac{mc}{\square}\right)^2 1|A_\parallel\rangle \quad (15)$$

According to the equation interpretation, elastic shocks also occur in terms of electric, weak or strong charges. That is, we have to find out the corresponding four-impulses in any couple system. Considering the particle intrinsic voltage U as acting between both entities, we write $\tilde{p}_\perp = i\vec{\tau}a_\perp qU/c^2$; $\tilde{p}'_\perp = -i\vec{\tau}a'_\perp qU/c^2$. Then ce$\tilde{p}_\perp\tilde{p}'_\perp = q^2U^2/c^4$ and the equation (5) translates by

$$\square_\perp 1|A_\perp\rangle = \left(\frac{qU}{\square c^2}\right)^2 1|A_\perp\rangle \quad (16)$$

The intrinsic voltage depends on the charge unity. With the gravitational field, q is identical to the mass m and U to c^2.

One remarks that both scalar and vector fields are unified for the same source factor or equal normalized four-impulses at rest ($\tilde{p}_\parallel\tilde{p}'_\parallel = \tilde{p}_\perp\tilde{p}'_\perp c^2$) such as

$$m^2c^4 = q^2U^2 \Rightarrow mc^2 = \mp qU \quad (17)$$

For illustration, the intrinsic voltage of electrons or positrons in the vacuum is, $U = 0.5MV$ since $m = \pm 0.5MeV/c^2$ and $q = e$.

Eigen states of fields: The quantum solutions of equations (15) and (16) are those of a free particle and express under the following form for any component j in spherical coordinates (r, θ, φ):

$$\begin{cases} |A_\alpha\rangle^{j}_{l,m} = \mathrm{A}^{j}_{\alpha,l,m} R_l(r) Y_l^m(\theta,\varphi) \\ m = -l, -l+1, .., l-1, l \end{cases} \quad (18)$$

Where: l = integer representing the kinetic momentum number. m = that of its projection on an axis; $\mathrm{A}^{j}_{\alpha,l,m}$ is anintegration complex constant; $R_l(r)$ and $Y_l^m(\theta,\varphi)$ are the normalized radial and spherical functions respectively, defined by:

$$\begin{cases} \mathrm{R}_l^{\pm}(kr) = (-1)^l \left(\frac{d}{d(kr)}\right)^l \frac{e^{\pm ikr}}{r} \\ Y_l^m(\theta,\varphi) = (-1)^m (i)^l \sqrt{\frac{(2l+1)}{2}\frac{(l-m)!}{(l+m)!}}\, \mathrm{P}_l^m(\cos(\theta)) \frac{e^{im\varphi}}{\sqrt{2\pi}} \\ \mathrm{P}_l^m(\cos(\theta)) = \frac{1}{2^l l!} \sin^m(\theta) \frac{d^{l+m}}{(d\cos(\theta))^{l+m}} \left(-\sin^2(\theta)\right)^l \end{cases} \quad (19)$$

k is the particle wave number. The normalized solutions represent wave functions; this implies, indeed, there quired relationships between these and the particle fields. The probability to find a particle at a given position is equivalent to the field intensity at that position.

The field expressions get from the Table-1 definitions. Both scalar and vector fields are quantified. In the primmest cases of fundamental particles where $a_\alpha = 1$, *l=0* for the scalar field ($|A_\parallel\rangle$) and *l=1* for the vector field ($|A_\perp\rangle$); otherwise for ($|a_\alpha| > 1$), the component general solution is the linear combination on all l values. This shows that even macroscopic objects have quantum solutions with scalar and vector bosons of higher values ($l \gg 1$); the gravitation quantization is obvious for one object in the vacuum. The next section examines the case of one object interacting with others.

Interpreting interaction with general relativity: The gauges expressions given in Table-1 are available whatever the field source is; the object velocity can vary in space-time. However, we assumed in the construction procedure of gauges that the four-potentials remain unchanged at any space-time position, i.e. for an isolated object. For an interacting object with another, the transformation from a potential to another can be different. The relations (8) and (9) write now

$$\begin{cases} c\vec{\mathrm{A}}'_\parallel = \pm\mu \int \vec{\nabla} \mathrm{V}_\parallel c dt \\ V'_\perp = \pm c\eta \int \vec{\nabla}_\perp \vec{\mathrm{A}}_\perp c^2 dt \end{cases} \Rightarrow \begin{cases} \vec{\mathrm{A}}'_\parallel = \mu \vec{\mathrm{A}}_\parallel \\ V'_\perp = \eta \mathrm{V}_\perp \end{cases} \quad (20)$$

Where: μ and η are dimensionless factors indicating respective changes. With the space-time symmetry, there are scalars; otherwise, μ is a tensor 3x3 in three dimensions space. We consider here the most general case of that symmetry. There are two cases in respect to the factors nature.

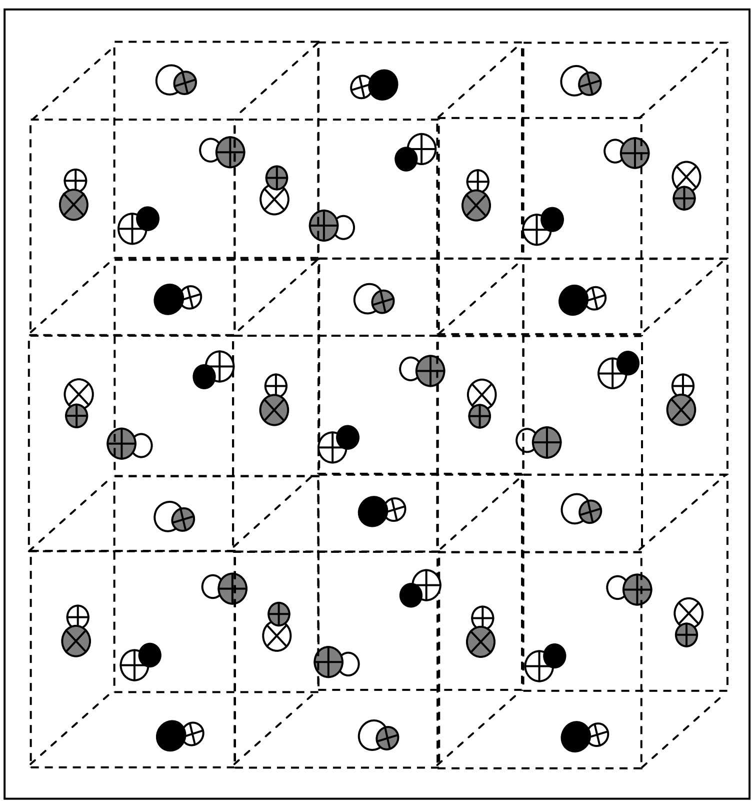

Figure-1: Vacuum equilibrium state: each couple represents a scalar component (bigger circle) and a vector component (smaller circle); each component is either a boson or an antiboson facing the opposite.

Case of constant factors: vacuum instability: The substitution in the gauge relations allows deducing the complementary relations $V_{\parallel}^{'} = \mu V_{\parallel}$ and $\vec{A}_{\perp}^{'} = \eta \vec{A}_{\perp}$) so that we can write

$$|A_{\parallel}^{'}\rangle = \underbrace{\begin{bmatrix} \mu & 0 \\ 0 & \mu \end{bmatrix}}_{\hat{\mu}} |A_{\parallel}\rangle \; ; \; |A_{\perp}^{'}\rangle = \underbrace{\begin{bmatrix} \eta & 0 \\ 0 & \eta \end{bmatrix}}_{\hat{\eta}} |A_{\perp}\rangle \tag{21}$$

$$\langle A_{\perp}^{'}|A_{\parallel}^{'}\rangle = \langle A_{\perp}|\hat{\eta}\hat{\mu}|A_{\parallel}\rangle \tag{22}$$

If $\hat{\eta}\hat{\mu} = 1$ then the scalar product between both states is constant. We remain within the Special Relativity framework for unit factors corresponding to isolated and stable objects. In the general case ($\hat{\eta}\hat{\mu} \neq 1$), we have partial fields explaining amplitudes partitions, reflections, refractions or decay processes in the vacuum; these lasts imply that the particle or the vacuum is instable. For two final partial-fields, the other field defines with the coefficients (1-μ) and (1-η).

Case of variable factors: interaction process: The equations on $\vec{A}_{\parallel}^{'}$ and $V_{\perp}^{'}$ write from Table-1 relations by substituting the initial fields. We have

$$\Box \mu^{-1} \vec{A}_{\parallel}^{'} = \mp \vec{\nabla} \Gamma_{\mp} \; ; \; \Box_{\perp} \eta^{-1} V_{\perp}^{'} = -\vec{\nabla}_{\perp} \vec{E}_{\pm} \tag{23}$$

This situation is relative to General Relativity. The product ($\hat{\eta}\hat{\mu}$) represents the metric tensor for any kind of field. In the simplest case, the modified fields yet describe waves with a different field source if we write

$$\Box \mu^{-1} = 0 \; ; \; \Box_{\perp} \eta^{-1} = 0 \tag{24}$$

We can interpret the corresponding plane solutions as determining the interacting energy and impulse. According to the field nature and its resulting energy-impulse during the interaction, there is attraction or repulsion of the considered object.

Results and discussion

To highlight the theory, we interpret the vacuum behavior; propose to identify the field explaining its cubic structure and the possible unknown fermions.

On the vacuum understanding: We determined the vacuum structure from the gauge couplings identification showing the existence of phonons in the vacuum. We showed that this generates each phonon accordingly to the particle or object. There are three kinds of elastic phonons, which correspond to fundamental bosons only for fermions travelling at the velocity of the light ($v = c$). Consequently, we deduce that: i. the wave nature justify with gravi-phonons, electro-phonons, weak-phonons or strong-phonons; when the corresponding field is of long range. For the two lasts, it is non-fundamental bosons, i.e. when the wave bundle divides, as in experiments[9,11]. ii. Each field is defined elastically by three fermions and three bosons; inelastic shocks justify more fermions and bosons. iii. The interaction process from vector fields occur at the velocity of the light in advance to fundamental bosons, according to (24).

Field structuring the vacuum: As in all known quantum theories, the vacuum is not empty as we obtained. The early Casmir effect is a reference illustrating the appearance of forces from nothing and many studies still refer to it[12,13]. One also observes the vacuum fluctuations or decays during interactions[14,15] as it appears here. The structure we proposed is not however familiar to our knowledge. To identify the field structuring the vacuum, it is enough to bear in mind that the vacuum behaves accordingly to any field. Therefore, we can deduct that its bosons differentiate contextually to energy. These must then belong to the field defining the vacuum. Since its structure does not rely on a specific field, this can only be an anonymous field: the unified field originating all the others in respect to the stimulation.

Fundamental fermions prediction: We saw that fundamental bosons determine by gauge unification (Table-2) from equivalent four-potentials. Each one is composed of one fermion and one antifermion according to the four-impulses. Therefore, each photon, graviton, weak boson or strong boson is such a coupling. Even if one does not yet have details on the others, the decay of weak bosons illustrates the fact, e.g. with $W^- \rightleftarrows e^- + \bar{\nu}_e$. Therefore, we have to expect finding fundamental fermions and antifermions of the electromagnetic, gravitational and strong fields too. The boson-fermion symmetry is natural in the way.

Conclusion

We began by associating both scalar and vector fields to a free particle from the Dirac equation and Ade Broglie wave equation respectively. This last defines in the kinetic momentum space-time. The field four-potentials are quantum states representing the interaction particle-vacuum. We generalized those equations and found four gauge couplings applying a simple procedure of gauge construction. These describe waves associated to any particle whatever is the field. We showed that the unification of both coupling gauges defines associated fundamental bosons, which are like phonons in crystals.

The phonon concept allows deducing a vacuum elastic structure we represented. We found that this is made of undetermined bosons and antibosons we attributed to the unified field originating all others. The three elastic bosons and their opposites composed of fermions and antifermions of spins 1/2 and -1/2. The spin appears as a property of the space-time symmetry defining fundamental fermions. However, we showed that the field equations are available for any microscopic or macroscopic object. We indicated the Eigen states of fields, showed that the gauge breaking explains decay processes of any kind as well as interaction processes. These put in evidence the General Relativity necessity with any fundamental field.

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