Boson Journal of Modern Physics (BJMP)
ISSN: 2454-8413

SCITECH
RESEARCH ORGANISATION

Volume 3, Issue 2
May 15, 2017

Boson Journal of Modern Physics
www.scitecresearch.com

Vacuum crystalline structures in field presence: the unified field versatility

Louis-Marie MOUKALA[1], Timothée Nsongo[2]

[1]Département des Sciences Exacts, Groupe de Recherche sur les propriétés physico-chimiques et minéralogiques des matériaux, École Normale Supérieure, Université Marien Ngouabi, Brazzaville, Congo. Email: lmmouk@hotmail.fr

[2]Groupe de Recherche sur les propriétés physico-chimiques et minéralogiques des matériaux, Faculté des Sciences et Techniques, Université Marien NGOUABI, Brazzaville, Congo. Email: nsongo@yahoo.com

Abstract

The quantum vacuum structure is essential when trying to understand its manifestations in experiments. In material sciences, its homogeneity and isotropy present cubic system properties. In this work is shown this evidence from a moving free particle relatively to the Helmholtz field definition. This represents both scalar and vector modes of a field. Its stationary states energy-location point out geometrical structures. Hence, it happens that the electromagnetic field organizes the vacuum cells as simple cubic systems; the gravitation organizes these as body-centred-cubic systems. The weak field models them as faced-centred-cubic systems and the strong field in peculiar cubic systems. The cubic lattice parameter appears proportional to the field wavelength. Those stationary states let quantizing fields according to 3-dimensions harmonic oscillators in field presence; in field absence, the vacuum is non-differentiated as the unified field is. Besides, the result analysis allows understanding qualitatively the Casimir effect origin from weak phonons associated to electrons within the field-particle duality framework. These particles are transformed into fundamental bosons at high energy physics. Owing to the space-time symmetry, the impulse quantization in time-space implies that dark-matter would only be detectable in 3-dimensions time as matter is in the real space.

Keywords: Casimir effect; cubic system; dark matter; harmonic oscillator; unified field; vacuum structure.

1. INTRODUCTION

Etymologically, the vacuum is space void of matter. To explain however classically the high speed of the light, physicists of the 19th century considered as evident the ether existence as a vacuum substance, by analogy to material media where sound celerities depend on medium characteristics. One knows that to explain the Michelson and Morley experiment [1], Ernest March proposed first to abandon the ether existence as it seemed, at down of the Special Relativity birth in 1905. Nowadays, the vacuum new concept seems yet mysterious but could look like an update of that classical idea since the quantum electrodynamics theory. The quantum vacuum is defined as the ground state of non-interacting fields. One assumes that it is full of appearing and disappearing fermion-antifermion pairs [2, 3] of any field. In the Standard Model of particles physics, one considers it stable or metastable [4, 5] while studying fundamental fermions or bosons. It is yet the object of study in the Large Hadron Collider and in the Relativistic Heavy Ion Collider, relatively to the nuclear fields [6]. One distinguishes then vacua according to the studied field, which are translatable as different vacuum behaviors. The vacuum can also manifest itself by fluctuations [7]. Some authors also consider its decay or instability in topics dealing with gravitation [8, 9].

The standard theories do not rigorously define the vacuum as one can remark. One can ask "why does it change structure according to the field?" If however we want to catch its meaning, the definition should be unique. With all of these aspects, the vacuum looks like a versatile medium. Its definition as a unique state mixing all fundamental fields seems ambiguous unless these are all in one. Like any medium, its cohesiveness must be then assumed by a field linking different elements. The best existing analogy to understand such a field is the electric field assuming the cohesiveness of material structures. This can differentiate in chemical links from molecules to crystalline structures.

In a previous article [10], we proposed the unified energy as structuring the vacuum divisible in cells. We showed that it is stable or instable according to the perturbative source, ordinary or dark. We found that each vacuum cell is defined with independent magnetic and electric like fields, which can serve to justify the vacuum permeability and permittivity respectively. Here, we complete that study showing that the structure adopted by the vacuum depend indeed on each of the four fundamental fields but does not imply potential vacua, otherwise the differentiation or versatility of the unified field. To the best of our knowledge, this is the first attempt on vacuum crystal structures including in addition all fundamental fields.

The basic theory is rather soft and different from the hard standard theories of particles physics or cosmology. It seems however an ideal model for understanding the unification of all fields at any energy scales, without complex formalism. It could be called the versatile unification theory since it expresses the vacuum versatility. It is based on the initial wave equations of the field-particle duality. We will then begin by the theory background based on the Helmholtz field theorem and the examination of its stationary states. These reveal the vacuum cell structures depending on the responsible field to identify. Then, we will discuss the field quantization, the space-time symmetric results and the vacuum status. Any vector appears in bold.

2. THEORY BACKGROUND

We previously showed the interest of defining two wave equations associated to a free particle in motion. One is related to a scalar-field mode defined by a longitudinal 4-potential and the other to a vector-field mode defined by a transversal 4-potential (see Appendix). The vacuum is then the seat of propagating waves and must be represented by a lattice of cells like in elasticity. Here, we are going to show that if the four gauge couplings describe the set motion of cells, the stationary solutions of the correspond field defined from the Helmholtz theorem determine the cell structures.

2.1. Helmholtz field stationary states

According to the Helmholtz theorem, any field vanishing to infinite is expressible as a rotational and a gradient sum. To take into account both scalar and vector modes, one can then define the Helmholtz field by

$$\boldsymbol{u} = \boldsymbol{\nabla} \times \mathbf{A}_{\perp} + \boldsymbol{\nabla}\mathrm{V}_{\parallel}/\mathrm{c}_{\parallel} \quad (1)$$

Where $\mathbf{A}_{\perp}$ is the vector potential of the transverse field and $\mathrm{V}_{\parallel}$ is the scalar potential of the longitudinal field having the celerity $\mathrm{c}_{\parallel}$. This field also writes $\boldsymbol{u} = \boldsymbol{u}_{\perp} + \boldsymbol{u}_{\parallel}$ and is orthogonal to the plane defined by the vector surface $\boldsymbol{P}_{\pm} = \pm\mathbf{u}_{\parallel} \times \mathbf{u}_{\perp}$, which indicates the energy propagation direction of both modes set, by analogy to the Pointing vector in electromagnetism. The $\boldsymbol{u}$ components define then a moving surface in course of time. As these are orthogonal and may have different frequencies, one can assume that the stationary solutions for a free particle are such as

$$\begin{cases} \boldsymbol{u}_{\parallel}(\boldsymbol{r},t) = \boldsymbol{u}_{\parallel}^{o}(\boldsymbol{r})\cos(\omega_{\parallel}t) \\ \boldsymbol{u}_{\perp}(\boldsymbol{r},t) = \boldsymbol{u}_{\perp}^{o}(\boldsymbol{r})\sin(\omega_{\perp}t) \end{cases} \quad (2)$$

Defining the $\boldsymbol{u}$ wave characteristics by $(\boldsymbol{k}, i\omega/\mathrm{C})$ and those of $\boldsymbol{u}_{\alpha}$ by $(\boldsymbol{k}_{\alpha}, i\omega_{\alpha}/c_{\alpha})$, its extremity trajectory is then given by the equation

$$X^2 - 2\,XY\sin[(\omega_{\perp} - \omega_{\parallel})t] + Y^2 = cos^2[(\omega_{\perp} - \omega_{\parallel})t] \quad (3)$$

With $X = u_{\parallel}/u_{\parallel}^{0}$ and $Y = u_{\perp}/u_{\perp}^{0}$. When propagating, the Helmholtz field changes direction in course of time on the surface it defines. Inside a cell, this must be periodic for a stable particle so that $\boldsymbol{u}(\boldsymbol{r}, t+T) = \boldsymbol{u}(\boldsymbol{r}, t)$ if $T = 2\pi/\omega$ is the period. This yields the relations

$$\begin{cases} \omega_{\parallel} = n_{\parallel}\omega \\ \omega_{\perp} = n_{\perp}\omega \end{cases} \text{with } n_{\parallel},\ n_{\perp} \in \mathbb{Z}^* \quad (4)$$

By defining the third variable $Z = P/P^o$, we can then estimate the energy variation inside a cell in respect to $n_{\parallel}$ and $n_{\perp}$. Taking $n_{\parallel}$ values for reference, both vector surfaces must give the cell geometry in respect to a given plane knowing that there three independent plans in the real space.

We represented in 3-dimensions the function $Z(X,Y)$ and noted the corresponding geometrical structures appropriated to a homogeneous and isotropic vacuum. The methodology section gives a brief algorithm of curve plotting. Here are the four cases corresponding to gauge couplings for only one Helmholtz field plane:

1. The first coupling corresponds to $n_{\perp} = n_{\parallel}$. Figure 1a illustrates the case. The surface vectors describe symmetric complementary curves showing eight tops where energy is extremum. All the extremum are localized into a cube whose tops are sites of interacting particles like ions in a simple cubic crystalline system (cP). In respect to this, $\boldsymbol{P}_{\pm}$ would represent the motion of electrons pairs corresponding to field bosons. The curve projections in *XOY* plane give circles of course.

2. The second coupling corresponds to $n_{\perp} = 2n_{\parallel}$. Figure 1b illustrates the case. In addition to the previous tops, the centre also presents another energy extremum. The nine extremum are analogous to sites of interacting particles like ions in the body-centered-cubic system (bcc). The curve projections in *XOY* plane correspond to the infinite sign. With the preceding, this is the second case of isotropy intrinsic to cubic systems.

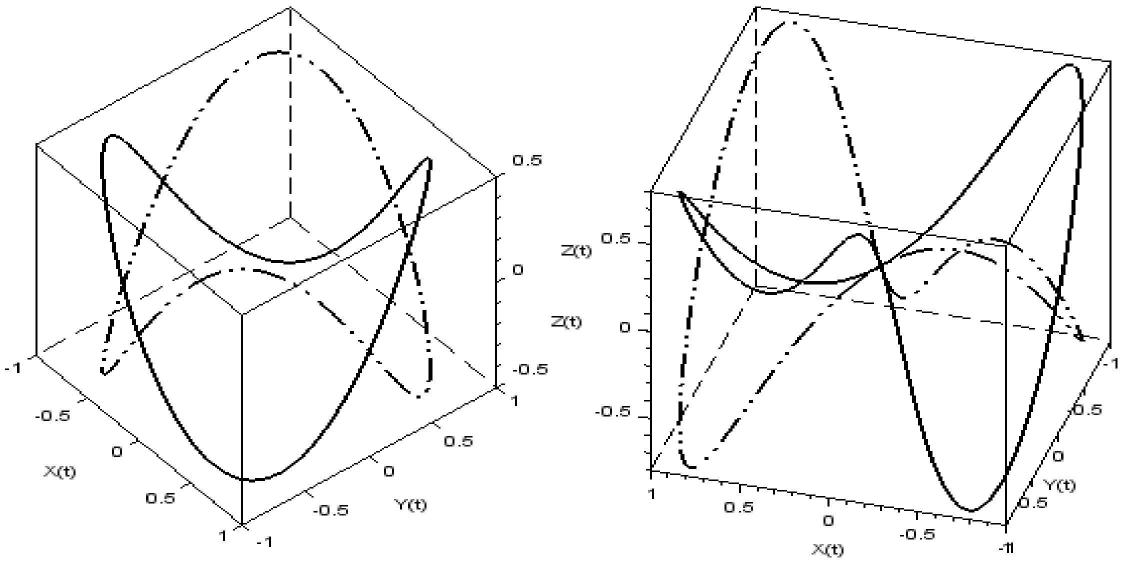
3. The third coupling corresponds to $n_\perp = 3n_\parallel$. Figure 2a illustrates this. In addition to the eight tops, there are also two opposite centered sites of energy extremums where cross both curves. With all planes representations, the corresponding crystalline system is the face-centered-cubic (fcc).

4. The last and four gauge coupling corresponds to $n_\perp = 4n_\parallel$. Figure 2b illustrates this situation. In addition to the standard tops, there are also four secondary energy extremums on each cubic face and two others inside. The centre is not one. Four additional sites appear then on faces and two on a perpendicularly line to them. We gave in Figure 3 in appendix the corresponding cubic system we qualified by complex-cubic (cc). Hence, considering the entire cube there are 8 extremums on each face and six others inside.

2.2. Field originating each cubic structure

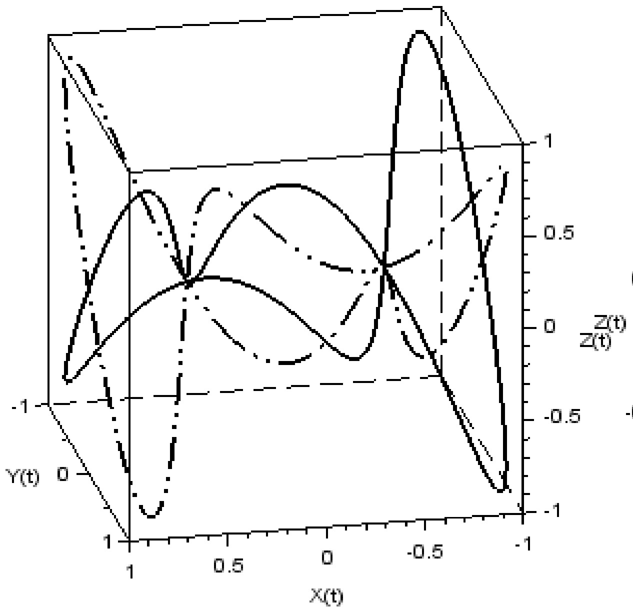
To identify each configuration in respect to a gauge coupling, we are going to use our previous results summarized in Table 1. We assumed that at cell interfaces both 4-potentials are identical, i.e. $|A\rangle_\parallel \equiv |A\rangle_\perp = |A\rangle$, such as both field modes are continue. In the gauge coupling column, the first sign identifies the scalar gauge and the second the vector gauge (see Table 3 in Appendix for the explicit relations). In addition, we also have the coefficient definitions $\beta_\pm = 1 \pm c_\perp^2/c_\parallel^2$ and the d'Alembertian operator for the imaginary time $\bar{\Box}_\perp = \Delta + \partial_t^2/c_\perp^2$.

The vector $\boldsymbol{E}$ is an electric like field proving the charge transmission from one interface to another in any direction while $\boldsymbol{B}$ is a zero magnetic like field showing their non-rotation.

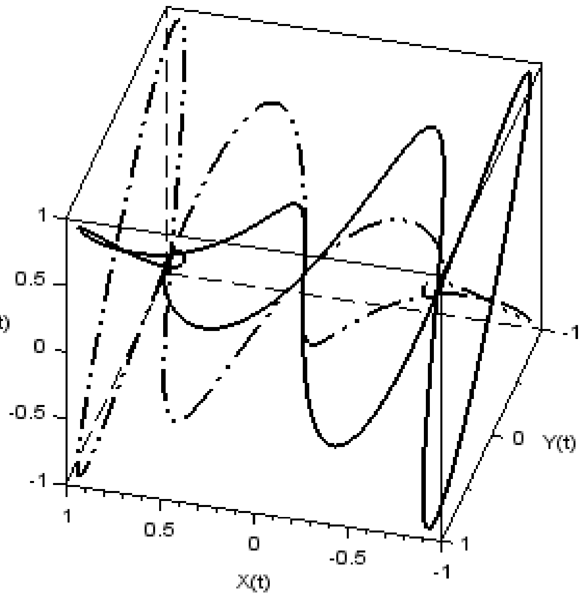


a) **b)**

Figure 1: Energy localization vs time in cP and bcc cells: The solid lines represent P_+ and the other P_- definitions; (a) case $n_\perp = n_\parallel$ showing eight tops of energy extremum; b) case $n_\perp = 2n_\parallel$ showing in addition another extremum at the centre.



a)



b)

Figure 2: Energy localization vs time in fcc and cc cells: Same meaning in respect to lines as before. (a) Case $n_\perp = 3n_\parallel$ showing the eight tops of extremum energy plus one on each face where both curves cross; b) case $n_\perp = 4n_\parallel$ showing four additional extremums on each face.

The scalar field Γ is understandable as a link energy between two cells of the vacuum lattice. It is zero for a particle moving at the velocity c of light. It allows identifying each cubic system if one assumes that the factors $(-\beta_-)$ and $(-\beta_+)$ express the mass presence inside a cube structure (bcc or cc). Therefore, the others correspond to cP and fcc systems (β_- and β_+).

Table 1: **Field expressions at interfaces ($\boldsymbol{B} = \mathbf{0}$) [10]**

Coupling	***Equation***	$\boldsymbol{\Gamma}$	$\boldsymbol{E}$
(+,+)	$\Box_\perp \lvert A\rangle = 0$	$\beta_- \boldsymbol{\nabla A}$	$\mathbf{0}$
(-,-)	$\Box_\perp \lvert A\rangle = 0$	$-\beta_- \boldsymbol{\nabla A}$	$\mathbf{0}$
(-,+)	$\bar{\Box}_\perp \lvert A\rangle = 0$	$\beta_+ \boldsymbol{\nabla A}$	$-2\boldsymbol{\nabla}\mathrm{V}$
(+,-)	$\bar{\Box}_\perp \lvert A\rangle = 0$	$-\beta_+ \boldsymbol{\nabla A}$	$-2\boldsymbol{\nabla}\mathrm{V}$

When $\boldsymbol{E} = \mathbf{0}$, there is no charge on cube faces like in cP and bcc systems (see Figure 3 in Appendix). Hence, the coupling $(+,+)$ identifies the cP system while the second $(-,-)$ identifies the bcc system. From the Lorenz vector mode gauge (+), the former is related to the electromagnetic field and the latter to the gravitational field.

When $\boldsymbol{E} \neq \mathbf{0}$, the third coupling (-, +) identifies then the fcc system relatively to β_+ and must correspond to the weak field less complex such as the last is the cc system corresponding to the strong field. The Table 2 summarizes the results with the previous conventions.

Table 2: **Field originating each cubic structure**

Case	***Coupling***	***System***	***Field***
$n_\perp = n_\parallel$	$(+,+)$	cP	EM
$n_\perp = 2n_\parallel$	$(-,-)$	bcc	Gravitation.
$n_\perp = 3n_\parallel$	$(-,+)$	fcc	Weak
$n_\perp = 4n_\parallel$	$(+,-)$	cc	Strong

Owing to the fact that the host particle must define the central cube in the lattice with maximum energy, it appears the following. (1) From the cellular structures due to the gravitational and strong fields, the particle must be at the cube centre, the mass-centre position. Both fields have the common property implying mass. (2) The electromagnetic (EM) and weak field energies do not cross the centre, i.e. are located around the particle. This certifies the identification procedure and matches with their unification in respect to vector mode gauges (– for the first situation and + for the second) while the scalar mode gauges are different.

3. METHODOLOGY

We got the figures by representing in three dimensions the function $z(x,y) = \pm xy$, where $x(t) = cos(\omega t)$ and $y(t) = sin(n\omega t)$ for $n = 1, 2, 3, 4$ on a time period such as $\omega t \in [0, 2\pi]$. We identified the energy extremums from numerical values. By axis rotations, we chose the best views here given. The representation according to the ISO standard is not always appropriated. We used the $Scilab$ software with the plotting instruction *param3d*.

4. RESULTS AND DISCUSSIONS

This section illustrates the theory interpretation and investigates the quantum consequences of the stationary Helmholtz field. This yields establishing the vacuum composition in any field absence, the status of dark matter manifestation and the vacuum lattice parameter in field presence.

4.1. Casimir forces and the field-particle duality

According to the field identifications, the vacuum cells can be positively or negatively charged at their interfaces by the weak or strong field propagation. The host particle and its charge are virtually transmitted though the vacuum such as it can interact attractively with an analogous field. Such interactions could dominate that electromagnetic between particles having the same electric charge beyond nuclear dimensions. Two macroscopic systems can then attract one to another. This explains qualitatively the Casimir attractive forces appearing between uncharged conductive plates or dielectrics as illustrated in various experiments [11-13]. Schwinger, DeRaad and Milton [14] explain unconventionally the Casimir effect, from Quantum Electrodynamics, as the effects of the electron motions on the electromagnetic field they called the source field effect. This argument is maintained by Milonni [15] and Jaffe [16]. Here, the weak field propagation is enough to understand the phenomenon from electrons at plate surfaces, which polarize the vacuum. The corresponding bosons are vacuum phonons comparatively to what appends in a real crystal.

The duality field-particle comes to define them. When the particle velocity equals that of the light ($v = c$), they define certainly the so-called fundamental bosons, i.e. photons, gravitons, weak bosons or gluons. This is the sphere of high energy physics which prove their existence. At low or intermediate energy physics, we have phonons justifying any field-particle duality.

4.2. Field energy quantization

In the same previous article [10], we showed that the elastic interpretation of a wave equation points out fermion-antifermion couples as propagating bosons. These must already exist in the vacuum with certain energy. Consequently, the perturbative energy is the sum of both object energies variations. Hence, one can write the relation $\Delta E^{f}_{n_\alpha} + \Delta E^{af}_{n_\alpha} = n_\alpha \hbar\omega$. Therefore, the fermion energy variation is given by

$$\Delta E^{f}_{n_\alpha} = (n_\alpha + 1)\hbar\omega - \Delta E^{af}_{n_\alpha}\ ;\ \forall\, n_\alpha \geq 0 \qquad (5)$$

If the antifermions have energy constant variations when the vacuum disturbance is due to matter, each expression represents energy of an oscillating fermion in 3-dimensions. The oscillations are independent and harmonic if we can write

$$\begin{cases} \Delta E^{af}_{n_\alpha} = -\frac{1}{2}\hbar\omega \\ \Delta E^{f}_{n_\alpha} = \left(n_\alpha + \frac{3}{2}\right)\hbar\omega \end{cases} \qquad (6)$$

One verifies that the one and two dimensions harmonic oscillators are excluded so that the antifermion energy variation must always be negative to exclude the antifermion transformation into fermion. Then, the result only fits with the space reality as illustrated in figures. The symmetric case with an antiparticle disturbance comes to consider constant the fermion energy variation such as the expressions have opposite values.

4.3. Unified energy and undefined vacuum

We previously showed that the cells electric-like field is quantized as the gradient of a function we can now translate to a great extend by

$$\mathrm{f}_\perp(\mathbf{r}, \mathrm{t}) = \sum_{n=-\infty}^{\infty} f_n(\mathbf{r})\, e^{-i\omega_n t} \qquad (7)$$

Where $f_n(\mathbf{r})$ writes in relation to radial and spherical functions product of a free particle generating waves. We considered it to be the unified field expression as it is gauge invariant. We can now specify that $\omega_n = n\omega \equiv \Delta E_n/\hbar$. The n index is related to $n_\perp$. The zero value defines the static state excluded before ($n_\perp \neq 0$) and corresponding to the *permanent existence* of the previous both fermion and antifermion. These combine to form for each mode either one boson or one antiboson having a non-zero energy. From the zero state in particle field presence, they acquire the energy variations given by (6); in antiparticle field presence, the opposite variations. Otherwise, they stay non-differentiated. This illustrates the vacuum versatility origin from the unified matter. Thus, admitting the unified field existence seems evident such as the vacuum is stable. Here, there is no place for sudden appearance and disappearance of fermion-antifermion pairs as usually admitted.

Consequently, the vacuum original composition is as undifferentiated as the unified energy assuming its cohesiveness. Its structure is certainly flexible for it to change from one field to another. The lattice points in different cubic structures play the role of unified ions between which move unified electron-electron or electron-hole couples.

4.4. Dark-matter scale

To consider the space-time symmetry, we can use the temporal gradient applying the Helmholtz's theorem. We previously defined it for any mode by the operator $\boldsymbol{\partial}_{t\alpha} = \boldsymbol{\tau}\,\partial_{\mathrm{t}}/\mathrm{c}_\alpha$ where $\boldsymbol{\tau}$ is an anti-unitary vector such as $\boldsymbol{\tau}^2 = -1$. This implies the 3-dimensions time we attributed to dark matter. The dark Helmholtz field $\boldsymbol{w}$, by analogy with the ordinary, translates then by changing the spatial gradient by $\boldsymbol{\partial}_{t\perp}$, which depends on the particle velocity, instead of $\boldsymbol{\partial}_{t\parallel}$. One gets

$$\boldsymbol{w} = \underbrace{\boldsymbol{\partial}_{t\perp} \wedge \mathbf{A}_\perp}_{\boldsymbol{w}_\perp} + \underbrace{\boldsymbol{\partial}_{t\perp}\mathrm{V}_\parallel/c_\parallel}_{\boldsymbol{w}_\parallel} \qquad (8)$$

Its stationary expressions in scalar space write

$$\begin{cases} \boldsymbol{w}_\parallel(r, \boldsymbol{t}) = \boldsymbol{w}^o_\parallel(\boldsymbol{t})\cos(k_\parallel r) \\ \boldsymbol{w}_\perp(r, \boldsymbol{t}) = \boldsymbol{w}^o_\perp(\boldsymbol{t})\sin(k_\perp r) \end{cases} \qquad (9)$$

In respect to the wavelength ($\lambda = 2\pi/k$), a dark field periodicity inside a cell writes $\boldsymbol{w}(r+\lambda,\boldsymbol{t}) = \boldsymbol{w}(r,\boldsymbol{t})$. As before, this is true if we have $k_\alpha = m_\alpha k \;\; \forall\, m_\alpha \in \mathbb{Z}^*$. Each boson impulse-variation writes then

$$\Delta P^{f}_{n_\alpha} + \Delta P^{af}_{\alpha} = m_\alpha \hbar \mathrm{k} \tag{10}$$

The dark fermion impulse-variation is given by

$$\Delta P^{f}_{n_\alpha} = (m_\alpha + 1)\hbar \mathrm{k} - \Delta P^{af}_{\alpha}\,;\; \forall\, m_\alpha \geq 0 \tag{11}$$

Comparatively to the previous result, each expression represents oscillations in 3-dimensions. These are harmonic and independent if

$$\begin{cases} \Delta P^{af}_{\alpha} = -\frac{1}{2}\hbar \mathrm{k} \\ \Delta P^{f}_{m_\alpha} = \left(m_\alpha + \frac{3}{2}\right)\hbar \mathrm{k} \end{cases} \tag{12}$$

As above, this result is only valid in the 3-dimensions time. This quantization corresponds to that of dark matter. We have to deduct that in 3-dimensions time, dark matter is represented by the impulse as matter is by energy in ordinary space. It seems then impossible to detect dark matter with the usual scalar time. One can however expect the vector time appearance at large scale implying great mass and velocity as it appears in cosmological observations [17, 18].

4.5. Kinetic momentum quantization

In Appendix, we indicated that any vector field mode is describable in kinetic momentum coordinates. On condition that the impulse-variation of bosons in a cube (10) of parameter a is the same than that of dark bosons, this can write as $L = m_\perp \hbar k a.\mathrm{u}$. Owing to the usual quantization, e.g. in Cartesian coordinates where $u = \cos\alpha i + \cos\beta j + \cos\gamma k$, one obtains

$$\begin{cases} ka.\cos\alpha = \mathrm{n} \\ ka.\cos\beta = \mathrm{p}\;;\;\; \forall\, n,p,q \in \mathbb{Z} \\ ka.\cos\gamma = \mathrm{q} \end{cases} \tag{13}$$

This system yields the expression

$$a = \frac{\lambda}{2\pi}\sqrt{n^2 + p^2 + q^2} \tag{14}$$

The lattice parameter is then proportional to the wavelength. In addition, one notes that the kinetic momentum of a vector mode cannot be zero.

5. CONCLUSIONS

From the previous theory essentials, we defined a field from the Helmholtz theorem representing both scalar and vector field modes in one expression. We studied its stationary states from the energy location given by a Pointing-like vector known in electromagnetism and found four vacuum configurations. Each corresponds to a cubic crystal system.

We identified the responsible fundamental field in each case via local gauge couplings presenting charge location at cube interfaces. We found that the electromagnetic field makes the vacuum vibrates as a lattice of primitive cubic systems; the gravitational field as one of body-centered-cubic, the weak field as that of the faced-centered cubic and the strong field as a lattice of peculiar cubic systems we represented. We explained these various structures by the unified field versatility. Each gauge field propagates then differently according to the ratio between both mode frequencies. This allows understanding qualitatively the Casimir attractive effect from the electron weak field propagation via vacuum phonons. These correspond to the field-particle duality manifestation at any energy scales and become the so-called fundamental bosons at high energy scale.

We discussed the field quantization on energy and impulse and found that the stationary states define 3-dimensions oscillators. The first allowed specifying the unified field expression in ordinary fields. The second, got from the gauge-field space-time symmetry we obtained before, defined the manifestation scale of dark matter. This would manifest itself in 3-dimension time, surely available at cosmological scale or simply at high energy scale. Any result got in ordinary fields is besides translatable in dark fields. At last, the kinetic momentum quantization yielded determining the cubic lattice parameter for each propagating field associated to the host particle.

6. APPENDIX

Here, we give complementary information related to the theory origin as well as the representations of cubic crystalline systems implied in the main text.

6.1. Complements of the basic theory

In this work we consider a free particle of mass $\boldsymbol{m}$ and velocity $\boldsymbol{v}$. The Klein-Gordon equation of its wave function φ is

$$\Delta\varphi - \frac{1}{c^2}\partial_t^2\varphi = \left(\frac{mc}{\hbar}\right)^2 \varphi \qquad (15)$$

This describes the de Broglie waves of celerity $v_B = c^2/v$ through the signal observation of velocity c as stated in Relativity. The mass is the wave source. On the other side, the de Broglie wave equation can simply write

$$\Delta\varphi - \frac{1}{v_B^2}\partial_t^2\varphi = 0 \qquad (16)$$

One can show that this is equivalent to the previous owing to the energy definition. This corresponds to a non-charged particle. For a particle of charge q, it convenes to assume that the additional wave function Ψ is observable with the de Broglie celerity. As for its source, it is enough to substitute the gravitational energy at rest (mc^2) by the charge energy at rest (qU), if U is the potential under which the particle is submitted. One then writes

$$\Delta\Psi - \frac{1}{v_B^2}\partial_t^2\Psi = \left(\frac{qU}{\hbar c}\right)^2 \Psi \qquad (17)$$

As by definition a wave function defines globally a gauge field component, it is obvious that this equation defines the vector mode (relatively to the charge) while that of Klein-Gordon defines the scalar mode (relatively to the mass).

We lastly postulated [10] the Dirac and de Broglie wave equations in relation to the 4-potentials $|\boldsymbol{A}_\parallel\rangle = (\boldsymbol{A}_\parallel, \boldsymbol{iV}_\parallel/\boldsymbol{c}_\parallel)$ and $|\boldsymbol{A}_\perp\rangle = (\boldsymbol{A}_\perp, \boldsymbol{iV}_\perp/\boldsymbol{c}_\perp)$ respectively such as

$$\Box_\alpha \mathbf{1}|A_\alpha\rangle = |S_\alpha\rangle \ ; \ \alpha = \parallel, \perp \qquad (18)$$

with $\Box_\alpha = \Delta - \partial_{t\alpha}^2$ the d'Alembertian operator such as $\partial_{t\alpha} = \partial/(c_\alpha\, \partial t)$; $c_\parallel = c$ and $c_\perp = v_B$; $|s_\alpha\rangle$ expresses the wave sources related to the above equations. The first equation represents the particle scalar mode. The particle vector mode also moves at c if one writes the corresponding equation under the form

$$\left[\frac{1}{v^2}\Delta - \frac{1}{c^2}\frac{\partial^2}{\partial(ct)^2}\right]\mathbf{1}|A_\perp\rangle = \frac{1}{v^2}|S_\perp\rangle \qquad (19)$$

Here, we can see that the coordinate system suitable for such a description is that of $(\boldsymbol{L}, ic^2t)$, where $\boldsymbol{L}$ is the particle kinetic momentum defined for $\boldsymbol{v}.\boldsymbol{r} = 0$, e.g. $\boldsymbol{L} = (0, -mvz, mvy)$ for $\boldsymbol{v}(v, 0,0)$ and $\boldsymbol{r}(0, y, z)$.

In addition, we showed that those equations are valid for four gauge couplings corresponding to four fundamental fields (of long range). Table 3 recalls the different gauge and field expressions of both scalar and vector modes with analogies to the Maxwell electromagnetic theory for the last kind.

Table 3: Gauge and mode field definitions [19]

Mode	*Gauge relation*	*Field expression*
Scalar	$\boldsymbol{\nabla} V_\parallel \pm \partial_t \mathbf{A}_\parallel = \vec{0}$	$\Gamma_\pm = \pm\boldsymbol{\nabla}\mathbf{A}_\parallel + \frac{\partial_{t\parallel} V_\parallel}{c_\parallel}$
Vector	$\boldsymbol{\nabla}\mathbf{A}_\perp \pm \frac{\partial_t V_\perp}{c_\perp^2} = 0$	$\mathbf{E}_\pm = -\boldsymbol{\nabla} V_\perp \mp \partial_t \mathbf{A}_\perp$ $\mathbf{B} = \boldsymbol{\nabla} \times \mathbf{A}_\perp$

The signs indicate two scalar fields (Γ_+, Γ_-) and two electric-like fields $(\mathbf{E}_+, \mathbf{E}_-)$ with a unique magnetic-like field $\mathbf{B}$. Moreover, one remarks that the usual electromagnetic field is defined with a scalar field available even in the vacuum. This additional field is related to the photon dynamic mass while the vector field implies the photon energy. In this work, we defined a scalar field as describing the link energy between vacuum cells.

6.2. Cubic crystal systems from the Helmholtz field quantization

They are presented in Figure 3. The three firsts systems are the Bravais lattices known in crystallography. The last is unknown in our knowledge. In this *cc* system, the sphere peripheries help distinguishing the different ions. One can suppose that others elementary cubic systems correspond to intermediate structures between the fcc system and this, e.g. those of diamond and rock salt. This final structure seems the topmost elementary structure, having to present special properties as quarks and gluons are for matter.

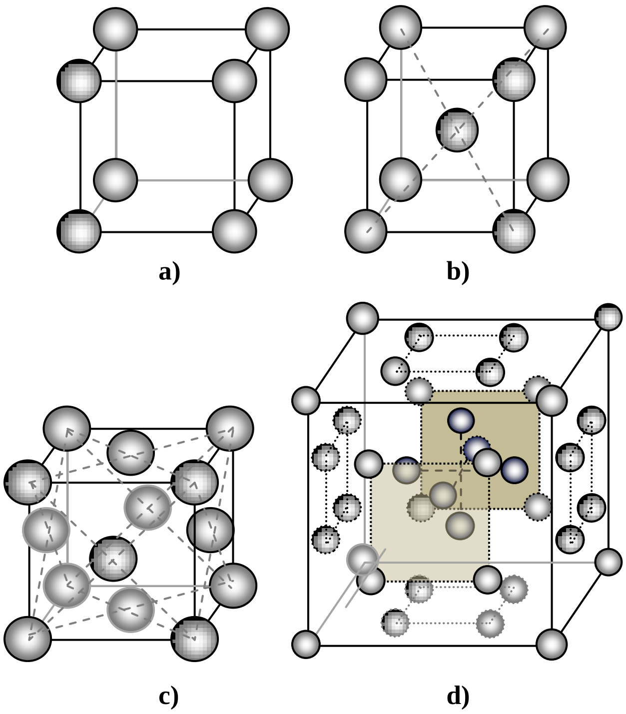


Figure 3: **The four fundamental crystalline cubic systems**: a) the cP system of Polonium; b) the bcc system of Iron-α, c) the fcc system of Copper and d) the mysterious complex-cubic (cc) system

REFERENCES

[1] Michelson, AA & Morley, EW (1887). On the relative motion of the Earth and the Luminiferous Ether. *American Journal of Science* XXXIV (203), 333-345. http://history.aip.org/history/exhibits/gap/PDF/michelson.pdf

[2] Walter, D & Gies, H (2000). Probing the quantum vacuum: perturbative effective action approach. Berlin: Springer.

[3] Focus (1998). The Force of Empty Space. *Phys. Rev*. 2.

[4] Laperashvili, LV, Nielsen, HB & Das, CR (2016). New results at LHC confirming the vacuum stability and Multiple Point Principle. *Int. J. Mod. Phys.* A31, 1650029.

[5] Branchina, VE, Messina & Platania, A. (2014). Top mass determination, Higgs inflation, and vacuum stability. *JHEP* 09, 182.

[6] Letessier J & Rafelski, J (2002). Hadrons and Quark-Gluon Plasma. Cambridge University Press.

[7] Hoi, I-C et al. (2015). Probing the quantum vacuum with an artificial atom in front of a mirror. *Nat. Physics* 11, 1045–1049.

[8] Salvio, A, Strumia, A, Tetradis, N & Urbano, A (2016). On gravitational and thermal corrections to vacuum decay, *JHEP* 09, 054.

[9] Alexander, S, Mbonye, M & Moffat, J (2004). The gravitational instability of the vacuum: insight into the cosmological constant problem. RIT Scholar Works.

[10] Moukala, L.M (2017). The unified energy as vacuum quintessence in wave equations. *Res. J. Phys. Sci*. 5 (3), 1-6.

[11] Bordag, M, Klimchitskaia, GL., Mohideen, U & Mostepanenko, VM (2009). Advances in the Casimir effect. *Physics Today* 63 (8), 50-51.

[12] Mohideen, U & Anushree, R. Precision (1998). Measurement of the Casimir Force from 0.1 to 0.9µm. *Phys. Rev. Let.* 81, 4549.

[13] De la Luz, ADH & Moreno, MAR (2011). Casimir Force Between Two Spatially Dispersive Dielectric Parallel Slabs. *Brazilian J. Phys.* 41(4), 216-222.

[14] Schwinger, J, DeRaad, LL, & Milton, KA (1978). Casimir effect in dielectrics. *Annals of Physics*. 115, 1–23.

[15] Milonni, PW (1994). The Quantum Vacuum. An Introduction to Quantum Electrodynamics. Academic Press, Boston.

[16] R.L. Jaffe (2005). Casimir effect and the quantum vacuum. *Phys. Rev*. D72, 021301.

[17] U. V. AlamSahni & A. A. Starobinsky (2004). The case for dynamical dark energy revisited. *J. Cosmological and Astroparticle Physics* 2004 **(**6), 8.

[18] D. Clowe et al. (2006). A direct empirical proof of the existence of dark matter. *Astrophysical Journal* 648**,** 109-113.

[19] L.-M. Moukala & T. Nsongo (2017). A Maxwell like theory unifying ordinary fields. *Res. J. Engineering Sci.* 6(2), 20-26.