Of rhythm, sound, and metric:
A vierbein representation of fine structure of hydrogen, spinning string metric, and elementary particles from excitation of spacetime

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ABSTRACT. While the idea of unification of gravitation and electromagnetic theories via Kaluza-Klein metric is known for decades, there is known disadvantage that 5th dimension is not yet observed in experiments. In the meantime, there are known experiments suggesting analogy between condensed matter physics and various cosmological phenomena, therefore it seems reasonable to expect to observe this 5th dimension via condensed matter physics. However, only few attempts have been made in this direction. In the present article we argue that it is possible to find neat linkage between Kaluza-Klein metric and condensed matter physics via spinning string metric and Aharonov effect. From this viewpoint, elementary particles could be described from excitation of quantized spacetime. We start with alternative description of fine structure of hydrogen in terms of four-velocity (*vierbein*). An obvious advantage of the alternative interpretation of hydrogen fine structure and spin outlined here is that it could be used to find direct observables, in particular using superfluid experiments. This *vierbein* representation implies that elementary particles could also be described in terms of phonon metric. Some prediction of elementary particles is also discussed, in particular in the context of Meessen's framework. While for known particles our prediction is essentially similar, for new prediction beyond Standard Model the present article suggests that there is 'shifting' of time-component of the modified-Minkowski metric due to Kaluza-Klein effect. Further observation to verify or refute this proposition is recommended. Other viable observation method is also considered, using Cherenkov radiation. In effect, this proposition of describing elementary particles from excitation of phonon metric seems to support the known condensed-matter analogue of chromodynamics theory with gluonic interaction, albeit from different viewpoint.

1 Introduction

The story begins when Nordström started his program to seek unification between electromagnetic and gravitation theory [1]. While his theory was soon replaced by GTR, his proposition of five dimensions became the basis of Kaluza-Klein theory, which then was considered again by Einstein and his colleagues [2][3]. Therefore we could say that in principle his method to unify electromagnetic and gravitation theories using spacetime metric remains appropriate. In recent years, this approach has gained new interests [4][10].

Nonetheless, there is known disadvantage that 5th dimension hypothesized in Kaluza-Klein theory is not yet observed in experiments [1]. In the meantime, there are known experiments suggesting analogy between condensed matter physics and various cosmological phenomena [5][6], therefore it seems reasonable to expect to observe this 5th dimension via condensed matter physics. However, only few attempts have been made in the literature to look for the 5th dimension in this direction, with exception that there is a recent discussion suggesting a plausible analogy between Randall-Sundrum metric and Bose-Einstein condensate [7]. While elementary particle has not been derived yet using this framework, this new possibility seems interesting as complementary alternative to pure geometrical approach [10], at least because its consequences could be observed in experiments. While we know that the notion of 5th dimension is merely the result of human's theoretical model, it seems conceivable to suppose here that a carefully designed observation could detect this 5th dimension, albeit via indirect effects.

In the present article we argue that it is possible to find neat linkage between Kaluza-Klein metric and condensed matter physics via spinning string metric and Aharonov effect in relativistic spacetime. Furthermore elementary particles could be derived from excitation of spacetime quantization. We start with an alternative relativistic quantum wavefunction, where fine structure and electron spin of hydrogen could be given *new interpretation* in terms of four-velocity (*vierbein*). An advantage of the alternative method outlined here is that it could be used to find direct observables, in particular using superfluid experiments. This alternative vierbein representation implies that elementary particles could also be described in terms of *phonon*, which has a physical meaning in the context of superfluidity [6]. In the subsequent section, we extend this vierbein representation to get a spinning string metric, corresponding to the superfluid phonon in cylindrical metric. This phonon's spinning string metric could then be interpreted as extension of Minkowski metric taking into consideration 5th dimension (Kaluza-Klein) effect. This effect could also be given interpretation in the context of Aharonov effect.

Some prediction of elementary particles is also discussed, in particular in the context of Meessen's framework [28]. While for known particles our prediction is essentially similar, for new prediction beyond Standard Model our theory suggests that there is 'shifting' due to Kaluza-Klein effect to Minkowski metric. Further observation to verify or refute this proposition is recommended, in particular using Cherenkov radiation. In effect, this proposition of describing elementary particles from excitation of phonon metric seems to support the known condensed-matter analogue of chromodynamics theory with gluonic interaction, albeit from different approach [34].

Throughout the present article, we argue in favor of *vierbein* representation of the superfluid phonon. To avoid ambiguity, we use Bakhoum's notion $E=m.v^2$, instead of more convenient form $E=m.c_s^2$. This notion would imply [8]:

$$H^2 = p^2.c^2 - m_o{}^2.c^2.v^2 . \tag{1}$$

Therefore, for phonon speed in the limit p→0, we write [9]:

$$E(p) \equiv c_s.|p| . \tag{2}$$

Furthermore, provided all of these correspond to the observed facts, and then it seems to correspond to Winterberg's superfluid Planckian model, suggesting that the subtle medium of subparticle structure and also cosmological phenomena could be described using phonon-roton with Planck mass, m_p [11][12]. This proposition also has similarities with Kaivarianen's bivacuum theory, describing elementary particles in terms of superfluid torus-antitorus [13]. Further research is recommended, for instance to describe the full spectrum of elementary particles [14], and also to explain the known hidden-variable problem in Quantum Mechanics [15]. Other implications of this alternative proposition to gravitation and other cosmological issues remain to be explored.

2 A vierbein representation of fine structure of hydrogen and alternative relativistic wavefunction

It is known that in the literature, fine structure and electronic spin of hydrogen could be derived using various approaches. In this regard, it is worthnoting that Simulik & Krivsky [17] have derived Bohr's quantization rule in hadronic scale using a slightly extended Maxwell electromagnetic theory. However, very few attempts have been made to describe relativistic wavefunction or electronic spin in terms of four-velocity (vierbein) of relativistic continuum [18], except perhaps in [19]. Therefore in the present article we offer an alternative version of relativistic wavefunction for hydrogen based on Cui's method [20][21][22], where the notion of electronic spin could be given a *new interpretation*. This alternative Cui's method has obvious advantage that it does not require multicomponent wavefunction in Dirac equation, while its disadvantage is that physisal meaning of four-velocity is not so clearly defined. Threfore we argue instead to interpret the vierbein in terms of superfluid phonon. An advantage of the proposed method outlined here is that it could be used to find direct observables for the four-velocity (*vierbein*), in particular using superfluid experiments [23][24]. Furthermore, Bohr-Sommerfeld quantization also emerges from *topological* vortice dynamics, which seems to support Simulik & Krivsky's argument [17]. This topological nature of electromagnetic and quantization also seems to support arguments by Post [17a].

In his subsequent article, Bakhoum [8a] argues that the fine structure of hydrogen could be derived directly from the expression of potential energy for a bound electron:

$$\left(\pm v\sum_r \vec{p}_r\left[b_r\right]\right)^2 - \left(-e^2/R\right)^2 = 0\,, \tag{3}$$

by using Dirac's analysis procedure. And because $-e^2/R = -mv^2$ [8a], then equation (3) could be expressed in terms of relativistic four-velocity:

$$\left(\pm v\sum_r \vec{p}_r\left[b_r\right]\right)^2 - \left[-m.(u_m u_m)\left(v/c\right)^2\right]^2 = 0\,. \tag{4}$$

This equation (4) suggests that the fine structure of hydrogen could be derived alternatively from four-velocity of relativistic continuum [18]. Interestingly, Cui [20][21] argues that the motion of particle of an ideal fluid could be represented in terms of the relativistic Newton's law:

$$m.du_m/dt = q.F_{mn}.u_n\,, \tag{5}$$

$$u_m.u_m = -c^2\,, \tag{6}$$

where equation (6) is the relativistic energy-momentum relation *when multiplying it by squared mass*. Note that we use c^2 instead of v^2 in the right hand side of equation (6), in accordance with Bakhoum's argument [8a] that for fine structure analysis, we consider electron in its lowest possible theoretical position, therefore its velocity is c. Therefore term (v/c) in equation (4) becomes 1.

Substituting the following momentum-wavefunction relation by introducing vector potential of electromagnetic field [20]:

$$mu_m = y^{-1}.\left(-i\hbar\partial_m - qA_m\right)y \qquad (7)$$

into equation (6), then we get a new representation of quantum wave function:

$$\left[\left(-i\hbar\partial_m - qA_m\right)y\right].\left[\left(-i\hbar\partial_m - qA_m\right)y\right] = -m^2.c^2.y^2. \qquad (8)$$

A noted characteristic of equation (8) is that the fine structure of hydrogen energy could be calculated directly, without introducing multicomponent wavefunction in Dirac equation [20][21]. However, its disadvantage is that the meaning of assertion in equation (6) is not quite clear, in particular how to find experimental observables of four-velocity. Therefore we will discuss here how this relativistic wavefunction could be improved.

To find observational meaning of equation (6), it is conjectured here that we could introduce a slight modification by using the definition that equation (6) is the relativistic energy-momentum relation *when multiplying it by squared mass*. In other words, we could use instead of equation (6) an alternative assertion proposed by Carter & Langlois sometime ago [23]:

$$m_r.m^r = -c^2.m^2, \qquad (9)$$

by replacing m with the effective mass variable m. This equation has the meaning of cylindrically symmetric superfluid with known metric [23]:

$$g_{rs}.dx^r.dx^s = -c^2.dt^2 + dz^2 + r^2.df^2 + dr^2. \qquad (10)$$

Furthermore, equation (9) could be made similar to equation (6), by dividing with quadratic of the effective mass:

$$m_r.m^r / m^2 = -c^2. \qquad (11)$$

Introducing this term directly to define equation (7), then we get an alternative relativistic wavefunction instead of equation (8):

$$\left[\left(-i\hbar\partial_r - qA_r\right)y\right].\left[\left(-i\hbar\partial^r - qA^r\right)y\right] = -m^2.c^2.y^2. \qquad (12)$$

An interesting characteristic here compared with equation (8), is that in the strong equilibrium conditions, we could define energy, momentum, and angular momentum per particle [23]:

$$k^r.m_r = -E, \qquad (13)$$

$$\ell^r.m_r = L, \qquad (14)$$

$$m^r.m_r = M, \qquad (15)$$

and then we could also write [23]:

$$c^2.m^2 = E^2/c^2 - M^2/r^2 - L^2. \tag{16}$$

Therefore, in this condition, equation (12) could be rewritten for the cylindrically symmetric superfluid as:

$$\left[\left(-i\hbar\partial_r - qA_r\right)y\right].\left[\left(-i\hbar\partial^r - qA^r\right)y\right] = -\left[E^2/c^2 - M^2/r^2 - L^2\right].y^2. \tag{17}$$

Now it seems possible to find out some physical observables, in particular in the context of rotating superfluid experiments.

Further extension of equation (17) is possible, as discussed by Fischer [24], where the *effective mass* variable term also appears in the LHS of velocity equation (6), by defining:

$$p_a = m.u_a. \tag{18}$$

Therefore equation (9) now becomes:

$$m^2.u_a.u^a = -c^2.m^2, \tag{19}$$

where the effective mass variable now acquires the meaning of chemical potential [24]:

$$m = \partial \in /\partial r, \tag{20}$$

and

$$r.p_a/m = \left(K/\hbar^2\right)p_a = j_a, \tag{21}$$

$$K = \hbar^2\left(r/m\right). \tag{22}$$

The quantity K is defined as the stiffness coefficient against variations of the order parameter phase. Now the *sound speed* is related to the equations above, for a barotropic fluid [24], as:

$$c_s = d\left(\ln m\right)/d\left(\ln r\right) = \left(K/\hbar^2\right)d^2 \in /dr^2. \tag{23}$$

Using this definition, then equation (21) could be rewritten as follows:

$$p_a = j_a\left(\hbar^2/K\right) = (j_a/c_s).d^2 \in /dr^2, \tag{24}$$

Introducing this result (24) into equation (12) via our definition (18) and (19) yields:

$$\left[\left(-i\hbar\partial_r - qA_r\right)y\right].\left[\left(-i\hbar\partial^r - qA^r\right)y\right] = -\left((j_a/c_s).d^2 \in /dr^2\right)^2.y^2, \tag{25}$$

which is an alternative expression of relativistic wavefunction (12) in terms of superfluid sound speed, ç. This is the main result of this section. Note that this equation could appear only if we interpret Cui's equation (6) in terms of superfluid four-velocity.

Furthermore, the circulation is in the relativistic dense superfluid, defined as the integral of the momentum [24]:

$$g_s = \oint p_m dx^m = 2p.N_v\hbar \ , \tag{26}$$

and is quantized into multiples of Planck's quantum of action. This equation is the covariant Bohr-Sommerfeld quantization of g_s. It is worthnoting here, because here vortices are defined as elementary objects in the form of stable topological excitations, then equation (26) could be interpreted as signatures of Bohr-Sommerfeld quantization of topological quantized vortices. Fischer [24] also remarks that equation (26) is quite interesting for the study of superfluid rotation in the context of gravitation. Interestingly, application of Bohr-Sommerfeld quantization to celestial systems has been discussed elsewhere [25][26], which suggests that *quantization of celestial systems* actually comes from superfluid quantized-vortices at large-scale.

And then Fischer [24] also argues in favor of an alternative expression for Lorentz force in terms of this *vortodynamics* :

$$(F_{Lorentz})_a = q.F_{am}.\dot{X}^m \ , \tag{27}$$

$$F_{mu} = H_{mub}\,X'^b \ , \tag{28}$$

$$\vec{E} = r_0 \vec{u} x \vec{X}' , \tag{29}$$

$$\vec{B} = \in_{0123} r_0 u^0 \vec{X}' . \tag{30}$$

Then he concludes that the Maxwell equations of ordinary electromagnetism can be cast into the form of conservation equations of relativistic perfect fluid hydrodynamics [18].

From this viewpoint, it seems also possible to derive fermion and also hadrons in terms of *vortodynamics* [19], in particular in the context of superfluid phonon in the same way of relativistic wavefunction for hydrogen (25). The use of sound term to describe elementary particle is not entirely a new idea, however, because there is a discussion of the meaning of '*chords*' in chromodynamics theory [35]. Schwinger also discussed phonon description of nuclei dynamics a decade ago [36], albeit in the context of sonoluminescence phenomena. However, it seems that to describe elementary particles in terms of excitation of the superfluid phonon metric has not been attempted before, and this issue will be discussed subsequently.

3 Distance-energy equivalence in relativistic spacetime. Plausible excitation of quantized spacetime

In order to describe elementary particles in terms of 'excitation' of the spacetime metric, we should clarify first what is the meaning of quantization of the metric, because 'excitation' is not possible without quantization. Therefore, in this section we discuss an alternative route to define distance in relativistic spacetime in terms of energy. This discussion was particularly motivated by further thought on the notion of 'distance' in relativistic spacetime. It is known that the theory of special relativity basically asserts that we could define distance ($\Delta x = \sqrt{x_2^2 - x_1^2}$) in terms of time-elapsed, and *vice versa*. For instance, perhaps we often hear one says something like this to his friend: "Normally, it would take half an hour for me to get home from the school." This implies that distance could be measured in terms of time (Δt) unit, and *vice versa*. Terms 'normally' here would mean that if he/she uses bike then it defines 'average speed' of biking. Similarly, in special relativity we 'normally' use speed of light (c) as a standard rod, where all other velocities are measured.

However, it does not mean that we cannot define distance in terms of other measure. For example, if somebody asks how far is our city to a friend's city, perhaps we could answer: "It would take approximately five gallons of gasoline to go there." This would mean that distance could also be expressed in terms of matter, or by using STR equality $E=m.c^2$, then a distance could always be expressed in terms of energy. However, in this section we argue in favor of Bakhoum's argument to use $E=m.v^2$ instead of $E=m.c^2$ [8], in order to define distance in terms of energy for relativistic spacetime. This notion will be proved useful, because it could naturally reconcile STR and Quantum Mechanics [8].

Another plausible logical reasoning to express distance in terms of energy is as follows: Using Gibbs-Ehrenfest theorem, it is argued that time could be related to entropy flow [37], therefore we could say that time is also another form of energy (entropy). Because in STR distance is equivalent to time, therefore we could also say that distance also has similar energy (entropy) meaning. However, this Gibbs-Ehrenfest argument has disadvantage because it implies that time is irreversible. While this notion could be useful (albeit arguable) to describe time arrow, it seems meaningless to argue that distance is also irreversible. Therefore we don't use this kind of argument in the present article. For further discussion on the meaning of time irreversibility in the light of Quantum Mechanics, see Aharonov [16] and Zurek [38].

To describe plausibility of spacetime quantization from neat linkage between distance-energy in relativistic spacetime, we start with the standard Minkowski metric:

$$ds^2 = dx^2 + dy^2 + dz^2 + (ic)^2 dt^2 \,. \tag{31}$$

Now it seems possible to define distance in terms of energy by using Bakhoum's argument of E=m.v^2, which could be written in the form:

$$\Delta x^2 = E.\Delta t^2 / m \,. \tag{32}$$

Therefore, equation (31) could be rewritten in terms of:

$$dx^2 + dy^2 + dz^2 + (ic)^2 dt^2 = E.\Delta t^2 / m \,. \tag{33}$$

Supposing spacetime is composed of Planckian solid oscillators [39], then energy of spacetime (i.e. vacuum energy [27]) is also quantized according to:

$$E = \hbar v \,. \tag{34}$$

Therefore, inserting (34) into equation (33) yields:

$$dx^2 + dy^2 + dz^2 + (ic)^2 dt^2 = \hbar v.(\Delta t^2 / m) \,, \tag{35}$$

or

$$(m / \Delta t^2).\left[dx^2 + dy^2 + dz^2 + (ic)^2 dt^2\right] = \hbar v \,. \tag{36}$$

which could be interpreted as quantization of spacetime energy. We argue that this result provides rationale for Meeseen's argument that elementary particles could be interpreted as the result of excitation of quantized spacetime [28]. Therefore the following arguments to describe elementary particles are based on this assumption of quantization of spacetime energy.

4 Spinning string metric, and its Kaluza-Klein interpretation

Before we discuss plausible extension of our result in previous section [23]-[30] to describe spinning string metric, it appears useful to reconsider some basic notions in Kaluza-Klein theory.

As mentioned above, it is known that an alternative method to derive a unified representation of gravitation and electromagnetic field is given by Kaluza-Klein metric [29], where:

$$dx_m.dx^m = a^2.(dx_o + b.A_m.dx^m)^2 \,, \tag{37}$$

and

$$dx_m = g_{mn}.dx^n \,. \tag{38}$$

In rotating metric, this expression could be rewritten as [29]:

$$dx_m.dx^m = r^2.(dj + f_m.dx^m)^2 \,. \tag{39}$$

An alternative viewpoint to interpret equation (39) can be obtained by considering that the Aharonov effect involves a charge particle moving outside a region with magnetic flux (f). What interests us here, is that if the flux is confined in a string, and then it can be described as the fivedimensional metric of Kaluza-Klein [30], when the speed of light is assumed in the time-component of the metric:

$$ds^2 = c^2.dt^2 - dz^2 - dr^2 - r^2.d\varphi^2 - (dx^5 + d\varphi.\Phi/2\pi)^2 . \qquad (40)$$

Now this metric is comparable to the four-dimensional metric of a dislocation (normal convention is to write c=1 in the metric):

$$ds^2 = dt^2 - (dz + d\varphi.b/2\pi)^2 - dr^2 - r^2.d\varphi^2 , \qquad (41)$$

where the Burgers vector b represents the same role as the magnetic flux (Φ). Therefore, the Aharonov-type effect should appear for a particle moving in the presence of dislocated medium. This metric seems to imply that Aharonov effect could be used to observe signatures of the fifth dimension, by considering dislocated medium [30] similar to equation (41):

$$ds^2 = dz^2 + dr^2 + \alpha^2.r^2.d\varphi^2 . \qquad (42)$$

Now we return to the metric of cylindrically symmetric superfluid in equation (10). It is known that this metric could be written in terms of line element of cosmic spinning string [31]:

$$ds^2 = (c_s.dt + A.d\varphi)^2 - dr^2 - r^2.d\varphi^2 - dz^2 , \qquad (43)$$

where *sound velocity* is used instead of the speed of light, c. We note that this metric is different from Randall -Sundrum metric discussed in [7].

Comparing equation (43) and (40), we find this equivalence:

$$(c_s.dt + A.d\varphi)^2 = c^2.dt^2 - (dx^5 + d\varphi.\Phi/2\pi)^2 , \qquad (44)$$

which suggests that there exists exact correspondence between Kaluza-Klein metric and spinning string metric of superfluid phonon. An alternative metric to describe spinning string far from vortex ($c_s/c \ll 1$ and negligible) is discussed by Volovik in [6]:

$$ds^2 = (dt + d\varphi/\omega)^2 - (dr^2 + r^2.d\varphi^2 + dz^2)/c_s , \qquad (45)$$

where characteristic angular velocity is given by [6]:

$$\omega = 2\pi.c_s/\kappa . \qquad (46)$$

It is argued that in gravitational setting, this characteristic angular velocity could be related to gravitational constant G by [6]:

$$\omega = 1/4GJ . \qquad (47)$$

It is very interesting here to note, that equation (45) and (46) could be interpreted that far from vortex center, there is small ‘shifting’ of the time component of Minkowski rotating metric by:

$$t' = t + \kappa\varphi/(2\pi.c_s) , \qquad (48)$$

so we could rewrite (45):

$$ds^2 = (dt')^2 - (dr^2 + r^2.dj^2 + dz^2)/c_s . \qquad (49)$$

This result will be proved useful in our prediction of elementary particles from excitation of quantized spacetime. Of course, this result could be different if we assume metric near the vortex center [6], however its effect will not be discussed here.

5 Elementary particles from excitation of quantized spacetime. Going beyond Standard Model

As discussed in the foregoing section, it appears reasonable to suppose that spacetime energy is quantized. In order to derive elementary particles from this viewpoint using Meessen's approach [28], we should first derive Klein-Gordon equation. However, here we will not use the same form of Klein-Gordon equation in Meesen [28], but instead we will derive it from Bakhoum's notion [8], which is more consistent with phonon metric (49), because phonon speed is not the same with the speed of light \[31].

So we start by writing again equation (1):

$$H^2 = p^2.c^2 - m_o{}^2.c^2.v^2 . \qquad (1)$$

By introducing a new parameter:

$$z = i(v/c) , \qquad (50)$$

then we can rewrite equation (1) in the known procedure of Klein-Gordon equation:

$$E^2 = p^2.c^2 + z^2 m_o{}^2.c^4 , \qquad (1a)$$

where E=mv^2. [8]

By using known substitution [32]:

$$E = i\hbar.\partial/\partial t , \quad p = \hbar\nabla/i , \qquad (51)$$

and dividing by $(\hbar c)^2$, we get:

$$-c^{-2}.\partial\Psi/\partial t + \nabla^2\Psi = k_o'^2.\Psi , \qquad (52)$$

where

$$k_o' = zm_o c/\hbar . \qquad (53)$$

For simplicity, we will use here Meessen's notation for (52):

$$\partial_x{}^2\Psi - \partial_{ct}{}^2\Psi = k_o'^2.\Psi . \qquad (54)$$

The only distinction here is that Meessen assumes dx=n.a where n is integer number and a→0, while we suppose quantization of spacetime as represented in equation (36). However, its implications are similar. Thus,

$$dx = n.a' , \qquad n = 0, \pm 1, \pm 2, \ldots \text{ or } n = 0, \pm 1/2, \pm 3/2, \ldots \tag{55}$$

where in accordance with equation (36), we could define :

$$a' = \sqrt{\hbar v.\Delta t^2 / m} , \qquad a' \rightarrow 0 \tag{55a}$$

The subsequent analysis follows Meessen's argument [28], which in principle seems to correspond with statistical interpretation of Klein-Gordon equation [33], instead of electromagnetic interpretation. By assuming for normal lattice:

$$y = A.e^{ikx} , \tag{56}$$

and for the inserted lattice:

$$y = U_x.A.e^{ikx} , \tag{57}$$

then

$$U = e^{i.u_x.p} = \pm 1 , \qquad \text{and } u_x = 0, \pm 1, \pm 2, \ldots \tag{58}$$

Here the new quantum number, u_x, defines an internal degree of freedom, while k defines external degree of freedom. Similar U-factors and u-quantum number can be introduced to all spacetime coordinate (x, y, z, ict). Particle states are now defined by sets of (u_x, u_y, u_z, u_{ct}) quantum number with integer values.

Using these assumptions, and for u_{ct}=0, it is sufficient to consider the triplet (u_x, u_y, u_z) to define different fermion states, while the electric charge (in units e) is defined by [28]:

$$Q = (u_x + u_y + u_z)/3 \tag{59}$$

Now when we consider u_{ct}=0, $\pm$1 with the same possibilites (u_x, u_y, u_z), then we get three families of quarks and leptons. As a result, there are new possibilities to find new particles, corresponding to u_{ct}. See Figure 2 below.

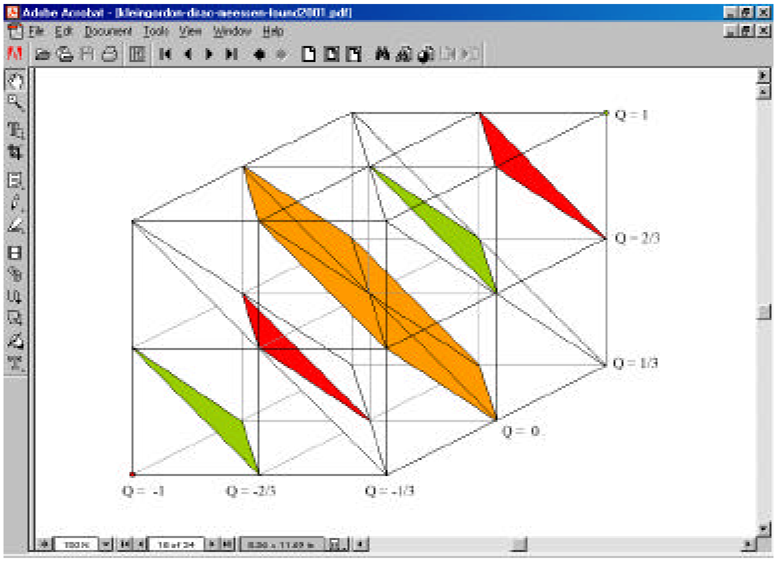

Figure 2. An extension to standard model, applying to fermion and boson (after Meessen [28]), without time-component ‘shifting’.

However, in this article, as we have derived before, there should be small ‘shifting’ due to spinning string metric effect to time component of Minkowski metric (48). It is recommended therefore to find this time-shifting effect in the future particle observation. We argue here that this ‘time-shifting’ will not affect the known particles in Standard Model, but only new unobserved elementary particles corresponding to $u_t=0, \pm 1$.

Provided this time-component shifting could be observed in particle colliders, and then this effect could be interpreted as verification of our alternative elementary particle decription based on excitation of superfluid phonon metric, which resembles Kaluza-Klein rotating metric. Furhermore, provided this proposition of time-shifting effect corresponds to the observed facts, then it could also be used to argue in favor of observation of 5th dimension in Kaluza-Klein metric, which so far lacks experimental support. Of course, there is always ongoing debate on which Kaluza-Klein metric is more proper to describe elementary particles, because it has been argued that elementary particles could be derived using 6D Kaluza-Klein [14].

In the subsequent section we discuss another plausible way to detect the effect of superfluid phonon metric by observing Cherenkov radiation emitted due to friction between elementary partides and their surrounding superfluid medium.

6 Superfluid phonon and Cherenkov radiation

As described above, it seems possible to describe elementary particles, at least in principle by using of conjecture of excitation of superfluid phonon spacetime. This notion corresponds to superfluid vortodynamics, where new expressions of electromagnetic equations could be rewritten (26-30). Therefore, we argue here that perhaps this superfluid vortodynamics interpretation is more consistent with what Maxwell himself envisaged [12]:

> "The aether, if it is the medium of electromagnetic phenomena, is probably molecular in the sense of Sir W. Thomson's hypothesis of vortex – molecules in a *perfect fluid*. Sir W. Thomson has shown that the magnetic influence on light discovered by Faraday depends on the direction of motion of moving particles, and that it indicates a rotational motion in the medium when magnetized…"

The subsequent development of electromagnetic theories based on Lorentz theory and special theory of relativity could be seen as attempt to avoid the difficulties to define a formal definition of the basic structure of spacetime. Now, with the notion of superfluid vortodynamics above, it seems that Maxwell was right with his far-reaching intuition of "molecules in a *perfect fluid*."

Of course, by arguing in favor of superfluid vortodynamics, it does not mean that we have reached an ultimate description of reality (or electromagnetic phenomena), because there is always philosophical 'distance' for it is known that mathematics language used by scientists is only an abstraction of reality, i.e it is merely '*Geisteswissenschaft*' instead of '*Naturwissenschaft*' [40].

In principle, the basic concept of superfluid vortodynamics (26)-(30) seems also to correspond to Winterberg's Planckian phonon-roton model [11][12]. In Winterberg's model, the Planckian superfluid aether consists of a lattice vortice made up of an equal set of elementary positive and negative Planck masses (m_p), the size of a Planck length, and with zero gravitational effect, where m_p is defined as:

$$m_p = \sqrt{\hbar c / G} \tag{60}$$

In each superfluid vortices can form with circulation quantized according to $\oint v_{+-}.dx = n\hbar / m_p$. This condition implies the Helmholtz vortex theorem, $d/dt\oint v_{+-}.dx = 0$. While it seems not possible to observe directly the 'excitation' spacetime Planckian phonon-roton, interestingly there is article suggesting that new entities having multiple integer of Planck mass have been detected experimentally [41]:

$$m_{Volkamer} = n.\sqrt{\hbar c/G} \quad \text{n=1,2,3,…} \tag{61}$$

Provided this kind of observation corresponds to the facts, and then it seems to support Winterberg's idea of Planckian phonon-roton as the basis of vacuum (spacetime).

Another plausible method to observe this effect is perhaps using Cherenkov radiation phenomena. This method could be useful in particular in the context of elementary particles, because quarks bring electrical charges, therefore the analogy to measurements of refractive index in a classical electromagnetic medium is worth reconsidering [42]. While this Cherenkov radiation has been proposed in the context of quark-gluon plasma (QGP) which is thus far unobserved, we suggest that it is perhaps more plausible to expect to observe Cherenkov radiation of phonon.

Along this line of thought, a possible observation is to find radiation of neutrino as they pass through a medium, as discussed by some authors elsewhere. It is argued that neutrino acquires an induced charge as they propagate through a medium, and therefore they can emit Cherenkov radiation. However, this kind of argument was conventionally assumes photon-based interaction, while our superfluid phonon metric implies phonon interaction instead.

An introduction to this issue has been described by Volovik [43], suggesting there could be radiation due to friction in superfluid rotating frame, albeit his description is not Cherenkov type. This phonon energy spectrum in the rotating frame is [43]:

$$E = c_s\sqrt{L^2/r^2 + p_z + p_r} - \Omega L \tag{62}$$

which is somewhat different from equation (2).

Alternatively, by assuming that the spacetime is composed of superfluid phonon, then elementary particles could emit sound radiation corresponding to Bose gas [44]. It is argued that the friction energy produces the drag force, which acts on the particle from its created field. This results in energy decrease of the particle in question:

$$\dot{E} = Fv = -2bv.\mathrm{Re}\left[dy\ /dR\right]_{r=vt} \tag{63}$$

Therefore, for certain time difference, we could write the phonon energy spectrum in superfluid rotating metric with energy decrease due to Cherenkov effect [44] as:

$$E = c_s\sqrt{L^2/r^2 + p_z + p_r} - \Omega L - 2bv.\Delta t.\mathrm{Re}\left[dy\ /dR\right]_{r=vt} \qquad (64)$$

7 Concluding remarks

In the present article, we derive an alternative description of hydrogen fine structure from vierbein. Furthermore, we argue based on phonon metric vierbein that the spacetime energy is quantized and therefore it is likely that elementary particles could be described in this way. Some predictions have been made in order to falsify the propositions outlined herein, including time-component shifting in the elementary particles beyond Standard Model. It is highly recommended therefore, to find new data corresponding to this prediction. Provided this time-component shifting could be observed in particle colliders, and then this effect could be interpreted as verification of our particle model based on excitation of superfluid phonon metric.

In effect, this proposition of describing elementary particles from excitation of spacetime seems to support the known condensed-matter analogue of chromodynamics theory with gluonic interaction, albeit from different approach.

Further research is recommended, for instance to describe the full spectrum and also mass of known elementary particles [14], and also to explain the known hidden-variable problem in Quantum Mechanics [15]. Other implications to gravitation and other cosmological issues remain to be explored.

After all, the present article was not intended to rule out the existing methods in the literature to describe elementary particles, but instead to argue that perhaps there is coherent way to describe these hadrons and leptons provided we suppose quantization of phonon metric.

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