QUANTUM VACUUM CHARGE

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The quantum vacuum can be modeled as if it has bound charge in addition to spectral energy density. This bound charge has a "cell" charge value that is $\pm\sqrt{\hbar c}$. We call this "cell" a zerton. And the zerton is possibly a representation of all fermionic charge mixed together. This scheme is realized via new concepts of zertons and a spin matrix of coupled oscillators. The quantum vacuum consists of a system of coupled and uncoupled oscillators. The coupled oscillators produce regular electromagnetic fields and the uncoupled oscillators are responsible for the spectral energy density of the vacuum. The coupled oscillators are fluctuating about a mean frequency so the true spectral energy density of the vacuum should be peaked up at the spots of allowed energy resonances. The true configuration of the spin matrix is established at an equilibrium state. We have a discrete energy spectrum in our model. Corresponding hexagonal diagrams clearly trigger a set of certain particles and resonances, starting from the electron with mass of 0.511 MeV/c^2.

The electromagnetic properties of electromagnetic radiation come from the bound charge of the vacuum, not from photons. The photon does not have charge, so it cannot have electromagnetic properties directly. The quantum objects that comprise vacuum charge are what are actually doing the "waving" in an electromagnetic wave. Vacuum inductance and capacitance have been derived and properly related to vacuum charge. Vacuum capacitance, C_{vac} is representative of the actual physical length of the **E** field vector for electromagnetic radiation**.** We deduce energy density volume, connected with each photon.

1. Introduction

We can study quantum field theory (QFT) and especially quantum electrodynamics (QED) to find out that QED has made some really accurate predictions that are verified by experiment. Such as the magnetic moment anomaly for the electron, explanation of Lamb shift, the hydrogen atom, and antiparticles. We also learn that the vacuum is polarized in the vicinity of charged fermions with virtual pairs coming into and out of existence. This leads us to believe that the quantum vacuum is not an empty space devoid of action. The quantum vacuum definitely seems to be a dielectric medium screening charge. Simply take the case of free space electromagnetic (EM) radiation fields. What is going on here? When the free space EM fields are quantized, we seem to have the result that Planck's constant $\hbar$ must be due to a quantum vacuum process. Now we already know that the speed of light c is due to a vacuum process so if we combine the two constants we end up with $\hbar c$. In the case of free space EM fields, this should represent a vacuum process of some sort. Dimensional analysis shows us that this expression is simply charge squared. Charge from what though?

We can see from the expression for the fine structure constant that,

$$\alpha = \frac{e^2}{\hbar c} \rightarrow \sqrt{\alpha} = \pm\frac{e}{\sqrt{\hbar c}}. \qquad (1)$$

What is $\sqrt{\hbar c}$? We postulate that it has to be vacuum charge. Of course we have in mind, the virtual pairs from vacuum polarization. The virtual pairs seem to represent a vacuum process of momentary charge separation. Is this the source of $\sqrt{\hbar c}$? We think it is more complex than just that since the $\sqrt{\hbar c}$ has a value of approximately 11.706e with e being the value of a positron's electric charge observed from a distance. We suspect that vacuum charge would have to be a mix of all possible fermionic charge. And it is quite possibly more than just electric charge. We can see in natural units of $\hbar = c = 1$, that vacuum charge is ± 1, a perfect relativistic quantum unit.

Even the classical form of Maxwell's equations allow for such an interpretation for the vacuum to consist of bound charge. In the vacuum in the absence of free charge or free currents, the vacuum is polarized by electromagnetic (EM) radiation and is frequency dependent. In fact, EM radiation seems to be simply just polarization of vacuum bound charge. We also know from QED that the vacuum is polarized in the presence of free charge. The obvious solution to both is that the vacuum does consist of bound charge with cells equal to $\pm\sqrt{\hbar c}$. We dub these cells as "zertons" for macroscopically they appear to have net zero spin, charge and are massless.

2. Semi-Classical Confirmations of Vacuum Charge

We can use some known relationships from classical electrodynamics theory and combine them with a relationship from quantum theory to confirm the existence of vacuum electric charge. If vacuum electric charge exists, then vacuum capacitance and inductance must exist also. At this point we postulate that $\pm\sqrt{\hbar c}$ is vacuum charge and it exists as a real physical process. Formally, capacitance is defined as the constant of proportionality of the ratio of charge per volts [1]. In a similar way, inductance can be defined as the constant of proportionality of magnetic flux per current. We will take a heuristic, dimensional analysis approach to show that free space EM radiation can be modeled using vacuum charge. We start with the expression relating angular frequency to capacitance and inductance, plus the relationship of angular frequency to the wavelength for electromagnetic radiation [2],

$$\omega = \frac{1}{\sqrt{LC}} \text{ and,} \tag{2}$$

$$\omega = \frac{2\pi c}{\lambda_\omega}. \tag{3}$$

Then combining we obtain,

$$LC = \frac{{\lambda_\omega}^2}{(2\pi)^2 c^2} = \frac{\lambda_\omega}{2\pi c^2}\frac{\lambda_\omega}{2\pi}. \tag{4}$$

In gaussian units, capacitance is equal to length, so given that, then we claim that vacuum inductance and vacuum capacitance in the case of free space electromagnetic radiation are,

$$L_{vac} = \frac{\lambda_\omega}{2\pi c^2}\text{, and } C_{vac} = \frac{\lambda_\omega}{2\pi}. \tag{5}$$

Which we can see in the case of units of $\hbar = c = 1$ reduces to,

$$L_{vac} = C_{vac} = \frac{\lambda_\omega}{2\pi}. \tag*{6)}$$

Now that we have derived vacuum inductance and capacitance we can show by substitution using equation (3) that,

$$q_{vac} = \pm\sqrt{\hbar c n} = \pm\sqrt{\frac{\hbar\omega n\lambda_\omega}{2\pi}} \text{ in CGS units.} \tag{7}$$

With n being an integer number of photons. Then by substitution using the right expression in equation (5),

$$q_{vac} = \pm\sqrt{\frac{\hbar\omega n\lambda_\omega}{2\pi}} = \pm\sqrt{\hbar\omega n C_{vac}} = \pm C_{vac}\sqrt{\frac{\hbar\omega n}{C_{vac}}}. \tag{8}$$

Capacitance is defined as charge per volt, so the following expression must be true [3],

$$V_{vac} = \pm\sqrt{\frac{\hbar\omega n}{C_{vac}}}. \tag{9}$$

We can express equation (9) as,

$$\frac{C_{vac}V_{vac}^2}{2} = \frac{\hbar\omega n}{2}. \tag{10}$$

Which we can see that the left hand side is the familiar expression for the energy of capacitance and the right hand side is one half a photon's energy when n = 1. Now for the other half of the photon's energy, we take a different approach and by appropriate substitutions,

$$q_{vac} = \pm\sqrt{\frac{\hbar c^2 n}{c}} = \pm\sqrt{\frac{2\pi\hbar c^2 n}{\omega\lambda_\omega}} = \pm\sqrt{\frac{\hbar\omega n}{\omega^2 L_{vac}}} = \pm\frac{1}{\omega}\sqrt{\frac{\hbar\omega n}{L_{vac}}}. \tag{11}$$

Current is defined as charge per time and taking angular frequency, ω, as being 1/time, so then the following expression must also be true for vacuum current based on vacuum charge,

$$I_{vac} = \pm\sqrt{\frac{\hbar\omega n}{L_{vac}}}. \tag{12}$$

And we can rearrange the expression as,

$$\frac{L_{vac}I_{vac}^2}{2} = \frac{\hbar\omega n}{2}. \tag{13}$$

We can see the expression on the left is the familiar expression for the energy of inductance and the expression on the right is one half the photon's energy when n = 1. So adding equations (10) and (13) together we obtain the full energy of a photon when n = 1.

$$\frac{C_{vac}V_{vac}^2}{2}+\frac{L_{vac}I_{vac}^2}{2}=\frac{1}{2}\int d^3r\left(\mathbf{E}^2+\mathbf{B}^2\right)=\hbar\omega n\ . \tag{14}$$

This seems a bit odd at first, but it is really showing us that the energy of a photon is definitely related to vacuum electromagnetic properties. A photon does not have intrinsic electromagnetic properties. So how does a bunch of photons make electromagnetic fields? They do it by exciting vacuum charge "cells". The electromagnetic properties of electromagnetic radiation come from the bound charge of the vacuum, not from the photons. Even QED has photons being created from the vacuum state for electromagnetic fields. But the funny thing is that the photon only ends up with properties of momentum and a spin of one. It does not have charge, so it cannot have intrinsic electromagnetic properties. We do know that light waves have electromagnetic properties. So it must be vacuum charge that is actually doing the *waving*.

We can also take the expression from equation (3) for the relationship of EM radiation frequency to wavelength and multiply both sides by Planck's constant to obtain,

$$\hbar\omega=\frac{2\pi\hbar c}{\lambda_\omega}\ . \tag{15}$$

Which shows us that the energy of a photon with frequency ω is vacuum charge squared divided by the rationalized wavelength, which we know by now, can be expressed as vacuum capacitance. We seem to have a problem here for a quantum of EM radiation that has long wavelengths. For a single low energy photon, this implies that many zerton cells would have to be involved. We will discuss this in the next section.

3. Electromagnetic Radiation Energy Density Volume

We can use equations (9) and (12) to express photon energy in the more traditional electric and magnetic field representation,

$$V_{vac}=\pm\sqrt{\frac{\hbar\omega n}{C_{vac}}}=\pm\sqrt{\frac{2\pi\hbar\omega n}{\lambda_\omega}}\ \text{, and} \tag{16}$$

$$I_{vac}=\pm\sqrt{\frac{\hbar\omega n}{L_{vac}}}=\pm\sqrt{\frac{2\pi\hbar\omega c^2 n}{\lambda_\omega}}\ , \tag{17}$$

Then setting the electric field per one wavelength [3],

$$E_0=\pm\sqrt{\frac{2\pi\hbar\omega n}{\lambda_\omega}}\frac{1}{\lambda_\omega}=\pm\sqrt{\frac{2\pi\hbar\omega n}{\lambda_\omega{}^3}}\ , \tag{18}$$

and since by the Biot-Savart law and in the plane wave case, the magnetic field is current divided by the speed of light per wavelength then [1],

$$B_0=\pm\frac{1}{c}\sqrt{\frac{2\pi\hbar\omega c^2 n}{\lambda_\omega}}\frac{1}{\lambda_\omega}=\pm\sqrt{\frac{2\pi\hbar\omega n}{\lambda_\omega{}^3}}\ . \tag{19}$$

Which gives us the magnitudes of the electric and magnetic field vectors for a free space quantum of electromagnetic radiation. Inserting these into the energy density equation obtains,

$$u_{em}=\frac{1}{8\pi}\left(E^2+B^2\right)=\frac{1}{4\pi}\frac{2\pi\hbar\omega n}{\lambda_\omega{}^3}\ . \tag{20}$$

However, we assert that equation (20) is not correct in the case of a single free space photon. In the case of a single photon, there is an extra 4π involved and the energy density for a single photon should be,

$$u_{em}=\frac{4\pi}{4\pi}\frac{2\pi\hbar\omega}{\lambda_\omega{}^3}=\frac{2\pi\hbar\omega}{\lambda_\omega{}^3}\ . \tag{21}$$

Here is why. We can see from our electric and magnetic field expressions that we have the square root of energy per volume. Wavelength as a function of frequency cubed divided by 2π should be the volume of the energy density. We also surmise that vacuum capacitance is representative of the physical length of the **E** and **B** vectors. Taking this to be the radius and along with the ED volume, we would surmise that the ED volume is two wavelengths long of a cylinder-like object. The circumference of the cylinder is one wavelength around.

$$\frac{\lambda^3}{2\pi} = \pi\left(\frac{\lambda}{2\pi}\right)^2 2\lambda \tag{22}$$

We can easily see that the above equation for the volume of a cylinder fits our description. Now we will justify the additional 4π that we needed in equation (21). We know from the Poynting vector relationship that an energy, $u_{em} A c \Delta t$, flowing through an area A, in a time Δt would be equal to $\hbar\omega$ [1]. So we know the energy, area and time, let's solve for energy density, u_{em}.

$$\hbar\omega = u_{em} A c \Delta t = u_{em} \frac{\lambda_\omega{}^2}{4\pi} c \frac{2\lambda_\omega}{c} \tag{23}$$

$$u_{em} = \frac{\hbar\omega 2\pi}{\lambda_\omega{}^3} \tag{24}$$

We can see from the last expression above that it only can be resolved for this volume if energy density is equal to E^2 instead of $E^2/4\pi$ for a quantum of EM energy.

We know that photons have spin of 1, so if our object is two wavelengths long, this will give it a 4π rotation. The **E** and **B** fields are twisted around twice, which is consistent with circularly polarized EM radiation. The classical EM energy equation (20) does not take spin into account on an individual photon basis. Equation (20) does take spin into account for a large collection of photons because a large collection of randomly polarized photons would have their collective spin cancelled out. So this is why we need the additional 4π for equation (21). This cylinder description seems to work well for helical radio wave antennae also where the circumference of the helix is set to match the wavelength of the radio waves being transmitted or received [4]. This would tend to make us think that the energy might be higher in value toward the surface of the cylinder. Well, that makes some sense, as that is where the **E** and **B** fields reach their maximum value relative to the antennae.

It is quite astounding that we can obtain an energy density volume for a single photon. This doesn't seem to make sense. But if we take the quantum mechanical interpretation, it would just mean that we would have a probability of one to find the photon somewhere in that volume. A more classical interpretation is that the energy is spread out evenly throughout the volume but we can see that there might be more energy out toward the surface of the cylinder than there is closer to the center. In our analysis here, we can see that the only adjustment needed between classical and quantum theories of free space EM radiation is 4π relating to spin. A prediction of our theory is that photon energy density volume for radio waves could be as big as a house or bigger! But our theory does not have a problem with that as we can see that a radio wave photon would necessarily have to involve many vacuum charge cells. This also indicates that something is not quite right with quantum mechanics if a single photon can be described by more than one quantum object. De Broglie originally thought that photons might be composite particles of two electron-like entities [5]. This shows that photons are possibly composites of many entities. So in a way he was right about them being composites.

So how do we know the number of vacuum charge cells involved with a low energy photon? We think an approximation would be,

$$\hbar\omega = \frac{\hbar c}{x_{vc} n_{vc}}. \tag{25}$$

With x_{vc} being a length associated with vacuum charge and n_{vc} being the number of zerton cells associated with the energy. We would guess that x_{vc} is the rationalized electron Compton wavelength so that equation (25) becomes,

$$n_{vc} = \frac{m_e c^2}{\hbar\omega}. \tag{26}$$

This is a simplistic viewpoint because in reality each zerton cell is responding to the photon's energy in a different way and a full treatment is going to be complex. However, what happens when a quantum of EM radiation's wavelength gets smaller than the size of a vacuum charge cell? And what is this size? This means there has to be a natural free space boundary condition happening. There should be a difference between soft photons and hard photons. Well, one difference is that hard photons can create real particles from the vacuum. Soft photons could only do this if you could get the electric field strength high enough by combining quite a lot of them [6]. *And, in fact, THIS has been done at the SLAC E144 experiment* [7].

A common argument is that a photon's wavelength is a representation of the probability wave for a photon so it doesn't represent the same thing classically. It is fairly common knowledge that the probability wave pattern in quantum theory for even a single photon is the same as the wave pattern in classical theory [8]. The difference being that the probability of detecting a photon is higher where the field strength squared is higher in absolute value. We see no problems with this in our semi-classical model.

4. Quantum Mechanical Descriptions of Vacuum Charge

When reviewing other coupling constants besides the fine structure constant, and having them in CGS units, we can see that $\hbar c$ is involved in all of them [9]. The Fermi coupling constant is usually expressed as [9],

$$G_F = \frac{\sqrt{2}}{8}\left(\frac{g_w}{M_W c^2}\right)^2 (\hbar c)^3 \cong 8.96\times10^{-44}\,\mathrm{MeV\,cm^3} \quad (27)$$

Where g_w is the weak coupling constant and M_W is the W boson mass. So we can see that vacuum charge would be involved to the sixth power in weak interactions. The strong coupling constant is defined as [9],

$$g_s = \frac{2\sqrt{4\pi}q}{\sqrt{\hbar c}}. \quad (28)$$

Where q is "strong charge". So again we see that vacuum charge is also involved in strong interactions. However, the strong coupling constant varies greatly with interaction energy. We would have to attribute this to q varying as $\hbar c$ is taken to be invariant. In fact, all the couplings vary and the common factor of $\sqrt{\hbar c}$ is the constant between them all. It has been common practice in particle physics to set $\hbar$ = c = 1 for many years as these constants show up all over the place in many calculations and for most calculations setting the quantum vacuum equal to one does not matter since it is a perfect relativistic quantum medium that equals one in natural units.

We can also investigate the Dirac Lagrangian for a spinor field, ψ [9],

$$\mathcal{L} = i(\hbar c)\bar{\psi}\gamma^{\mu}\partial_{\mu}\psi - (mc^2)\bar{\psi}\psi. \quad (29)$$

Which can also be expressed as,

$$\mathcal{L} = (\hbar c)[i\bar{\psi}\gamma^{\mu}\partial_{\mu}\psi - \left(\frac{2\pi}{\lambda_m}\right)\bar{\psi}\psi]. \quad (30)$$

Where λ_m is a Compton wavelength associated with the mass, m. The expression in the brackets, [], is simply a four dimensional volume in relation to $\hbar c$, so we are wondering about extra length dimensions here? But again, we can see that vacuum charge is involved in the definition of a spinor field. In fact, one can simply split $\hbar c$ and insert whatever coupling constant might be appropriate for $\sqrt{\hbar c}$ and we can see that the Lagrangian for a spinor field is an interaction between vacuum charge and whatever we are interested in per a 4D volume. In our evaluation of the quantum vacuum as a medium, there really are just spinor fields and other fields should be just combinations of them.

Naturally this leads to the question what would the Lagrangian be for a vacuum charge cell? Since we think that a cell would be comprised of a mix of all charged fermions, this Lagrangian would be quite complex. Plus we think there are undiscovered particles (resonances) involved so the task of specifying a Lagrangian for a cell is at this point not feasible. But you can believe that we will be working on it.

5. General Discussion

A zerton (vacuum charge cell) is possibly a mix of all known charged fermions. Possibly one of each fermion. If we add up all known positively charged fermion's charges, we get 12e with e being the charge of a positron observed from a distance. When we calculate the value of $\sqrt{\hbar c}$ we get ~11.706e. These values are very close and it makes us wonder what the mix would be to obtain this value. We can imagine that screening and/or anti-screening effects might be involved here is why we don't get exactly 12e. But later on we will see that the mix is possibly not one for one. Vacuum charge also seems to govern more than just electromagnetic charge. It seems like it is involved in strong and weak charge also as it shows up in the coupling constants for all three forces [9]. Plus if the EM properties associated with photons come from vacuum charge, this should mean that photons might really be a mix of all forces to some extent. Or vacuum charge is the relationship between all gauge bosons.

Something else that QFT predicts is the possible existence of composite particles that have zero mass, spin, and charge [9]. However, it looks somewhat like a fictitious particle since it is basically "zero everything" so it is understandable why it might be ignored. But we know from past experience that net zero does not necessarily mean there is nothing there.

Now a question would be, what are the characteristics of the zerton? First we have to set a scenario that is like a Dirac sea for the vacuum. However, this sea would have to be a more "balanced" Dirac-like sea where we have to realize that negative energy states are more like opposite states due to CP conjugation. That is; a negative energy state is opposite from a positive energy state like left and right are opposites of each other or positive and negative charge are opposites of each other. In other words, all *possible* energy states are full and an electron would be a hole in the sea as well as a positron would have to be a complementary hole in the sea. What happens when an electron and positron come together is the two complementary holes restore the vacuum equilibrium perfectly. This could only work if the zerton *cells* are a network of coupled oscillators that fill the entire Universe. Therefore, zertons are not free particles but are part of a *spin matrix* of coupled oscillators. It is the geometrical configuration of these coupled vacuum oscillators that determine the *possible* energy states. There is not an infinite number of energy states possible in the *vacuum sea* for *charged* fermions.

6. The Spin Matrix of the Quantum Vacuum

We present a naive model of the quantum vacuum that we call the spin matrix. We have to imagine that all resonances in this spin matrix are produced by the same basic entity. The fundamental structure of this matrix is hexagonal although it is easy to imagine other possible geometric configurations. The basic premise is this; that the Universe is composed of quite a large number of basic fundamental entities that are very small. We consider these entities to be massless or of a very very tiny mass. We won't try to conjecture as to what these entities are. Maybe string theory or some other theory could have an answer as to what they are. Also these fundamental entities are neutral as far as any charge properties go. A big consideration is how do these tiny entities interact. Do they simply bounce off of each other? Or is there a more complex interaction scheme?

We suspect that since these entities are most likely massless and if they were released from a compacted state with a great force, that they would probably bounce off one another but eventually form a stable geometric linked system throughout the entire Universe that is extremely uniform. The quantum vacuum consists of coupled oscillators as opposed to only uncoupled oscillators. However, there still could be a combination of coupled and uncoupled oscillators. We think all the properties of the Universe are emergent from this idea of the quantum vacuum.

Why don't we notice this? Well, in many ways we do. Particle pairs are created from the quantum vacuum all the time now in high-energy accelerator experiments by just adding the appropriate energy to it. Quanta of EM radiation would be somewhat like phonons only they don't disperse. It is a matter of interpretation. But there are still problems with having the vacuum in our space be some kind of medium. We suspect that there is an *inner* space that this spin matrix *lives* in [5, 14]. The only link from our space-time is through the very small domain of quantum objects [5, 14].

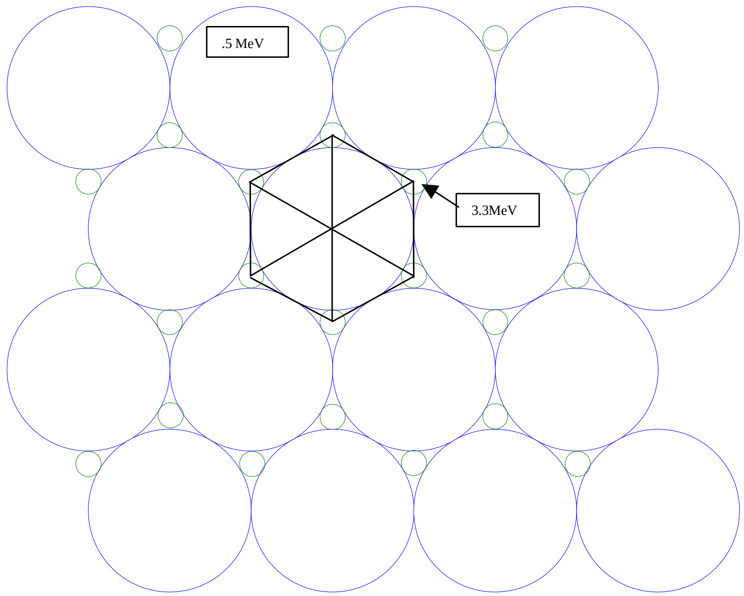

Fig. 1. Hexagonal configuration of a two dimensional slice through the Spin Matrix. If we take the larger areas to be 0.511 MeV, then the smaller areas shown, geometrically come out to be ~ 3.3 MeV.

Figure 1 shows a possible hexagonal configuration of the Spin Matrix. We can see that this produces areas that are "isolated" from each other in the space where the 3.3 MeV resonances form and this immediately brings to mind regions where the "weak" and "strong" interactions operate. And that higher energy resonances can form in the smaller spaces. What is not shown here are that these areas are *coupled* together by magnetic-like links perpendicular to the page. In other words, this is really a duality possibly involving extra dimensions or another space. The hexagon outlined in Fig. 1 would be a "cell" of the Spin Matrix, as that would tile all of the area of this slice. Now we can see that the electromagnetic interaction is not isolated and this can explain its "infinite" range. Whereas the smaller areas, being isolated from each other, have interactions that are limited in range. It looks like there is the possibility of *tunneling* between the isolated regions though. Could this be the source of the weak interaction?

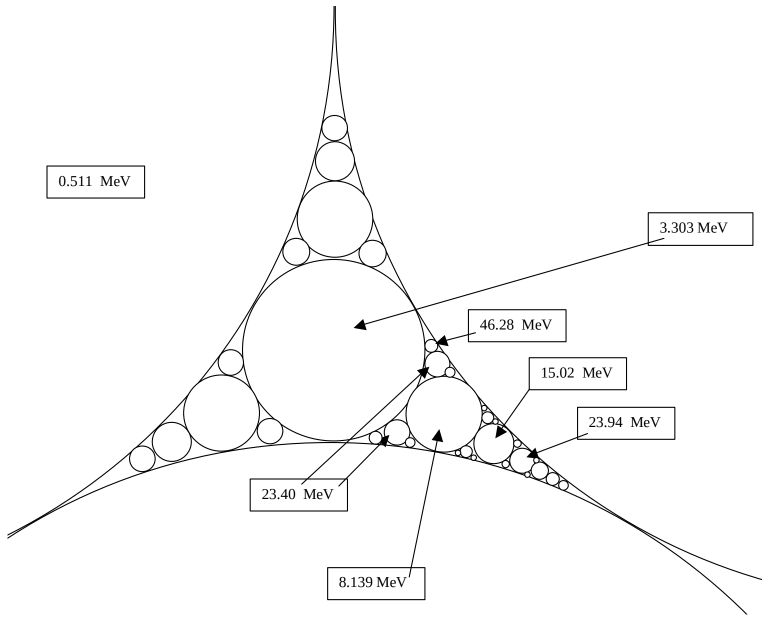

Fig. 2. Zoom in on *isolated* region of hexagonal configuration.

In Figure 2 we have zoomed in on one of the isolated regions. We have scaled the energy geometrically based on the 0.511 MeV resonances using the radius of the circles taking the radius of the 0.511 MeV resonances to be equal to 1. So the formula is simply $m_e c^2/r$ for each of the smaller sized resonances with r just being the value of radius relative to 1 with no units. In other words, the radius of the 0.511 MeV resonance is the electron Compton wavelength divided by 2π so the circumference is the Compton wavelength. Using the formula for Compton wavelength we can scale the energy like so,

$$m_e c^2 = \frac{2\pi\hbar c}{\lambda_C}. \tag{31}$$

So we can see that the energy resonances depend only on a radius and as the radius gets smaller the energy becomes larger. We just set the rationalized Compton wavelength to be 1 and scale from there.

We immediately see that we have a ~ 3.3 MeV resonance and a ~ 8.1 MeV resonance that makes us think of the current masses of the up and down quarks respectively. So right away we have resonances that possibly represent the first generation of charged fermions. But we also see that we have many extra resonance areas that don't seem to correspond to any known elementary fermions. At this point, let's assume they are Goldstone-like resonances. It is interesting to note that the 3.3 MeV resonance has three immediate couplings to 0.511 MeV resonances whereas the 8.1 MeV resonance has only two immediate couplings to them and one to the 3.3 MeV resonance. We can imagine that this is possibly the source of fractional charges for the quarks.

However, this is a schematic for the configuration of the quantum vacuum so we will have to analyze this further with the introduction of how real fermions fit into this picture. Another thing to note is that all these resonances are coupled together leading us to think that all the couplings are working together as a "unit". We are just taking the energy of one pair of the resonances. In other words, each resonance area actually has zero net energy overall in the pairs conjugate configuration. The 0.511 MeV resonance area is an electron-positron; the 3.3 MeV area is an up anti-up quark configuration, etc.

We also have the problem of where do neutrinos fit into the spin matrix? We have to suppose that neutrinos don't form conjugate pairs and are somewhat free quantum entities. That is; they are somewhat free from the constraints of the vacuum spin matrix that must be residing partially in its own inner space and partially in our space. They are as close to the "bare" quantum entities that form all of this that we are ever going to get to.

This *inner* space brings us to the concept of *dual* space. From the current proceedings of the Physical Congress-2004 conference, we have received rock solid proof and confirmation for the dual nature of our space-time by G. Melnikov [13] that was first presented to us via the book "Dual Space" by J. Polasek [14] and also by A. Michaud [5] who proposes a triple space. Melnikov proved with rigorous math, based on hyper-complex numbers, that the world which surrounds us is the one unified entity of the *right handed* (Euclidian, linear) and *left-handed* (Minkowsky-Riemann, hyperbolic, with variable metrics) space-time. This result will have far-reaching consequences in physics, altering many well-known symmetry and dynamical results. And also, everything connected with the conservation of the internal quantum numbers! Many physics books will be rewritten!

Now, let us gather more arguments in favor of our hexagonal spin matrix. David Hilbert, in his famous book [10] wrote on page 44; "The cell, constructed from right triangles, gives the most dense packaging of the circles:

$$\mathbf{D} = \frac{\pi}{2\sqrt{3}} \cong 0.289\pi.\text{"}$$

This system is identical to our 2D slice of the spin matrix, Fig.1. In the same book, Gilbert absolutely clearly demonstrates the topological equivalence of our Fig.2 and the Boy surface. It has a 3D model from wire (see page 319).

Janna Levin in the review [11] has a wonderful example of why the hex structure should arise (see p.258): "To construct a Dirichlet domain, pick an arbitrary point in the manifold of interest to serve as a *basepoint*. Start inflating a balloon with the center at the basepoint and let the balloon expand uniformly. Eventually, different parts of the balloon will bump into each other. When this happens, let them press flat against each other, forming a flat (totally geodesic) boundary wall. Eventually, the balloon will fill the whole manifold, at which point it will have form of polygon in two dimensions or polyhedron in 3-dimensions whose faces are aforementioned boundary walls." Here we see the hexagonal structure. Using the method of images, Levin [11] has obtained wonderful images of a hexagonal prism for the antipodal maps of the sky (see fig.43, p.320). As we see now, hexagonal structures naturally appear in both micro- and macro- scales!

Herman Weyl, in his famous book "Symmetry" [12], describes snowflakes as crystals with six order symmetry – it is one of the most economical and energy minimizing configurations in nature. Weyl again states that hexagonal symmetry naturally arises also in floor decorations in bathrooms and in bee's cells. It has been proven that such geometry of surfaces provides the most economical way to fill cells with wax. Due to the capillary laws, soap film, covering a given contour from slim wire, will take the form of a minimal surface, i.e. the surface with area less than the area of any other surface, bounded by the same contour. Weyl figure 49 is identical to our fig.1. From Weyl again: let's turn to ornaments and examine the window in the mosque in Cairo, XIV century, which possesses the hex symmetry of D6 class. The main figure is a loop in the form of trefoil."

In figure 3 we show a "quad" configuration possibility for a vacuum spin matrix. In this configuration we don't get some features that we think are necessary for a more complete picture. Such as, we don't get the 1/3 and 2/3 possibilities for fractional charge and while the resonance areas for up and down quark current masses are not "out of the ball park", we think the hexagonal configuration is better.

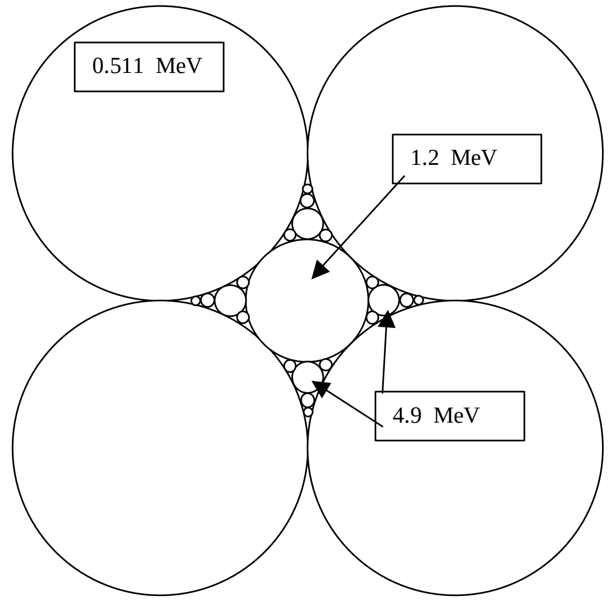

Fig. 3. Quad Spin Matrix configuration.

7. Conclusions

The quantum vacuum is one of the last frontiers of physics that is not fully explored. One can study Volovik's "The Universe in a Helium Droplet" to see that superfluids have emerging properties that resemble what might be going on with the quantum vacuum [15]. We have shown with our presentation here that the quantum vacuum might be more organized that we think it is. All it takes is the concept of coupled oscillators. However, we know how strange quantum theory is where everything seems to be governed by probability waves. We think these probability waves are due to the stringy-like behavior of massless very tiny quantum objects. Mass is just an interaction of "real" particles with the quantum vacuum which can easily be illustrated from analysis of the Compton wavelength expression for an electron by expanding it out,

$$m_e = \frac{2\pi\hbar}{\lambda_C c} = \frac{4\pi^2\hbar c}{\lambda_C^2 c\,\omega_C} = \frac{8\pi^3\hbar c}{\lambda_C^3 \omega_C^2}. \quad (32)$$

Then make the replacement from the fine structure constant we obtain,

$$m_e = \frac{8\pi^3\hbar c}{\lambda_C{}^3\omega_C{}^2} = \frac{8\pi^3 e\sqrt{\hbar c}}{\lambda_C{}^3\omega_C{}^2\sqrt{\alpha}} = \left(\frac{e\sqrt{\hbar c}}{\omega_C{}^2}\right)\left(\frac{2\pi}{\lambda_C\alpha^{1/6}}\right)^3 . \qquad (33)$$

So we can see that this expression is vacuum charge times electronic charge per a volume of space per frequency squared. We imagine that the square root of the fine structure constant is a geometric factor and goes with the volume of space. The frequency-squared component is not necessarily electron Compton frequency squared and the same goes with all the wavelength components. But this is just an illustration that mass could simply be emergent from an interaction with the quantum vacuum. Which is not inconsistent with the Higgs concept of the Standard Model. Previous attempts at doing this from considerations that spectral energy density of the vacuum could be responsible for mass were never fully realized. Spectral energy density does not have enough of what it takes. Vacuum charge does.

We hope that these ideas will make people think more about the quantum vacuum and see that it can be possible for it to be organized. Considering quantum "fuzziness", it is more like ordered chaos. Our naïve diagrams for the vacuum spin matrix have to still be considered as averages or expectation values. But we can see that the quantum vacuum might have additional resonances that don't correspond to real fermions, which can possibly help to explain the multitude of resonances found. Plus we think this is a possible clue to dark matter and dark energy.

REFERENCES

[1] David J. Griffiths, *Introduction to Electrodynamics, 3rd ed.*, (Prentice Hall, Upper Saddle River, 1999).

[2] Halliday and Resnick, *Physics, 3rd ed.*, (John Wiley & Sons, Inc., New York, 1978).

[3] The idea for this procedure was obtained from Thomas N. Lockyer, *Vector Particle and Nuclear Models*, (TNL Press, Los Altos, 2000).

[4] Dr. D.T. Emerson, *The Gain of the Axial-Mode Helix Antenna*,

(http://www.tuc.nrao.edu/~demerson/helixgain/helix.htm , 1995).

[5] André Michaud, *Expanded Maxwellian Geometry of Space, 4th ed.*, (SRP Books, Québec, 2004).

[6] A. Ringwald, arXiv: hep-ph/0112254, hep-ph/0304139.

[7] C. Bamber, S. J. Boege, T. Koffas, T. Kotseroglou, A. C. Melissinos, D. D. Meyerhofer, D. A. Reis, W. Ragg, C. Bula, K. T. McDonald, E. J. Prebys, D. L. Burke, R. C. Field, G. Horton-Smith, J. E. Spencer, D. Walz, S. C. Berridge, W. M. Bugg, K. Shmakov, and A. W. Weidemann
Phys. Rev. D **60**, 092004 (1999)

[8] Peter W. Milonni, *The Quantum Vacuum: An Introduction to Quantum Electrodynamics*, (Academic Press, Inc., San Diego, 1994).

[9] David J. Griffiths, *Introduction to Elementary Particles*, (John Wiley & Sons, Inc., New York, 1987).

[10] D. Hilbert, S. Cohn-Vossen, *Geometry and the Imagination*, Nauka, M., 1981, 344 p.

[11] J. Levin, *Topology and the cosmic microwave background*, Phys. Rep. 365 (2002) 251-333.

[12] H. Weyl, *Symmetry*, Nauka, M., 1968, 192 p.

[13] G. Melnikov, *These Proceedings of Physical Congress-2004 – Fundamental Problems of Natural Sciences and Engineering, Volume 29*, (St. Petersburg, Russia 2004).

[14] John C. Polasek, *Dual Space-New Physics for a New Century*, (Principia Publishing Co., Maitland, Florida, 2004).

[15] Grigory E. Volovik, *The Universe in a Helium Droplet*, (Clarendon Press, Oxford, 2003).

ADDITIONAL REFERENCES

John Baez, Michael Weiss, *Photons Schmotons*, (http://math.ucr.edu/home/baez/photon/ , 1999).

Richard P. Feynman, *QED The Strange Theory of Light and Matter*, (Princeton University Press, Princeton, 1985).

John D. Jackson, *Classical Electrodynamics, 3rd ed.*, (John Wiley & Sons, Inc., New York, 1999).