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Electron Properties Explained as Quantum Field Effects

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Electrons are surrounded by the quantum field, so it is necessary to understand the response of the quantum field to the presence of an electron in order to completely understand it. Given the quantum field particle pair model, and consequently polar nature of the quantum field, we can reinterpret Gauss's Law so that polarization causes charge rather than charge causing polarization. That is how unit charge is independent of particles, and thus the same for all free particles. It is also important to note that as the quantum field becomes polarized, rotation is induced, leading to the spin quantum and magnetic moment. The author has previously shown that mass-energy can be explained as a quantum field effect since, as Dirac first hypothesized, a particle must exert energy for a particle to exist in the quantum field, which equals its mass-energy. This is also true for quantum fluctuation particle pairs, such that their energy and energy continuum are due to the instantaneous local energy of the quantum field exerted on individual quantum fluctuations. Likewise, frequency and wavelength are also a function of this quantum field interaction. This origin of frequency and wavelength also gives us the origin of time and spatial dimensions. An electron behaves like it has a central bare electron that acts as a negative polarizer and is matter as opposed to antimatter. Its remaining properties, including charge, spin, magnetic moment, and mass are explainable as quantum field effects.

1. Introduction

Few problems in physics have been as difficult to solve as understanding the physical nature of electrons. In proton scattering experiments an electron appears almost point-like in size while its mass appears to be related to its Compton wavelength. It has angular momentum and a magnetic field, so it cannot possibly be a point, as some dimensionality is required for those properties to occur.

There is no accepted physical cause of electric charge. This problem is further complicated due to the fact that numerous different particles with different sizes, and hypothetical structures have the same magnitude of charge. The same problem occurs with the spin quantum, as there is no accepted way to understand how the various particles of different masses and sizes have the same spin. And, when people do attempt a semi-classical model of an electron, they encounter the problem that in order to achieve the electron's magnetic moment, their model often violates the speed of light limit.

While people have tried, no one has satisfactorily explained the electron. So, the electron, and in particular many of its properties such as charge, mass, and spin, are left as unexplained things and treated as constants of undetermined origin.

Regardless of the structure of the electron, it must be filled with quantum fluctuations that make up the quantum field of standard model quantum field theory. Quantum fluctuations are known to exist down to dimensions as small as the Planck length and perhaps smaller, so there is no region of space we know of anywhere that cannot be filled with quantum fluctuations.

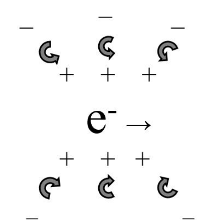

Fig. 1. As an electron moves through space nearby quantum fluctuation dipoles are polarized and rotate.

We also know from the existence of the Casimir effect that quantum fluctuations behave like quantum dipoles that are capable of interacting through van der Waals forces. Van der Waals forces between quantum fluctuations also cause bodies of matter to move, such as in the case of the original two-plate Casimir effect.[1]

Quantum dipoles are polarized in the presence of an electric charge. Consequently, we must consider the polarization of the quantum field adjacent to and within the structure of an electron. Further, we can consider that the structure of the electron is composed of the quantum field.

2. Unit of Electric Charge

Electrons are thought to have a unit of negative electric charge which produces an electric field around it. In terms of quantum field theory, the electron's charge polarizes the quantum field producing the electric field. In this way, charge can be thought of as an electron's ability to polarize quantum particle pair dipoles.

Equation 1

$$Q = \oint_s P \cdot dA$$

Electron charge is directly related to the polarizability of the quantum field as described by Gauss's Law expressed mathematically in Equation 1. It shows that for a volume of space polarized by a given amount of charge (***Q***), the surface integral of the flux of the polarization (***P***) over a surface area ***A***, equals the charge inside. The total flux over the area of any radius sphere around a charge is the same as is necessary to comply with the principle of conservation of energy and the inverse square law.

For the electron's single unit of electric charge (***e***), we instead have Equation 2, where ***P*** is the polarization due to a single unit charge.

Equation 2

$$e = \oint_s P \cdot dA$$

This brings up the intriguing idea that perhaps we have been looking at charge in the wrong way. Instead of thinking of charge as a property of electrons, and other particles, we can think of charge as being a property of the quantum field. The quantum field is the same for all particles. In that way we can overcome the problem of figuring out the physical cause of charge as a property of a vast array of particles that happen to always have the same magnitude. Instead we can think of any particle as a polarizer that polarizes the quantum field, and the uniformity of the quantum field causes the unit charge to be the same for all particles. Unit charge exists because the polarizability of space is the same for any polarizer. This argument avoids the problem of hypothetical fractional charges that are never seen in a free state.

In this way we can think of an electron as a polarizer of undetermined but small dimensions. It has charge because it polarizes the quantum field around it. We can refer to this polarizer as a bare electron, when we think of it separately from its surrounding polarized quantum field. Note that there is additional discussion of this interpretation of unit charge in a prior paper.[2]

3. Electron Spin Quantum

The spin quantum has the same problem as electric charge in that it is impossible to conceive of a physical mechanism causing particles of varying mass, hypothetical size, and structure to have the same physical spin. But we can, once again, turn to the quantum field as something that is uniform around any given particle that could yield quantized spin.

Equation 3

$$S = \frac{1}{8\pi\epsilon_0}\frac{e^2}{\alpha c}$$

The spin quantum occurs in increments of the reduced Planck's constant divided by two ($\pm\frac{1}{2}\hbar$), which can also be written in terms of Planck's constant as $\pm h/4\pi$. The spin quantum (***S***) is usually stated as simply ±½, with the $\hbar$ assumed. It can be expressed in terms of electric charge, the permittivity of space (ε_0), the fine structure constant (α), and the speed of light (***c***) as shown in Equation 3.

Equation 4

$$S = \frac{1}{8\pi}\frac{e^2}{\alpha}$$

Equation 3 can be simplified by expressing it in natural units where ε_0, and ***c*** are equal to one. This gives us Equation 4. Note that the spin quantum and Planck's constant are proportional to the ratio e^2/α.

In natural units where ε_0, c, and h equal 1, we find that $\alpha = e^2/2$. This tells us that the fine structure constant is due to the polarization of space along with charge. Also note that the equation has the appearance of a simple calculus problem. By solving and inserting Equation 2 for e we find that the fine structure constant is equal to the volumetric polarization of the quantum field due to a single polarizer.[2][3]

Consequently, the spin quantum must arise due to the physical polarization of the quantum field. In order to answer the question of how that occurs, we must consider what happens around a bare electron as the quantum field becomes polarized. We might guess at first that no net rotation occurs within the quantum field during polarization. After all, wouldn't the dipoles rotate in various directions during the polarization process making the field spin neutral as a whole? The answer is actually no.

To understand the origin of spin we must consider that quantum dipoles undergoing polarization are continually being produced in somewhat random orientations and then they annihilate and get replaced. There are also vastly more quantum dipoles in space than are needed to form an electric field, so only a few quantum dipoles need to rotate a fraction of a degree to sufficiently polarize the quantum field.

If we envision two partially polarized dipoles with similar wavelengths side-by-side, their like charges are near each other. If they rotated in opposite directions as they are further polarized, one pair of like charges at one end of the dipoles moves further apart while the other pair of like charges moves closer together. Energy is required for like charges to move toward each other.

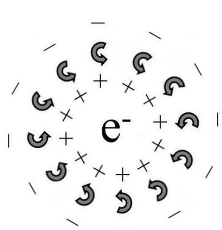

Fig. 2. Quantum dipoles around an electric charge tend to rotate in a single direction in any given plane in order to achieve the correct state of polarization with the least amount of energy expenditure.

Alternatively, if dipoles rotate in the same direction, the distance between both pairs of like charges remains constant or nearly so. This requires less energy expenditure. Nature automatically adapts to the lowest energy polarization process. Consequently, quantum dipoles tend to rotate in the same direction while being polarized as illustrated in Fig. 2. In a related situation dipoles travel in a geodesic around a rotating spherical surface.[4] A collection of stable dipoles does the same.

As dipoles of the same wavelength in a single plane polarize, they rotate on a common axis. The spherical situation is more complicated particularly considering the potential that there is continuum of quantum dipole wavelengths. Quantum dipoles cannot all rotate on a common axis, but they do rotate in a preferred direction. This gives the physical appearance that the quantum field around a bare electron is rotating as a whole on an axis, when it is not. The bare electron at the center does not need to rotate to induce a quantum field that does. And, the center of each quantum dipole in the field does not necessarily move with respect to a bare electron.

A natural process of quantum dipole rotation must occur during quantum field polarization, which leads to particle spin and the spin quantum. We can therefore see that the quantization of spin occurs because it is a quantum field process rather than because it is some other type of physical property of particles.

4. Electron Magnetic Moment

Spin arising during quantum field polarization not only produces the spin quantum, it produces the electron's magnetic moment. Rotating quantum dipoles produce a magnetic field consisting of more rotating quantum dipoles, so electron spin and magnetic moment have the same axis of rotation.

In early attempts at calculating the electron's magnetic moment, physicists treated the electron as a rotating spherical surface of charge and then computed the magnetic moment based on that simplified description. This model is now known to be incorrect, but it is historically important.

Equation 5

$$\mu_S = g\frac{-e}{2m_e}S = -g\mu_B\frac{S}{\hbar} \cong \mu_B$$

Based on this early electron model, physicists calculated the electron spin magnetic moment ($\boldsymbol{\mu_s}$). As shown in Equation 5 it is usually expressed in terms of the g-factor ($\boldsymbol{g}$), electric charge, spin quantum, and the electron mass ($\boldsymbol{m_e}$). It can alternatively be expressed in terms of the Bohr magneton ($\boldsymbol{u_B}$) and reduced Planck's constant. The electron's magnetic moment is approximately equal to the Bohr magneton since g = 2.00231930436182, and $\boldsymbol{S}/\boldsymbol{\hbar}$ = ½.

The g-factor was a bit of a surprise as physicists expected that it would be unnecessary, being equal to one. The question of how the g-factor comes to be close to two, is a previously unanswered question in physics. There is a small correction term applied to the g-factor due to properties of the quantum field including the self-energy of the electron. Those correction terms tell us there is already a strongly established connection between the electron's magnetic moment and the quantum field around the electron.

Fig. 1 shows us why the g-factor is close to two instead of one. If we modeled Fig. 1 as spherical shells we would need to have a negatively charged shell rotating one direction and a positively charged shell inside it rotating the opposite direction. Then we would have to compute the magnetic moment based on both shells, which makes the g-factor equal two. The g-factor is approximately two because the electron structure is composed of quantum dipoles consisting of both charges rather than distributed negative charge.

5. Electron Mass

Looking at Equation 5 we see that the electron's mass is related to the magnetic field. There are also well-known relationships between the masses of the heavier unstable particles and the fine structure constant, which is also electromagnetic in origin as noted previously. These two relationships tell us that mass is electromagnetic in origin.

Equation 6

$$\lambda_e = \frac{h}{m_e c}$$

We can remove the electron mass from Equation 5 by using the electron Compton wavelength from Equation 6 and substituting to get Equation 7.

Since the spin quantum equals $\boldsymbol{h/4\pi}$ we can simplify the second term of Equation 7 to get the third term where Planck's constant and the spin quantum have been eliminated. While this paper has focused on Planck's constant in terms of spin quantization and angular momentum it also is necessary for converting frequency or wavelength to energy or mass-energy.

Equation 7

$$\mu_S = -g\frac{e\lambda_e c}{2h}S = -g\frac{e\lambda_e c}{8\pi}$$

When faced with the problem of having a positive and negative energy solution to the equation that bears his name, Paul Dirac hypothesized that both particles might have the same mass-energy due to the energy required for an electron to maintain its place in the Dirac Sea, his early quantum field model.[5]

We can test Dirac's hypothesis by treating an electron as a Compton wavelength sized Casimir cavity that scatters other quantum fluctuations.

Equation 8

$$\rho = \frac{\hbar(\omega_2^4 - \omega_1^4)}{8\pi^2 c^3}$$

We can then use Equation 8 for the energy density ($\boldsymbol{\rho}$) of the quantum field in terms of circular frequency ($\boldsymbol{\omega}$) of the quantum fluctuations to calculate the amount of quantum energy displaced by a Compton sized spherical shell. The shell thickness can be due to quantum uncertainty. When we do this, we find that a Compton sized spherical shell displaces an amount of quantum field energy equal to the electron mass-energy. This relationship is outlined in greater detail by the author in a prior paper.[6] This relationship is also true for protons when we calculate the quantum energy displaced by a spherical shell the size of the proton's charge radius.

The electron's magnetic field and mass are both indicative of a Compton wavelength sized structure. If that structure is composed of quantum fluctuations, that explains why it does not scatter high energy protons or participate in the strong force. For this model to be true, electrons must only be known to scatter light at the electron's Compton wavelength.

6. The Speed of Light Problem

As mentioned in the introduction, the classical spherical shell model of an electron ran into the problem that it would have to rotate faster than the speed of light in order to produce the known magnetic moment of the electron. Any successful electron explanation must obviously avoid exceeding the speed of light limit.

The quantum field explanation of the electron avoids this problem since quantum dipoles do not necessarily move relative to the bare electron. While undergoing polarization the quantum dipoles may rotate at speeds up to the speed of light about the center of their axis of rotation. Under the constraints of a Planck resonator, a quantum dipole can rotate 180 degrees during its existence, which is far more than is needed to produce a polarized electric field.

Dipole polarization progresses very rapidly around the bare electron such that it appears like the dipoles are almost rotating in unison. This gives the physical appearance of charges moving faster than light on a spherical surface, when that is not what is happening. We can think of it like a string of lights that are wired so they can be turned on and off such that it looks like a single light is moving down the strand very rapidly, when the lights are not moving at all. And thus, the speed of light limit is not violated.

7. Quantum Electron-Positron Pairs

The quantum field explanation of the electron leads to the question; what about the quantum electron-positron pairs that are part of the standard model's quantum field? In a quantum electron-positron pair a bare electron must be coupled to a bare positron in some manner.

Since a quantum electron-positron pair is short lived and not permanent like free electrons, a fully polarized quantum field does not form around it. Thus, it does not scatter quantum fluctuations in a way that is needed to give them mass-energy. A quantum bare electron-positron pair is massless. A quantum bare electron-positron pair is still able to polarize and be polarized by other local bare electrons and positrons, but they do not achieve the stable state of a stable electron or positron, with all their inherent properties.

8. Bare Electron Frequency and Energy

In quantum theory as originated by Planck, a quantum oscillator has a frequency, wavelength, and energy. The energy ($\boldsymbol{E}$) is equal to Planck's constant times the frequency ($\boldsymbol{f}$), ($\boldsymbol{E} = \boldsymbol{hf}$). Or, we can use natural units where $\boldsymbol{h} = \mathbf{1}$, so that $\boldsymbol{E} = \boldsymbol{f}$, which tells us that energy and frequency are in some sense measuring the same thing, with only a scaling factor between them. Quantum oscillators also have a wavelength where the frequency times the wavelength ($\boldsymbol{\lambda}$) equals the speed of light ($\boldsymbol{f\lambda} = \boldsymbol{c}$). For any quantum fluctuation of a given frequency, it has a single wavelength. In this way, once one of these three properties are set, they are all set. As such, they all must have the same or interrelated underlying causes.

Hypothetically, the range of wavelengths can vary from the size of the visible universe to the Planck length, or perhaps even smaller. The associated energy range related to these extremes would go from almost zero to approaching infinity. Somewhere in-between we have the stable electron. In a semi-classical approach to modeling an electron we might assume that the electron has something in its physical structure that identifies its frequency, wavelength or energy. And, for some reason, out of all the possibilities, the free electron is permanently stable.

The quantum field explanation of electrons turns that around, for now the electron's frequency, wavelength, and energy, whether in a quantum fluctuation or stable form, is due to the quantum field. The simplest of the three properties to understand is the wavelength of a quantum electron-positron pair. In a quantum electron-positron pair the particles are produced at a central point, separate to the full extent of their wavelength, and then collapse back to the central point and annihilate.

In space filled with quantum dipoles there are van der Waals forces and importantly van der Waals torque. It takes energy for dipoles to rotate, and dipoles rotate whenever a charge, such as a bare electron, moves. As such, the rate of motion of the electron-positron pair, and thus the wavelength is limited by the van der Waals torque of the quantum field.

From there we can recognize that, while the energy of the quantum field can be averaged when we compute such things as Casimir forces, there are instantaneous large variations in frequency and energy of individual quantum fluctuations and the adjacent quantum field. Consequently, the range in quantum fluctuation frequencies is due to the range in van der Waals forces applied to any given quantum dipole. The continuum of quantum fluctuation frequencies does not occur due to the frequency being stamped somewhere on the body of a bare electron or positron. It occurs due to the instantaneous variation in local energy of the quantum field.

The energy of each quantum dipole is similarly due to the instantaneous quantum energy impressed upon it by the surrounding quantum field. This is in many respects the same idea proposed by Dirac for explaining the mass-energy of the electron. Like electrons, a quantum fluctuation must have energy to push against the surrounding quantum field. The quantum energy of an individual quantum fluctuation is therefore determined by the surrounding quantum field, which leads to the full continuum of energies we observe. Energy is linked to the quantum frequency. In this way it is possible for the quantum field to have energy and conserve energy at the same time.

Time in space is determined by the frequencies of the quantum fluctuations, while the spatial dimensions of space are determined by quantum fluctuation wavelengths. The quantum field explanation of energy, frequency, and wavelength then tells us that time and spatial dimensions are determined by interactions between individual quantum fluctuations and the instantaneous local quantum field. And thus, time and spatial dimensions arise naturally from the quantum field that fills all space.

As for a stable electron, the bare electron does not have its frequency, wavelength, or energy stamped onto some unidentified structure. But instead, every unpaired bare electron forms a stable electron. The same is true for unpaired bare positrons, which form a stable positron. Simply by existing independently, rather than as part of a quantum particle pair, the quantum field around the bare electron gives it its properties that make it an electron.

9. Electron Size

Electron mass and magnetic moment tell us that an electron has some kind of structure the size of the electron's Compton wavelength. Within the scope of a quantum field explanation for mass-energy and magnetic moment we must determine how the polarized dipoles around a bare electron acquire the ability to scatter at the Compton wavelength. In order to be consistent with the quantum field explanation, this must be due to quantum field interactions.

Casimir proposed a semi-classical model for the electron where he considered the electron as a shell and suggested that the outward Coulomb force would be balanced by an inward Casimir force.[7] Casimir's hypothesis was determined to be false as the net effect is that energy is exerted in an outward direction on such a shell assuming Coulomb force transmission is not subjected to quantum effects.[8] This result has been confirmed repeatedly.

There are a couple problems with Casimir's hypothesis. In the quantum field explanation of the electron there is no shell but rather an arrangement of quantum dipoles. His model also ignores the fact that Coulomb forces are transmitted by and through the quantum field and as such quantum field effects cannot be ignored when computing Coulomb forces at Compton wavelength distances from a bare electron.

With regard to the polarized dipoles around a bare electron the positive charge in a dipole is closer to the bare electron than the negative charge. Consequently, the Coulomb attractive force on the positive charge is substantially greater than the repulsive force on the negative charge. The net effect is that polarized quantum dipoles are attracted toward the bare electron by Coulomb forces. This force differential has the effect of briefly stretching the quantum dipoles just as we see in van der Waals forces.

Because electrons behave like they are the size of the Compton wavelength there may be some efficacy in treating them as shells. But we must consider a reduced Coulomb force effect since the shell is composed of dipoles that are polarized with respect to the bare electron, such that the opposing charges experience different forces. A mathematical solution that takes quantum effects into account when computing the Coulomb force and force transmission must be found, but will be left as a future project.

The other size question is; how large is a bare electron? Based on proton scattering experiments we could conclude that a bare electron must be very small to the extent of being almost point-like. The other possibility is that a bare electron does not scatter off a proton or a bare proton. This is a question that also needs additional study as the solution requires understanding bare electron structure.

10. Matter and Antimatter

With regard to the matter and antimatter problem we can recall that the matter and antimatter properties were first discovered by Dirac in his solutions to the Dirac equation. His positive energy solution equates to the electron and the negative energy solution equates to the positron. So, with respect to the Dirac equation we can think of the properties of matter and antimatter as being positive and negative matter-energy. Or, since it is confusing to think of all material, whether matter or antimatter as matter, and negative matter-energy as antimatter, it might be better to call it something else, perhaps Dirac-energy. Nonetheless, it will be referred to as matter-energy in this paper.

When considering a quantum field explanation of the electron we can recall the particle pair model of quantum fluctuations. When a bare electron is surrounded by quantum electron-positron pairs those pairs are oriented with respect to the bare electron's negative electric polarizer. Consequently, the matter-antimatter orientation of the quantum electron-positron pairs gives the appearance that the quantum field is polarized with respect to matter-energy. We need to keep in mind that there is no accepted theory for what this matter-energy is within the scope of the standard model, and that question is left for future consideration.

We can, however, recognize that the electron's quantum field polarization shows that it has both negative electric charge and positive matter-energy due to the orientation of the quantum electron-positron dipoles. We can then treat the matter-energy—matter and antimatter—property the same way we treat positive and negative electric charge in section 2 of this paper.

We can even define a unit for matter-energy using an equation taking a form like Equation 2. In this way an electron can be identifiable as matter at a distance from the bare electron. The same is true for a bare positron with reverse polarity of the quantum dipole structure.

11. Positive Charge and Matter-Energy

When we discuss the quantum field explanation of an electron, it is a bare negative polarizer with positive matter-energy surrounded by a field of quantum dipoles that give it its remaining properties. To go with that we have its antiparticle the positron which is a bare positive polarizer with negative matter-energy.

We have two properties that can conceivably be combined in four ways to complete a 2 x 2 symmetry. So, we have to consider the two possibilities of a bare positive polarizer with positive matter-energy and a bare negative polarizer with negative matter-energy. There are two stable particles that fit with those possibilities, the proton and antiproton. Like electrons, protons can be explained as quantum field polarization effects around a bare proton that is a positive polarizer and has positive matter-energy.

While this idea does not fit well with the quark model, it does fit well with proton scattering experiments since protons behave like they are filled with numerous quantum particle pairs. They do not behave like they are composed of only three point particles. So even in quark theory the scattering of a proton is thought to be due to it being filled with quantum particle pairs, and thus the quantum field effects cannot be ignored.

We also know from charge modeling within the proton that it has a strong central positive charge that becomes smaller further away from the center.[9] This is also indicative of a single small central charge or polarizer, so once again we must consider the quantum field effects around a small central polarizer. Consequently, treating a proton as a bare positive polarizer with positive matter energy fits the experimental evidence.

One argument against the electron and proton having similar structures is that the g-factor for the proton is so much larger in relative terms as the CODATA value is 2.7928473508 times the nuclear magneton rather than being closer to two like the electron.

The reason for this problem is that we historically do not use the proton's true radius when making this calculation, and the proton's magnetic moment is related to its true radius. To see the problem, we can note that the nuclear magneton is based on the proton mass, which assumes a diameter equal to the proton's Compton wavelength which has a CODATA value of $1.321409853 \text{x} 10^{-15}$ meters.

The proton's real physical radius, its charge radius, has a CODATA value of 0.8751×10^{-15} meters giving a diameter of 1.7502×10^{-15} meters. Thus, its real diameter is 1.3245 times larger than the proton's Compton wavelength. So, if we use the real proton size to determine the proton's magneton we get a g-factor of 2.1086.

While this g-factor is still larger than that of the electron it is close enough that we may be able to account for the correction term with quantum field effects. Since the proton's size is much smaller and more energetic than an electron, the quantum field effects may be greater in magnitude, relatively speaking. That work is left for a future paper.

As noted previously, the proton's mass-energy is equal to the quantum field energy displaced by a spherical shell with the proton's charge radius and thickness due to quantum uncertainty.[6] Therefore, as with the electron it is possible to account for the proton's electric charge, spin, magnetic moment, and mass as quantum field effects.

Because a bare proton is a positive polarizer with positive matter-energy, quantum dipoles of the same polar orientation will be attracted to it. These quantum fluctuations will have the polarity of a bare proton-antiproton pair. In this way, positive matter-energy property can also propagate.

We can now come back to the question of how an electron has a quantum structure that scatters at the electron's Compton wavelength? Protons give us a second data point at twice the proton's charge radius. Since the bare electron is positive matter-energy and a negative polarizer while a bare proton is positive matter-energy and a positive polarizer, it is possible that a bare particle that is positive or negative in both attributes is smaller and more energetic than one that has opposite attributes. The size problem is still a question that must be dealt with in the future, but if the proton has the same quantum structure as an electron that will help us find the solution.

12. Conclusion

Electrons are surrounded by the quantum field of standard model quantum field theory, and quantum dipoles exist throughout it. This opens up the possibility that some, or perhaps all of the electron's properties are due to interactions within the quantum field rather than being properties of the particle.

From Gauss's Law it is easy to reinterpret electric charge as the polarizability of the quantum field due to the polarizing nature of a bare electron. It is also easy to recognize that such a polarization process induces rotation in dipoles of the quantum field that leads to quantized spin and the electron's magnetic moment. The dipole nature of the quantum field also explains why the electron g-factor is close to two instead of one.

The electron's magnetic moment tells us that an electron behaves dimensionally like it has some kind of structure the size of the electron's Compton wavelength. If this structure consists entirely of the quantum fluctuations, that explains why we do not see interactions in certain scattering experiments. If, however, the electron scatters quantum fluctuations and light at its Compton wavelength, the displacement of quantum energy of the quantum field is equal to the electron's mass-energy. As such electron mass is another quantum field effect.

Given that the electron and positron are positive and negative energy solutions of the Dirac equation that we commonly call matter and antimatter, we can also recognize that quantum field dipoles will align with respect to matter orientation in addition to electric charge orientation. We can then interpret the polarization with respect to matter-energy in much the same way we look at electric charge. Matter-energy can be thought of in a way that mirrors Gauss's Law.

In this way we must recognize that a bare electron with the ability to polarize quantum dipoles with respect to both electric charge and matter-energy will be surrounded by a quantum field that gives the bare electron its other properties, including unit electric charge, spin quantum, magnetic moment, and mass. Other electric properties of the electron are also assumed to be accounted for as quantum field effects.

This model also applies to the quantum field. Since the quantum field consists of particle pairs including electron-positron pairs, the electron-positron pairs of the quantum field must be in their bare form. This explains how quantum bare electron-positron pairs are massless, since they do not exist long enough to displace other quantum fluctuations.

We can also consider the frequency, wavelength and energy of quantum fluctuations as properties due to the instantaneous interaction between the quantum field and each quantum dipole. The energy and frequency are determined by the energy exerted upon it by the quantum field and its wavelength is determined by the van der Waals torque of the quantum field. The energy of each quantum fluctuation is balanced by the energy of the quantum field so that energy is conserved.

The frequency and wavelength of quantum fluctuations also give space its time and spatial dimensions, so that time and spatial dimensions arise naturally from the quantum field.

Any free bare electron acquires its properties from the quantum field. Consequently, every free bare electron becomes a free electron. There is no continuum of free electrons because the electron's properties are uniquely fixed by the quantum field. It is not necessary for a bare electron, whether separately or as a pair to have its frequency, energy, or wavelength physically etched onto it in some manner.

It is also conceivable that a bare particle with positive electric charge and matter-energy exists that has properties attributed to it due to quantum field interactions. This particle is the proton, and the opposite bare particle is the antiproton. This is required to complete the expected 2 x 2 symmetry.

While this approach to explaining electrons accounts for most of their properties there are remaining questions. Perhaps the most elementary question of all is; what is the physical description of the bare election? To answer that we also need to understand how it has the ability to electrically polarize and how it comes to have matter-energy?

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