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Physical Constants as Properties of the van der Waals Torque of the Quantum Field

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One of the most important outstanding questions in physics is, what are the physical causes that lead to the magnitudes of each of the physical constants? This paper explores the hypothesis that the magnitude of each physical constant is determined by the van der Waals torque of the quantum field of standard model quantum field theory. The quantum field is known to produce van der Waals forces as they are necessary to explain the experimentally proven existence of the Casimir effect. There is little research, however, into the effects of the van der Waals torque that necessarily exists in a sea of dipoles that undergo van der Waals force interactions. The van der Waals torque of space resists all linear and rotating charge motion, and as such, it determines the polarizability and magnetizability of space and the related physical constants. Give that most of the physical constants are derivable from other physical constants, it is easy to show that the magnitudes of all the electromagnetic constants are a direct physical result of the van der Waals torque of space. Of particular importance, electric charge and the fine structure constant are derivable from the polarizability of space. Since the fine structure constant and, consequently, mass can be shown to be electromagnetic, there is also a brief discussion about the necessity that gravity is electromagnetic as well, possibly in a manner analogous to a theory by Wilson and Dicke.

1. Introduction

In standard model quantum field theory space is said to be filled with virtual matter-antimatter particle pairs. Depending on which types of particles are thought to be fundamental enough to make up the quantum field, some, or perhaps all of those particles have non-zero electric charge. These electrically charged particle pairs form electric dipoles. Even virtual photons have a rotating electric and magnetic field that makes them look and behave like an electric charge dipole.

In a quantum field, sometimes called the zero-point field, filled with electric charge dipoles, they necessarily experience van der Waals interactions leading to van der Waals forces. The most notable experimental proof of the existence of quantum van der Waals forces is the Casimir effect.[1] The Casimir effect occurs when physical boundaries made of normal matter restrict the wavelengths of quantum fluctuations in a region of space, which leads to differentials in van der Waals forces. These Casimir force differentials are known to cause bodies to move.[2][3] The simplest case of the Casimir effect is the two-plate example where two plates are pushed together by van der Waals forces when they are positioned close together.

There is another van der Waals interaction that must arise within a sea of quantum dipoles that receives little attention, van der Waals torque. The presence of an electric charge causes quantum dipoles to rotate and polarize with respect to the charge. Any motion of an electric charge or current causes adjacent quantum dipoles to rotate. Rotating quantum dipoles cause adjacent quantum dipoles to rotate, which is how electric and magnetic fields propagate through space.

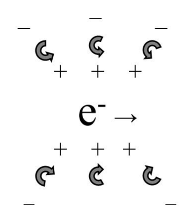

Fig. 1. As an electron moves through space nearby quantum dipoles are polarized and rotate.

Quantum dipole rotation comes at a cost, however, as quantum dipoles retain their initial state due to inertia unless energy is expended. As such, quantum dipoles resist rotation and this resistance is in the form of van der Waals torque.

Whenever a charge moves, its motion is resisted by van der Waals torque. Whenever a charge dipole rotates, its rotation is resisted by van der Waals torque. The torque resists motion of free and stable charges, dipoles, and fields, as well as the quantum dipoles themselves. The motion of each quantum dipole during its brief existence is met with the resistance of the quantum van der Waals torque.

Dicke examined the consequences of the polarizable medium of virtual particle pair dipoles in 1957, which was partly based on earlier work by Wilson in 1921.[4][5] He went on to discuss how gravity may arise in such a medium and used Mach's principle to relate the physical constants to the total matter in the universe. By dismissing his hypothesis that gravity can be derived via Mach's principle, justifiably in the author's opinion, physicists neglected the important points about how physical electromagnetic constants arise from the quantum field. They threw out the baby with the bathwater as it were.

More recently two groups independently attempted to tie permittivity, permeability and the speed of light together as a property of quantum fluctuations, but neither group considered the existence of van der Waals torque and its effects.[6][7]

It is not possible for a sea of dipoles to exist without producing van der Waals torque and it is not possible for an electric charge to move without its motion being resisted by that torque. As such, it is necessary to include an analysis of the van der Waals torque of the quantum field of standard model quantum field theory when examining the physical underpinnings of electromagnetic theory. Dicke stated that in his interpretation, "the polarizability of the vacuum at any point depends upon the distribution of the distant galactic matter."[4] Instead, the polarizability of the space at any point depends upon the local van der Waals torque of the quantum field.

2. Permittivity of free space

The permittivity of free space (ε_0) is a principle example of the how the van der Waals torque of the quantum field yields the physical constants. One definition of permittivity, which is also known as the electric constant, is the measure of resistance that is encountered when forming an electric field in a medium. Over much of the past century, space was treated as empty in electromagnetic theory, completely ignoring quantum field theory. Physically defining and deriving the permittivity of free space or the physical nature of the electric field is impossible if space is devoid of a medium. Fortunately, based on the evidence in favor of quantum field theory, we know that space is not empty. Space has a medium, the quantum field.

Physicists who deny quantum field theory, and by extension the Casimir effect, are left with assuming the permittivity of free space is a fundamental constant without a physical cause and that electric fields do not really exist. Other physicists will attempt to find the physical cause of fields and the physical cause of the resistance to field formation. As Dicke said "The most striking effect of the presence of virtual pairs in the vacuum is the polarizability of the vacuum." And, "With the neglect of quantum effects the polarizability of the vacuum can be described by classical field quantities $\boldsymbol{\varepsilon}$ and $\boldsymbol{\mu}$." [4]

With quantum field theory now firmly established, we can state authoritatively that space is known to be filled with quantum dipoles. Since quantum dipoles are polarized near electric charges, electric fields are physically real. The Faraday field line representation is real, except that since quantum fluctuation wavelengths exist in a continuum rather than being monoenergetic it is a misnomer to call them lines.

The electric field propagates as quantum dipoles rotate and become polarized. Once we acknowledge the existence of a continuum of quantum dipoles filling space, those dipoles must generate van der Waals torque. The van der Waals torque of space resists rotation of charge dipoles. So, the van der Waals torque of space resists the formation of electric fields.

The electromagnetic medium is the field of quantum particle pair dipoles of standard quantum field theory and permittivity is the resistance to field propagation due to the van der Waals torque produced by those dipoles.

Another way to look at it is in terms of the electric flux vector $\boldsymbol{D}$. In a medium, in addition to the quantum field medium, the flux vector can be described as shown in Equation 1.

Equation 1

$$D = \epsilon E = \epsilon_0 E + p$$

In this case, ε is permittivity of the medium, $\boldsymbol{E}$ is the electric field, and $\boldsymbol{p}$ is the induced dipole moment per unit volume. We can instead write $\boldsymbol{p}$ in terms of the polarizability per unit volume of the medium (α_V) and the electric field as shown in Equation 2.

Equation 2

$$D = \epsilon_0 E + \alpha_V E$$

Now if we consider the flux in space with no medium other than the quantum field, we recognize that the permittivity of space equals the polarizability per unit volume of the quantum field ($\varepsilon_0 = \alpha_V$).

What happens in the physics of ordinary textbooks is that they ignore the polarizability of the quantum field, renormalize, and set the permittivity to ε_0, thus ignoring the underlying physical cause.

3. Permeability of free space

Like the electric constant, the permeability of free space (μ_0) is another great example of how the van der Waals torque of the quantum field produces the physical constants. One definition of permeability, which is also known as the magnetic constant, is the measure of resistance that is encountered when forming a magnetic field in a particular medium. As with permittivity, physicists who deny quantum field theory and consider space empty, find they have no physical medium to explain permeability. They also cannot provide a physical explanation for magnetic fields.

Fortunately, the quantum field exists and it is the medium that determines the permeability of space. The quantum field is composed of dipoles and those dipoles can rotate. And when they rotate, they become quantum magnets, each with both a north and south pole. These quantum magnets then align with physical magnets and each other. In this way, we can understand the physical reality of magnetic fields and the magnetic Faraday field lines.

In order for magnetic fields to form, quantum dipoles must rotate and then their magnetic pole orientation must align in a way that resembles the magnetic lines of polarization. All forms of rotation meet the resistance of the van der Waals torque of the quantum field. Initially there is torque resisting the rotation of the dipole. Then the rotating dipoles form quantum magnets so there is a secondary torque resisting the rotation of the quantum magnets as they become polarized along the magnetic lines of force.

So as with permittivity, the medium is the quantum field and the source of the resistance encountered when forming a magnetic field is the van der Waals torque of the quantum field. Permeability is due to the van der Waals torque of the quantum field.

4. Impedance of space

The impedance of space (Z_0) is one of two important constants, three if we include Coulomb's constant, that can be derived from the permittivity and permeability of space. The impedance of space is a measure of the ratio of the electric field strength (**E**) divided by the magnetic field strength (**H**). This equals the square root of the ratio of permeability and permittivity as shown in Equation 3. Impedance is measured in the unit of Ohms (Ω), the electrical unit of resistance, and is approximately equal to 376.73 Ω.

Equation 3

$$Z_0 = \frac{E}{H} = \sqrt{\frac{\mu_0}{\epsilon_0}}$$

Consequently, the impedance of space is a measure of the electrical resistance of space due to the van der Waals torque of the quantum field. And, the known value of the impedance of space gives us an additional way to measure the van der Waals torque of space. In the bigger picture it tells us that all aspects of the electrical resistivity of space are ultimately due to the local van der Waals torque of space.

We can also consider the admittance of space (Y_0), which is the inverse of the impedance of space and can be thought of as a measure of how easily current flows through space. Admittance is important when we consider displacement current as defined by Maxwell. The rate of change of displacement current is governed by the van der Waals torque of the quantum field. Displacement current requires change in orientation of quantum dipoles in the same way we see with the admittance of space.

5. The Speed of Light

The other important constant that is derived from the permittivity and permeability of the quantum field is the speed of light. The relationship between the constants is shown in Equation 4. The speed of light ($\mathbf{c_0}$) must also be due to the van der Waals torque of the quantum field since it is equal to the inverse of the square root of the product of the permittivity and permeability, which are both due to the van der Waals torque of the quantum field. If it is true for one side of the equation, it is true for the other side as well.

Equation 4

$$c_0 = \frac{1}{\sqrt{\epsilon_0 \mu_0}}$$

The speed of light in free space can also be expressed in terms of the impedance of free space as shown in Equation 5. As such, we can think of the speed of light being due to the electrical resistance of space. This theory can be extended to discussions of the speed of light in other media as the van der Waals torque of the quantum field changes in the presence of matter.

Equation 5

$$c_0 = \frac{1}{Z_0 \epsilon_0} = \frac{Z_0}{\mu_0}$$

The idea that the speed of light is a constant in free space requires ignoring the effects of the quantum field, renormalizing, and setting $\mathbf{c_0}$ as a constant. Dicke expressed it as follows.

> *This property* [polarizability of the vacuum] *suffers from divergence difficulties which are usually ameliorated by "renormalization." By defining the velocity of light in empty space as* **c** *and "renormalizing," the vacuum polarization effects are made to disappear for a weak electromagnetic wave in free space whereas they still contribute to the space charge about a charged particle. This, however, is arbitrary. The velocity of light in a "bare" space could be greatly different from* **c** *or even meaningless.*

If we take the view that Planck's principle of quantum harmonic oscillators applies to space, then there can be no such thing as bare space or empty space, thereby making the idea of the speed of light in bare space meaningless as Dicke suggested. But beyond his conclusions about the speed of light, the speed of light is directly limited by the van der Waals torque of the quantum field.

We can understand the physical interaction mechanism better by considering that light has rotating electric and magnetic fields. It has been shown that light behaves as if it contains a rotating virtual particle pair each half wavelength as illustrated in Figure 2, as that interpretation is a standard part of quantum field theory.[6]

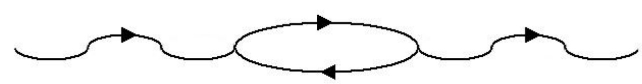

Fig. 2. A quantum electron-positron pair appearing as part of a photon.

De Broglie even suggested that photons are made of rotating electron-positron pairs as described in the following quote.[7]

> *We saw how the dualist view of light, in which photons are associated with light waves, serves as a guiding line in the structure of Wave Mechanics. The original aim of this mechanics was to provide a general theory of the connection between waves and corpuscles—a theory applicable equally to light and Matter, to photons and electrons. In its original form* [known as the Schrödinger equation]*, nevertheless, Wave Mechanics is far from providing us with the foundation of an adequate theory of Light under the twofold aspect as wave and corpuscle. Why is this so? The first reason is that the original Wave Mechanics is not relativistic, and therefore is valid only for corpuscles of low velocity as compared with that of Light. Consequently it cannot be applied to the corpuscles of which Light itself consists. Secondly, the original Wave Mechanics employed a scalar and isotropic wave, and lacked the necessary symmetry elements required to explain the polarization of Light. Finally, it also fails to provide us with any means for giving to light-waves the electromagnetic character which, since the days of Maxwell and Hertz, we know that it certainly possesses.*
>
> *With the introduction of Dirac's Electron Theory, however, the position has changed. For this is a relativistic Theory, and as such applicable to the photon. Further it introduces an anisotropic wave, having a certain analogy*

with the polarization of Light. Finally, it connects electromagnetic magnitudes, derived from its intrinsic magnetic moment, with the corpuscle, and these magnitudes have a certain analogy with the fields of Maxwell's electromagnetic wave. It might thus have been hoped that an application of Dirac's equations to the photon would give us a satisfactory dualist theory which could be applied to Light. Actually, however such was not the case, and without entering here into details I will merely say that a photon constructed on such lines would possess only half the symmetry necessary for an adequate theory of Light. Having made this discovery, the present author recently formulated a theory of Light in which the photon is regarded, not as a single Dirac corpuscle, but as a pair of Dirac corpuscles analogous to the pair formed by a positive and negative electron. This conception leads to very satisfactory results, at any rate as far as the propagation of Light in empty space is concerned. It accounts also for polarization of Light, and enables us to formulate exactly the real and deep relation subsisting between spin and polarization. We are also enabled to attach to the photon an electromagnetic field, completely identical with that by means of which Maxwell represented light.

De Broglie later switched to the idea that light is made of pairs of neutrinos, partly to deal with the mass issue since the idea of massless virtual electron-positron pairs was not yet understood. With the concept of massless virtual particle pairs firmly ensconced in quantum field theory, we can return to the original de Broglie electron-positron model of photons with the electron-positron particle pairs being identical to the quantum dipoles of quantum field theory.[8]

If we think of light as rotating quantum dipoles, or otherwise equivalent to them, we readily see that their rate of rotation and distance traveled per wavelength are regulated by the van der Waals torque of the quantum field. Even if one chooses not to accept a dipole model of photons, the rotation rate of the rotating electromagnetic fields of the photon is still limited by the van der Waals torque of the quantum field. The speed of light is determined by the van der Waals torque of the quantum field.

6. The Relationship Between Constants

We can further examine the importance of the van der Waals torque of the quantum field by considering the known relationship between some of the most important fundamental constants that appear in Equation 6. It shows that the fine structure constant (**α**), is a function of electric charge (***e***), the reduced Planck's constant (***ħ***), the speed of light, and the permittivity. It can alternatively be written in relation to the permeability (not shown), or the impedance of free space as shown and written in terms of Planck's constant (***h***).

Equation 6

$$\alpha = \frac{1}{4\pi\epsilon_0}\frac{e^2}{\hbar c} = \frac{e^2 Z_0}{2h}$$

While putting this equation in terms of ***h*** can be viewed as a simplifying step the use of the reduced Planck's constant helps remind us that Plank's constant relates to the quantization of angular momentum. Both ***h*** and ***ħ*** are related to the van der Waals torque of the quantum field as will be discussed in more detail in a section 8. This also leads to the conclusion that the van der Waals torque of the quantum field yields quantized effects.

Equation 7

$$Y_0 h = \frac{e^2}{2\alpha}$$

We can look at these relationships a little differently by thinking of them in terms of admittance Y_0 of space as shown in Equation 7. The quantized admittance is then equal to the ratio $e^2/2\alpha$. This leads us to consider that electric charge, the fine structure constant, and their ratio are likely a direct consequence of the van der Waals torque of the quantum field.

7. Electric Charge

What is electric charge? Particles are thought to possess charge, and free particles or resonances have unit charges of 0, ±1, or ±2. If we look at the decay products of those particles that decay, electrically neutral particles decay into an equal number of positively and negatively charged particles, ones with ±1 charge have a single charged particle that is not cancelled out by an opposing charge (ex. an electron) and

±2 charged particles have two charged particles that are not cancelled out (ex. an electron and anti-proton). In the quark model, quarks have fractional charges, but quarks are never detected as free particles, so fractional charges do not exist in a free state.

Particles are thought to have electric charge which produces electric fields and those fields lead to electric forces. Looking at it from the perspective of quantum field theory, the charge of a particle polarizes the quantum field which becomes the electric field. In this respect, charge can be thought of as a particle's ability to polarize quantum particle pair dipoles. Charge is directly related to the polarizability of the quantum field.

Equation 8

$$Q = \oint_S P \cdot dA$$

Based on Gauss' Law, when we have a volume of space polarized by a charge within that volume, the surface integral of the flux of the polarization (**P**) over the surface area **A**, gives us the charge inside as shown in Equation 8. In the simplest case of a spherical surface, the total flux over the area of any radius sphere will be the same. This is necessary to comply with the principle of conservation of energy and the inverse square law.

Since free particles have unit charge, we can see that the polarization of space in a given volume is related to the number of charged particles in that volume. We can better think of those particles as polarizers.

In the past, many physicists have explored the idea that charge may be distributed as smaller subunits of charge throughout a volume, surface or other structure. This approach runs into difficulty when we consider particles of different masses, sizes, and hypothetical structures as it fails to explain how the unit charge would be the same for every free particle. Consequently, that approach has not led to satisfactory results. It also fails to address the fundamental question of what is charge.

It turns out that we probably have been looking at the problem incorrectly. The polarizability of space is not dependent on free and stable particles. Quantum field theory and Equation 8 gives us a unit charge that is the same for every particle if we assume a consistent polarization mechanism. The unit charge exists because the polarizability of space is the same for any unit polarizer—charge.

Charge is a function of the polarization of space rather than being due to something else we might call charge. Instead of thinking that particles possess something called charge we should instead simply treat them as a polarizer. The magnitude of a single unit charge is determined by Equation 9 for a single polarizing particle.

Equation 9

$$e = \oint_S P \cdot dA$$

One might be tempted to say this is merely kicking the can down the road rather than solving the problem, as instead of defining a unit charge we have a unit polarizer. It is easy to see a path forward if we recall Dirac's discussion about the equation that bears his name when he had the idea that the positive and negative energy solutions to his equation could be thought of like bubbles and holes in a sea of electrons, the Dirac Sea.[9] Note that the Dirac Sea is an early conceptual model of the quantum field.

Bubbles fill holes and the particles annihilate, but bubbles are also repelled by other bubbles. This repulsion is possibly similar to the force responsible for the Pauli Exclusion Principle. In this view, the question of what the polarizer is could be seen as a vast simplification of the problem.

We can dispense with the notion of charge and frame the discussion on polarization and polarizability. Particles should not be said to have charge, but rather they are a polarizer. So, instead of asking what is charge, we should be asking how a particle polarizes the quantum particle pairs that fill space. And we can acknowledge that electric charge is a constant because the polarizability of the quantum field is constant.

Regardless of the physical mechanism responsible for polarization, framing the electric charge question as a polarizability of the quantum field question tells us that an electric charge is a measure of the polarizability of the quantum field, which is in turn determined by the van der Waals torque of the quantum field.

8. Planck's Constant and Energy

Planck's constant can be thought of in two principle ways, as the quantization of angular momentum and as a conversion term between energy and frequency. The latter is shown in Equation 10. This equation also shows that the wavelength and speed of light can be substituted for the frequency based on their well-known relationship.

Equation 10

$$h = \frac{E}{f} = \frac{E\lambda}{c}$$

As mentioned previously, angular momentum implies that something is rotating. Rotation of an electrically charged body causes the dipoles of the quantum field to rotate, and their rotation, and the rotation of the charged body, are governed by the van der Waals torque of the quantum field.

Perhaps the most fundamental quantization of angular momentum is found in the spin quantization of particles which occurs in increments of $\pm\frac{1}{2}\hbar$, which can also be written $\pm h/4\pi$. Spin is usually stated as simply ±½, with the $\hbar$ assumed. We can substitute into Equation 6 and rearrange to get Equation 11 for the spin quantum (***S***).

Equation 11

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

Equation 11 can be further simplified by expressing it in natural units where ε_0, and ***c*** are equal to one to obtain Equation 12. We can then see that the spin quantum is related to the ratio between the electric charge squared and the fine structure constant. Planck's constant is related to electric charge and the fine structure constant in the same way.

Equation 12

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

As with electric charge, it has always seemed peculiar that the spin quantization is the same for every particle regardless of the particle's mass or hypothetical size or structure. This is not the case for the angular momentum of objects in the macroscopic world. And like charge, this points to the possibility that spin is not a property of the particle itself, but rather a property of something else that is uniform with respect to all particles, namely the quantum field. A detailed analysis of how spin arises from the quantum field is big project and beyond the scope of this paper.

With regard to Plank's constant's relationship to the quantization of energy we can examine how it relates to light. Light photons, in addition to having frequencies and wavelengths, have rotating electric and magnetic fields. The rate of rotation of those fields is determined by the van der Waals torque of the quantum field. That torque determines the wavelength traveled by a given frequency photon. The relationship between frequency, wavelength and the speed of light are all fixed by the van der Waals torque of the quantum field.

Considering the relationship between Planck's constant and the energy (***E***) in Equation 10 we must note that ***E*** is not a constant. ***E*** is a measurement of energy. There are many units for energy, and units that are related to energy, and, consequently, Planck's constant has many different values in different units. We can even select a natural energy unit such that the value of ***h*** has a dimensionless value equal to one. In that case, the absolute numerical value of ***E*** in this natural energy unit is equal to the absolute numerical value of frequency ***f*** in cycles per second.

This leads us to an important consideration that it is more fundamental to think of energy as frequency and the conservation of energy is more broadly the conservation of frequencies. In particular we must consider energy as frequencies of the quantum fluctuations of the quantum field. The well-known equation for the energy density ($\boldsymbol{\rho}$) of the quantum field, is shown in terms of circular frequency ($\boldsymbol{\omega}$) in Equation 11.[6]

Equation 11

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

The energy density of space is determined by the range of quantum fluctuation frequencies present. Perhaps more importantly, the energy of space may be reduced locally by displacing a range of frequencies of quantum fluctuations. The constants ***c*** and $\hbar$ are fundamentally determined by the van der Waals torque of the quantum field, so the energy of space for a given range of frequencies is also determined by the van der Waals torque of the quantum field.

It is clear that Planck's constant, both in its role as a measure of the quantization of angular momentum and with regard to energy conversion, is a function of the van der Waals torque of the quantum field.

9. The Fine Structure Constant

Of the constants in Equation 6 only the fine structure constant remains to be considered. The fine structure constant is a dimensionless number that is approximately equal to the inverse of 137.

It has already been shown that the constants on the right side of that equation ε_0, e, c, and $\hbar$ are each dependent on the van der Waals torque of the quantum field. As with other equations, when a constant can be derived from a set of constants that are due to a physical cause then the first constant must also be due that cause. This tells us that the fine structure constant is due to the van der Waals torque of space.

Equation 12

$$\alpha = \frac{e^2}{4\pi}$$

If we want to examine the fine structure and get a better physical understanding of it we can start by presenting Equation 6 in natural units with ε_0, c, and $\hbar$ set to a unitless value of 1. This gives us Equation 12, which shows a direct relationship between the fine structure constant and electric charge. It also includes a 4π term that indicates a circular geometry or that we are at least working with circular frequencies as we should expect given Equation 6 is terms of $\hbar$. Additionally, we should note that this expression means α is related to e which is known to be due to the polarizability and van der Waals torque of space.

Equation 13

$$\alpha = \frac{e^2}{2}$$

Alternatively, we can put Equation 6 in terms of h, and set h to 1 in a slightly different set of natural units. In that case we get a simpler relation where the fine structure constant is equal to $e^2/2$ as shown in Equation 13. Using the known value of α we can determine the value of e in either set of natural units.

Using either Equation 12 or 13, we are left with the question of what does it mean physically for α to be proportional to e^2? To answer that question, we first have to go back to Equation 9 which shows us that electric charge is equal to the surface integral of the polarization of space for a single polarizer.

Then looking at Equation 13 we can readily see that the term on the left is in the same form as the answer to the simple calculus problem, the integral of x as shown in Equation 14.

Equation 14

$$\int x \, dx = \frac{x^2}{2}$$

Since electric charge equals the surface integral of the polarizability of space, we can perform a second integral on the polarization of space to obtain the polarization of a volume of space. The first integral inside the parentheses in Equation 15 equates to the unit charge (e) from Equation 9. We can perform this operation using only spherical surfaces to simplify the second integration. The second integration over a range of radii (r) from 0 to infinity yields the polarization of the entire volume of space due to a unit polarizer—charge.

Equation 15

$$\int_0^\infty \left(\oint_S P \cdot dA \right) dr = \frac{e^2}{2}$$

Per Equation 13 we then see that the volumetric integral of the polarizability of space gives us the fine structure constant when we are working in natural units with ε_0, c, and h set to 1. We must therefore conclude that the fine structure constant is a measure of the polarization of the entire volume of space due to a unit polarizer—charge.

Since the polarizability of space is regulated by the van der Waals torque of the quantum field, the fine structure constant is also due to the van der Waals torque of the quantum field. All the constants in Equation 6, which are among some of the most important of all the physical constants, are properties of the van der Waals torque of the quantum field. None of them are truly elementary.

10. Mass

The mass of the electron ($\boldsymbol{m_e}$) and proton ($\boldsymbol{m_p}$) are the next physical constants we must consider. Physicists need to understand the physical origin of the masses of the two permanently stable particles, and from there understand the physical explanations, for the masses of all the unstable particles or resonances.

We observe that the masses of many of the unstable resonances—particles—have a simple relationship relative the fine structure constant in units of millions of electron volts divided by the speed of light squared (MeV/$\boldsymbol{c}^2$). Common examples include the pions which have a mass approximately equal to $1/\boldsymbol{\alpha}$ MeV/$\boldsymbol{c}^2$. The muon mass is close to $\frac{3}{4}/\boldsymbol{\alpha}$ MeV/$\boldsymbol{c}^2$ while the tauon mass is close to $13/\boldsymbol{\alpha}$ MeV/$\boldsymbol{c}^2$. Perhaps the most complete cataloging of the relationship between the fine structure constant and the masses of the unstable resonances can be found in Malcolm H. MacGregor's book The Power of α: Electron Elementary Particle Generation with α-Quantized Lifetimes and Masses.

This strong relationship between $\boldsymbol{\alpha}$ and mass is problematic as it is possible to construct purely numerological approaches to calculating the masses of the unstable resonances—particles. Most numerological approaches to calculating mass fail to account for the physical origin of mass. Although, in some cases, a physical model is conceived that is physically impossible but can nonetheless be mated to a numerological model.

The relationship between the fine structure constant and mass is so clear that there must be a physical link between the two. Since it was shown in the previous section that $\boldsymbol{\alpha}$ is a purely electromagnetic phenomena, we must conclude that mass is also electromagnetic in origin.

To understand the physical origin of the mass of the proton and electron we can start with a hypothesis put forth by Dirac. When Dirac was faced with the problem of having a positive and negative solution to the Dirac equation, he came up with the idea that both particles have positive mass-energy because they are both a type of bubble in the Dirac sea of electrons—the quantum field. As such, they must have a certain amount of energy to push against the Dirac Sea, and that energy is positive for both particles.[9] He thought that energy may account for the positive mass-energy of both particles, but he never published a paper where he tested his hypothesis.

Starting with the proton, we know it has a charge radius and scatters protons and laser light in scattering experiments. It must also scatter quantum fluctuations that approach it's charge radius, consequently making a hole in the quantum field of space. We can test Dirac's hypothesis by treating a proton as a spherical shell and compute the quantum field energy it displaces using Equation 11. The effective thickness of the shell can be based on quantum uncertainty.

The author previously tested Dirac's hypothesis and showed that the proton mass-energy is equivalent to the quantum field energy displaced by a proton modeled in such a way. It was also shown that the mass of the electron can be similarly accounted for as Dirac predicted if the electron interferes with quantum field energy on the scale of the Campton wavelength.[10]

It has been known that the electron mass equates to a large electron rather than a point electron, so this result is not a surprise. It does leave the question of how the electron, or proton, interferes with or scatters the quantum field fluctuations. Based on the analysis of charge in prior sections we can speculate that the polarized quantum field around a particle interferes with the existence of other quantum fluctuations on the scale of the effective particle radius. Beyond that bit of speculation, we do not have enough detailed knowledge of electron or proton structure to answer the question.

The unstable resonances—particles—appear to have their physical masses determined in an entirely different way that has so far not been discovered. At least no model explains the physical electromagnetic relationship to the fine structure constant. As stated previously, it is straightforward to come up with a numerological model while failing to provide a proper physical explanation.

We can conclude that the mass of the electron and proton can be accounted for as purely electromagnetic phenomena consistent with the quantum energy density equation, Equation 11. Since the neutron has a similar mass and radius to the proton, the mass of the neutron can be computed the same way.

The constants in Equation 11 are all dependent on the van der Waals torque of the quantum field, which means that $\boldsymbol{m_e}$ and $\boldsymbol{m_p}$ are also dependent on the van der Waals torque of the quantum field. This is true in any physical model for mass based on the fine structure constant, since $\boldsymbol{\alpha}$ is solely an electromagnetic phenomenon.

11. The Physical Constants

At this point it has been shown that many of the most important physical constants are properties of the van der Waals torque of the quantum field. The list so far includes the permittivity of space, the permeability of space, the impedance of space, the admittance of space, the speed of light, electric charge, Planck's constant, the reduced Planck's constant, the spin quantum, the fine structure constant, and the masses of the proton and electron ($\boldsymbol{\varepsilon_0}$, $\boldsymbol{\mu_0}$, $\boldsymbol{Z_0}$, $\boldsymbol{Y_0}$, $\boldsymbol{c}$, $\boldsymbol{e}$, $\boldsymbol{h}$, $\boldsymbol{\hbar}$, $\boldsymbol{S}$, $\boldsymbol{\alpha}$, $\boldsymbol{m_p}$, $\boldsymbol{m_e}$).

Using the premise that if all the constants on the right side of the equation are due to one physical cause, the one on the left is due to the same physical cause, we can list many other important physical constants that are due to the van der Waals torque of the quantum field. This list includes Coulomb's constant, the Bohr magneton, the conductance quantum and its inverse, the Josephson constant, the magnetic flux quantum, the nuclear magneton, the van Klitzing constant, the Bohr radius, the classical electron radius, the Rydberg constant, and the Hartree energy ($\boldsymbol{k_e}$, $\boldsymbol{\mu_B}$, $\boldsymbol{G_0}$, $\boldsymbol{G_0^{-1}}$, $\boldsymbol{K_J}$, φ_0, $\boldsymbol{\mu_N}$, $\boldsymbol{R_K}$, $\boldsymbol{a_0}$, $\boldsymbol{r_e}$, $\boldsymbol{R_\infty}$, $\boldsymbol{E_h}$,). As MacGregor's book points out, based on our knowledge of the fine structure constant we can also account for particle lifetimes.

The two lists contain 24 of the most important constants in physics, and importantly, these constants represent the entirety of electromagnetic theory. This tells us that the entirety of electromagnetic theory is a direct consequence of the van der Walls torque of the quantum field. Consequently, none of these constants are independently variable and the constants form a unique set whose values are determined by properties of the quantum field. These constants are also not elementary.

12. Gravity Discussion

The most important remaining constant is Newton's gravitational constant $\boldsymbol{G}$, which brings us back to the Wilson-Dicke theory and related theories that gravity is an electromagnetic phenomenon. If the fine structure constant is electromagnetic, then mass is electromagnetic. And if mass is electromagnetic, gravity is electromagnetic. As Dicke described it.

> *The physical idea is simply that a space variation in the polarizabilities of the vacuum will lead to a number of results familiar as typical gravitation effects. For example, an increase of the index of refraction of the vacuum in the vicinity of the sun will cause a bending of light toward the sun.*
>
> *The gravitational force on a charged particle is interpreted as resulting from a change in its electromagnetic self-energy with position as a result of a variation in the polarizability of the vacuum. A gradient in the polarizability results in a force acting on the charged particle. This force results in part from the polarization charges induced in the vacuum by the charged particle. For a medium having a nonvanishing gradient in its polarizabilities there is more induced charge on one side of the particle than on the other and the electrostatic interaction with the induced charges leads to a force acting on the particle in the direction of increasing gradient.*

A development of electromagnetic gravity is beyond the scope of this paper, however the work of Wilson and Dicke that was further advanced by Puthoff who showed their theory can account for three of the so-called proofs of General Relativity, gives us a possible path forward when we substitute the van der Waals torque of the quantum field in those theories in place of Mach's principle.[3][4][11]

We can consider the intriguing idea that the presence of matter in local space increases the local van der Waals torque of space, which is then the physical cause of phenomena such as gravitational redshift, the bending of light, and the precession of the perihelion of Mercury as shown by Puthoff.[11]

As for the constant $\boldsymbol{G}$, we appear to have another case of physicists ignoring the quantum field effects, renormalizing, and setting a constant, rather than examining how that constant arises from the quantum field.

13. Conclusion

One of the consequences of mainstream quantum field theory is that the quantum field must produce van der Waals torque that regulates all charge motion and momentum, be it linear or angular. It regulates the quantum fluctuations themselves in addition to the motion of all electric charges. As a consequence, the van der Waals torque determines the polarizability and magnetizability of space and the constants of permittivity and permeability of space.

Given that beginning, it is a simple matter to extend the idea to all the electromagnetic constants and show that the magnitude of each of them is ultimately due to the van der Waals torque of the quantum field. As such, the electromagnetic physical constants can be grouped together as a unit where none of them is independently variable, nor are they elementary. Constants that describe the van der Waals torque and the polarizability of the quantum field are elementary.

It is particularly important to note that this paper shows that it is best to consider electric charge as the polarization of space surrounding a unit polarizer. This simplifies the task of explaining the physical origin of the unit electric charge. This approach can then be extended to allow us to derive the fine structure constant as the total volumetric polarization of space by a unit polarizer—charge.

The most important constant that must be studied further is the gravitational constant, and one possible path forward is to treat it as an electromagnetic constant due to the van der Waals torque of the quantum field. Additional research must be conducted to fully understand the quantum field origins of the force we call gravity.

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