The derivation of the Planck constant h and the quantization of space

Preprint · December 2022

DOI: 10.13140/RG.2.2.34369.07527

1 author:

Oyvind Alv Liberg

The derivation of the Planck constant *h* and the quantization of space

Version 2.0

December 17th 2022

Author: Øyvind Alv Liberg

Email: oyvind@liberg.info

Keywords
Planck's constant, energy of space, matter particles as standing waves, spin angular momentum, orbital angular momentum, quantized space

Summary

Based on a new model of particles having the shape of a torus, this paper derives the Planck constant h in terms of other known fundamental constants. An outline of the new particle model is presented as the introductory chapter.

The vacuum of space is not a void, as it is a huge reservoir of energy of unknown origin. All matter particles exist as pairs of standing waves in this energy medium, with the wave pairs themselves being in phase-lock. It is this phase-locked structure which gives energy of space the form of tangible matter, whereas the energy itself is not tangible. The energy medium has the structure of densely packed and extremely small spheres we refer to as granules. It is in this energy that we find Planck's constant. In terms of dimensions, h is a unit of momentum.

The physical interpretation of h was found to be the overall spin (angular momentum) of a volume of granules contained within a sphere of radius a_0, also known as the Bohr radius. With the granules being in phase-lock with the orbiting electron, this gives the granules spin. As the granules are locked in an immensely stiff grid-like structure, they are not free to move about. Thus, the momentum is due to the (intrinsic) spin of granules and not as orbital angular momentum.

The radius of a granule was calculated as $1.3574106807 \cdot 10^{-19}$ m.

An interesting conclusion is that the Planck's constant, which is the very building block of the quantum nature of reality, is actually in full accord with Newtonian principles. On basis of this theory, we could also conclude that space itself is quantized – a thought that might open a new path towards a deeper understanding of how Nature works at its most fundamental level.

Table of Contents

1 A new theory on the dimensions and other properties of particles

1.1 Introduction

Our quest for a new theory was based on the following observation: If the vacuum of space is really a complete void, how can the complete nothingness have measurable properties like the electrical constant and even an impedance of 377 ohm? Considering the incredible energy densities of all particles, we reasoned that space itself has to have some energy density, which must be truly stupendous. But how come this energy is so undetectable? How can matter propagate through space without slowing down? In short; what are the true properties of the vacuum of space?

There is no way to sense something that is absolutely the same everywhere. This simple fact gave rise to the idea that a particle of matter is the result of a *deviation* from the quiescent energy of space where the particle is located. This deviation is again due to a pair of highly localized standing waves in mutual resonance. In this view, a particle is not in the form of a spherical hard-shell body. Thus, the only things we might sense are *deviations* from the equilibrium of the space medium. This is why a particle of matter is tangible, whereas the space energy itself is not.

To overcome the problem of unimpeded motion through space, there was only one option: All matter particles must be resonances in this medium. To be sustainable, these resonances must be standing waves of certain wavelengths, which we assume represent extremely high frequencies. In this view, particle motion is the propagation of a certain amount of energy - this being the energy of the particle itself. We may liken the propagation of energy with Newton's cradle, where in theory energy and momentum can propagate with no losses over any distances. The energy of space can hence be viewed as a rigid grid, with particles represented as small, local distortions in this grid. Motion of a particle is therefore no other than the propagation of such distortions in the space grid. The highest possible propagation speed is that given by the properties of space itself, just like sound in air. This is of course the speed of light c.

1.2 Deriving the energy density of the space medium

We start with the well-known Coulomb force equation, which is expressed as:

$F = k_e \cdot \frac{q_1 \cdot q_2}{r^2}$ This is the force F between two electric charges.

Here q_1 and q_2 are unit charges and r is the centre-to-centre separation between them.

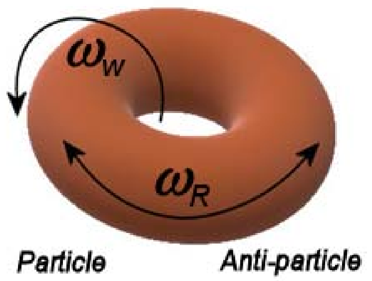
k_e is Coulomb's constant, of value $8.9875517873681764 \cdot 10^9$ N·m$^2 \cdot$ C^{-2}. It is given by $k_e = \frac{1}{4\pi\varepsilon_0}$.

The dimension Coulomb "C" is the SI unit of electric charge and is the amount of charge transported by a constant current of one Ampere in one second.

We see that the unit of charge is a product of both definition and convenience, as it contains no low-level dimensions that might allude to what charge actually is. The same can be said about Ampere as the unit of electric current.

In this theory we are working on the idea that the electron has the shape of a torus, like a smoke ring or a doughnut. This shape also gives a rational explanation for anti-particles. Thus, we strongly suspect that the electron and its electric charge is somehow associated with this shape, and also that electrostatic forces arise when torus-shaped particles interact by sharing their energy flows.

This view gives an easy and intuitive understanding of the observed reach of electric forces.
The torus also has some inherent stability, as can be demonstrated with a smoke ring.



We therefore *postulate* that the low-level dimension for electric charge is the rate of energy flow expressed in mass equivalents; that is kg/s. This is in keeping with Milo Wolff's model of a particle as a standing wave in the space medium, with wave components represented by an in-wave and an out-wave [1]. However, in this theory we interpret the in- and out-waves as being one and the same, flowing in and out of the particle's orifice in a *closed loop* and in one direction only. This will assist in maintaining the particle's shape, and at the same time explain the "where from" and "where to" of the flows of Wolff's model. The very idea of a flow in a dense and stiff medium might seem as a contradiction and an outright impossibility. However, with particles of matter taken to be standing waves, this is not at all contradictory.

In this theory the Coulomb's constant is taken to be the energy density of the space medium in its quiescent state. This energy density has an equivalent mass density through the relation $E = mc^2$. However, replacing Coulomb's constant with a new physical constant does that there is no longer a constant of proportionality in the Coulomb force expression to balance it, neither in terms of its numerical value nor its dimensions. If not doing this substitution, k_e takes the dimensions of inverse density, or m^3/kg. This is the direct consequence of defining electric charge as kg/s. As we shall soon see, the justification for this is that this value of density gives the exact value for unit electric charge, besides very credible values for particle dimensions and even particle spin and anti-matter.

Therefore, to make the dimension that of density and not its inverse would require the inclusion of a new constant in the numerator of the Coulomb expression, with a fixed value of 1 and having the dimensions of (m^3/kg)^2. Since this new constant has the value of unity, it will be "invisible" in any numerical calculations.

Rather than contemplating on what this new constant should be called and giving a symbol for it, we acknowledge that numerically k_e equals the density ρ_{space}, ignoring the new constant until further.

We know that Coulomb's law applies irrespective of the charged particles being electrons or protons or their anti-particles. Thus, the re-defined Coulomb constant k_e must still be constant. If not so, there would be a Coulomb's law that depended on the type of charged particle involved. Such a dependency has never been observed.

We shall see that by choosing the *numerical* value $k_e = \rho_{space}$, we can build a new theory that explains many of the problems and short-comings that trouble modern physics.

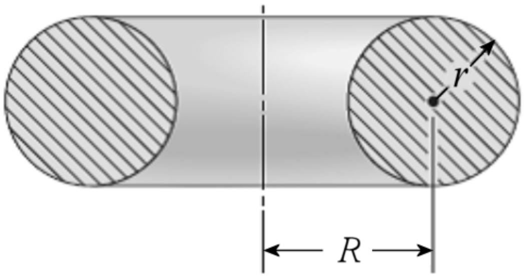
We can therefore *postulate* that: ρ_{space} = 8.9875517873681764·10^9 kg/m^3.

This is exactly $c^2/10^7$. The balancing factor 10^{-7} is included in the magnetic constant μ_0, as we recall that $c^2 = 1/(\mu_0\varepsilon_0)$. See the appendix 4.2 for more on this.

The extreme precision by which the Coulomb constant and therefore also ρ_{space} are defined, together with the exact definition of the speed of light, does that all the dimensions we can derive on basis of these will themselves have the potential to be defined with similar high precision.

1.3 Deriving the radius of a particle's core

Volume of a torus: $V_T = \pi r^2 \cdot 2\pi R = 2\pi^2 R r^2$



Here r is the radius of the solid torus body (ring) and R is the distance from the centre of the core opening out to the middle of the solid torus body.

Area of the torus core opening (orifice): $A_{TC} = \pi(R-r)^2$

Volume flow rate in m³/s through the core if flow speed is c:

$V_{FC} = A_{TC} \cdot c = \pi(R-r)^2 \cdot c$ m³/s.

The flow of space energy through the orifice, expressed in its mass equivalent: $V_{FC} \cdot \rho_{space}$ kg/s.

Equate unit charge q with the rate of energy (in mass units) flow through the particle's orifice.

Thus: $q = \pi(R-r)^2 \cdot c \cdot \rho_{space}$ kg/s. Rearranging: $(R-r) = \left(\dfrac{q}{\pi c \cdot \rho_{space}} \right)^{1/2}$

Inserting known values: $(R-r) = \left(\dfrac{1.602176634 \cdot 10^{-19}}{\pi \cdot 2.99792458 \cdot 10^{8} \cdot 8.987551792261 \cdot 10^{9}} \right)^{1/2}$

$\Rightarrow (R-r) = \Delta = 1.375780678807 \cdot 10^{-19}$ m

With reference to the figure above, Δ is the radius of the "hole in the middle" of the torus.

In our new theory, Δ is used as the unit of length for particle dimensions. As standing waves involve exact integer units of wavelengths, then wavelengths expressed in units of Δ will necessarily be an integer number of this unit.

1.4 Deriving the unit of electric charge

It is suggested without direct proof that $(R-r) = \Delta$ is constant for all charged particles. The reason for this is that unit charge is the same for all stable particles. It is independent of particle mass and the charge polarity. As transfer of momentum always propagates at c (according to the principle of momentum transfer in Newton's cradle), this assumption is reasonable if electric charge is taken to be the rate of flow of energy (mass) through the orifice of the particle.

This also explains why charge is found to be independent of particle velocity. As the flow speed is c at all times and cannot be exceeded, the particle's own motion cannot be added to it.

With this definition of unit electric charge, it can be given with the following expression:

$q = \pi \Delta^2 c \rho_{space}$ kg/s Inserting the values for Δ and ρ_{space} found above, this becomes:

$$q = \pi (0.137578067356 \cdot 10^{-18})^2 \cdot 2.99792458 \cdot 10^8 \cdot 8.987551792261 \cdot 10^9 \text{ kg/s}$$

$$q = 1.60217662178 \cdot 10^{-19} \text{ kg/s.}$$

Thus, in our theory the unit Coulomb is actually kg/s.

Note that the official value for the unit (elementary) electric charge was updated slightly on May 20th 2019 [5] and is now taken to be *exactly* $q = 1.602176634 \cdot 10^{-19}\, C$. It is therefore a slight difference at the 8th decimal place between the official and our value.

1.5 Deriving the size of the electron

The mass of the electron is given by: $m_e = V_T \cdot \rho_e$ where ρ_e is the mass density of the electron. It is expected to be greater than that of the quiescent space energy. And indeed, as will be shown;

$\rho_e \gg \rho_{space}$. We shall now find a value for this mass density of the electron.

$m_e = 2\pi^2 R r^2 \cdot \rho_e$, $\rho_e = \dfrac{m_e}{2\pi^2 R r^2}$ Inserting the known value for m_e:

$$\rho_e = \frac{9.10938355946 \cdot 10^{-31}}{2\pi^2 R r^2} = \frac{0.461486762248 \cdot 10^{-31}}{R r^2} \text{ kg/m}^3$$

We do not know the value of r nor R, only the difference $(R - r) = \Delta$. However, since we believe that all stable particles are in a state of resonance, there is good reason to believe that there is a simple *integer* relationship between the two.

Standing waves require an integer number of wavelengths. Thus, we can consider the radius Δ as the wavelength and use this as our unit of length for the dimensions of the particles.

But what might be the number of such wavelengths for an electron? The following calculation gives us a clue to this number we shall call n_e.

First, we do a calculation, assuming that the electron has a spherical shape and a radius r_{ec} equal to its classical value $2.8179 \cdot 10^{-15}$ m. For the classical radius, the electron's mass energy density ρ_{ec} is:

$$\rho_{ec} = \frac{m_e}{\frac{4}{3} \cdot \pi r_{ec}^3} = \frac{9.1094 \cdot 10^{-31}}{\frac{4}{3} \cdot \pi (2.8179 \cdot 10^{-15})^3}$$ giving: $\rho_{ec} = 7.7175 \cdot 10^{13}$ kg/m³.

Incredible as this energy density might seem at first; the classical value of the electron radius is nevertheless known to be much too large, possibly with a factor of 1000 or more. Besides, there is no proof that the electron has the shape of a regular sphere. Considering the cubic factor involved, we can conclude that the electron's energy density must be *at least* $(1000)^3 = 10^9$ times the value found above. This brings the true energy density up to something of the order of 10^{23} kg/m³.

Note that such extreme energy densities are real, whether one subscribes to this theory or not.

Next, we try using the expression for the volume of the torus and a value $n_e = 4$. At this stage this number is just an educated guess, but we shall see that it fits perfectly with other calculations.

Above, we calculated the energy density of the electron as: $\rho_e = \dfrac{0.461486762248 \cdot 10^{-31}}{Rr^2}$ kg/m^3.

Inserting $n_e = 4$ to give the radial dimension $R_e = 4\Delta$ and thus $r_e = 3\Delta$ for the electron:

$$\rho_e = \frac{0.461486762248 \cdot 10^{-31}}{n_e(n_e - 1)^2 \Delta^3} \text{ kg/m}^3 \quad \Rightarrow \quad \rho_e = \frac{0.461486762248 \cdot 10^{-31}}{4(4-1)^2(1.37578067356 \cdot 10^{-19})^3} \text{ kg/m}^3$$

$\rho_e =$ 4.9227653377 · 10^{23} kg/m^3. Being of the order of 10^{23} kg/m^3 and in light of what we calculated for the classical radius, then n_e = 4 might actually seem right.

To conclude this introductory chapter, the dimensions of the electron are:

$$r_e = 3\Delta = 4.12734204 \cdot 10^{-19} m$$

$$R_e = 4\Delta = 5.50312272 \cdot 10^{-19} m$$

The exact size of the electron is not known, but it is known to be less than 10^{-18} m. Thus, our values agree very well with this.

2 Deriving the Planck constant h

2.1 General

The Planck constant h [5] is related to the quantization of light and matter. The extreme minuteness of h reflects the fact that physical objects are made of a vast number of microscopic particles, which according to our theory are themselves waves of stupendous frequencies in the space medium.

We know that the photon energy is in accord with the Planck relation $E = hf$. This expression deals explicitly with frequencies and for which h is a constant of proportionality. However, the deeper meaning of this constant is not well understood. This paper aims to an improved understanding of this physical constant and also of the space medium itself.

Once you have a resonance, like a resonance in a string, then you automatically get harmonics - twice the resonant frequency, three times the resonant frequency, etc. On basis of this, Max Planck (1858 – 1947) hypothesized a constant h that could multiply integer multiples of a fundamental cavity frequency. He assumed that electromagnetic radiation can only be emitted or absorbed in discrete packets, called quanta of energy. And in reality, all of quantum physics and the very notion of the quantum of energy itself is based on the concept of the harmonic oscillator. As there is no such thing as a Planck constant specific for each element, the higher elements, like helium, lithium, etc. are really overtones of the fundamental “cavity” resonance represented by the hydrogen atom.

But how come a constant h is all there is to this relationship besides frequency? Aren't all waves associated with both an amplitude and frequency or wavelength when wave energies are considered? Besides, the number of periods of this frequency is not counted. See chapter 4.1 for more on these thoughts.

In spite of the simplicity of the Planck expression, it seems to safeguard its deeper interpretation. Incredible as it may sound; the value of h can be found to a reasonable accuracy through a simple experiment involving no more than 3-4 LED lamps of different colours, a multimeter and a voltage source [2]. But to derive the Planck expression to show how it relates to other fundamental constants is not that easy. That is – if there are any such relations at all. Is h after all a truly fundamental constant, as many physicists contend? Such a firm view is understandable, as it seems impossible if using current physics and its interpretation of the fundamental constants. Thus, we have to think a bit outside the proverbial box here.

2.2 Calculating Planck's constant

2.2.1 Spin and orbital angular momentum

The constant h expresses energy per cycle and as such has the dimensions kg · m^2/s. Considering its dimensions, this is actually angular momentum. The expression for orbital angular momentum is $L = mvr$, where m is some rotating point mass, v its speed of rotation and r its radial distance to this point. We can be confident that apart from the velocity, all these represent extremely small values.

Multiplied with a frequency f = 1 Hz, having the dimension Hz = 1/ (period time) = 1/s, this gives what we can reason is the smallest possible amount of energy, having the dimensions of kg · m^2/s^2. This is the unit of quantized energy. A larger energy requires a correspondingly larger number of this quantity; hence the multiplying factor is that given by frequency, in accordance with $E = hf$.

Angular momentum L can also be expressed in terms of the moment of inertia I, given by: $L = I\omega$. Here I is the moment of inertia of the mass m and ω its angular velocity around its central z-axis. For a small (point) mass: $I = mr^2$. For larger masses, the total moment of inertia will be the sum of the moment of inertia of the many individual point masses. It can be shown [3] that the moment of inertia of a solid sphere is given by: $I = 0.4{\cdot}Mr^2$, giving it a (spin) angular momentum: $L = 0.4{\cdot}Mr^2\omega$. As ω has the dimensions of radians/second or just 1/s, the spin angular momentum of a sphere can be expressed as: $L = 2/5 \cdot Mr^2/s$ or $L = 0.4{\cdot}Mvr$.

We make a note of the factor 0.4, as we shall see more of this later.

2.2.2 Attempting to derive an expression for h using the Bohr atom model

Consider energy E as force · distance, or expressed in its dimensions: E = kg · m/s^2 · m = kg · m^2/s^2. What might be the force here? The force between the electron and the proton at the Bohr level is: $8.23872283 \cdot 10^{-8}$ kg · m/s^2. Using this to find h and get the dimensions for momentum as kg · m^2/s, it must be multiplied with the product of a length and a time period, so that: m · s = $8.04259384 \cdot 10^{-27}$. But what might these be? This is like finding a solution to a single equation with two unknowns. If m is represented by the length: $\Delta = 1.37578067 \cdot 10^{-19}$, then the time period will be as long as: $5.84584011 \cdot 10^{-8}$ s. This time period is extremely long in an atomic context and hence unlikely.

If we instead of Δ use the much longer Bohr radius $a_0 = 5.29177211 \cdot 10^{-11}$ m, we get a time period of $1.51982997 \cdot 10^{-16}$ s. We recognize this as the time for one orbital period at the ground level. Thus, might the Bohr model of the hydrogen atom be of any help in deriving a value for h?

Bohr contended that there was a standing wave along the circumference of the orbitals, with $2\pi r = n\lambda_n$, or $\lambda_n = 2\pi r/n$. Combining this with the de Broglie relationship: $\lambda = h/p = \dfrac{h}{mv}$ gives:

$\frac{2\pi r}{n} = \frac{h}{mv}$. Rearranging this: $r = \frac{nh}{2\pi mv} = \frac{n\hbar}{mv}$.

Inserting this in the expression for orbital angular momentum: $L = mvr = mv \cdot \frac{n\hbar}{mv} = n\hbar$.

The orbital speed at the ground level of hydrogen is given by: $v_1 = \frac{q}{(4\pi\varepsilon_0 m_e a_0)^{1/2}}$ m/s.

Its value is $2.18769126 \cdot 10^6$ m/s, which is about 0.73 % of the speed of light c. At this speed, the relativistic mass increase appears at the 4th decimal place of m_e, so apparently insignificant.
The vacuum permittivity ε_0; known as the electrical constant, has a value: $8.8541878128 \cdot 10^{-12}$ F/m.

The Bohr radius $a_0 = \varepsilon_0 h^2 / (\pi m_e q^2)$ is $5.29177228 \cdot 10^{-11}$ m. Inserting for $mvr = mva_0$ for $n = 1$:

$mva_0 = m\frac{q}{(4\pi\varepsilon_0 m a_0)^{1/2}} \cdot \frac{\varepsilon_0 h^2}{\pi m q^2}$ Inserting for a_0 once more and compacting: $\frac{h}{2\pi} = \frac{h}{2\pi}$.

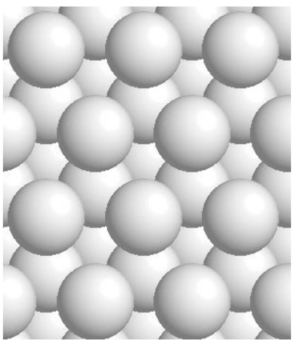
Thus, this approach is clearly futile in an effort to find h expressed in terms of the electron's mass and other constants.

2.2.3 Deriving the expression for h on basis of the energy of space

Consider instead the case if the mass term comes from a mass (energy) density of space rather than from the orbiting electron. In a classical sense with its well-defined orbitals, the Bohr radius a_0 envelopes a sphere of volume $4/3 \cdot \pi a_0^3$ m³. This volume multiplied with the uniform density ρ_{space} gives a mass energy of $5.57870576 \cdot 10^{-21}$ kg. This much larger mass will yield a much shorter length, which we call Δ'. We shall find that Δ' is just a tiny bit smaller than the more familiar Δ.

Putting all this together, we now have: $h = 0.4 \cdot 4/3 \cdot \pi a_0^3 \rho_{space} v_1 \Delta'$ kg·m²/s. The initial factor 0.4 stems from the spin angular momentum of a solid, uniform sphere, as stated in section 2.2.1. Rather than calling it L, we take the RHS of the expression to be the angular momentum h.

This can be taken to mean that h represents the angular momentum of some mass energy contained within a spherical volume of radius a_0 and this mass is rotating at speed v_1 at a radial distance Δ'. In terms of dimensions this sounds plausible, whereas the physical interpretation of it is puzzling. How can a relatively large mass be associated with such a short radial distance as Δ'?



We shall first demystify the physical interpretation. We recall that for larger masses, the total moment of inertia will be the sum of the moment of inertia of the many point masses it can be divided into. The rather huge mismatch between the volume of the rotating mass and the minute radial length Δ' takes on a different meaning if the spherical volume of space is instead the sum of a huge number of very much smaller spheres we shall refer to as space granules. These are hypothesized to be incredibly small pockets of space energy, structured in a regular grid, as shown here.

If Δ' is the radius of each granule and these are spinning, then there is no conflict with physical reality if we accept that there is something called energy in the vacuum of space. But at which speed are the granules contained within the sphere rotating? In section 2.2.6 we shall see that they will follow the angular velocity of the orbiting electron.

Might this be the "smoking gun" for the postulate that the vacuum of space itself is quantized? This idea is no longer as unheard of as it was in the earlier history of physics. Other than being some energy made of a non-tangible substance of unknown origin, we have based our theory on the postulate that its energy density ρ_{space} is numerically equal to the Coulomb constant and having the dimensions of kg/m^3.

On basis of the space granules, we might then also find out something about the fabric of space. We shall say a lot more about this in the following.

Returning to our preliminary expression for h; inserting the expression for speed gives:

$$h = 0.4 \cdot 4/3 \cdot \pi a_0^3 \rho_{space} \frac{q}{(4\pi\varepsilon_0 m_e a_0)^{1/2}} \Delta' K_h^{-1}$$

Here K_h^{-1} is a proportionality factor to balance the equation. (It will appear as non-inverted later).

As a_0 itself contains the factor h, we must first extract this and then group identical terms.

$$h = 1.6/3 \cdot \pi a_0^{5/2} \rho_{space} \frac{q}{(4\pi\varepsilon_0 m_e)^{1/2}} \Delta' K_h^{-1}$$ When inserting $a_0 = \varepsilon_0 h^2 / (\pi m_e q^2)$, this becomes:

$$h = 1.6/3 \cdot \pi \left[\varepsilon_0 h^2 / (\pi m_e q^2) \right]^{5/2} \rho_{space} \frac{q}{(4\pi\varepsilon_0 m_e)^{1/2}} \Delta' K_h^{-1}$$ Merging all identical terms:

$$h = \frac{0.8\, h^5 \varepsilon_0^2 \rho_{space} \Delta'}{3\pi^2 m_e^3 q^4} K_h^{-1}$$ Solve wrt. h:

$$h = \left[\frac{3\pi^2 m_e^3 q^4}{0.8\, \varepsilon_0^2 \rho_{space} \Delta'} K_h \right]^{1/4}$$ We can now see why we started with the inverted value of K_h.

Next, we need to test whether this makes sense. The critical factor here is Δ' and whether this distance gives a reasonably value for K_h. Thus, K_h = 1 when no correction is needed.

For these calculations we shall use a value for m_e = 9.10962611 · 10^{-31} kg that includes the slight relativistic mass increase resulting from the ground level speed of 2.18769126 · 10^6 m/s. For this speed the relativistic mass factor $\gamma = \frac{1}{\sqrt{1-(v/c)^2}}$ = 1.000026626741. This is the Lorentz factor.

Testing with the known value of h = 6.62607015 · 10^{-34} and K_h = 1, we find that:
Δ' = 1.3574106807 · 10^{-19} m. This is *very nearly* Δ, or 0.9866475825 Δ to be exact.

Using instead our value of Δ and K_h = 1, this gives: h = 6.603840014670 · 10^{-34}. Compared with the measured value, this is a factor 1.013533117 too low, i.e., by a little bit more than 1 %.
To make up for that, K_h = 1.013533117.

Our final expression for h can be presented as any of these:

$$h = \left[\frac{3\pi^2 m_e^3 q^4}{0.8\varepsilon_0^2 \rho_{space} \Delta} K_h \right]^{1/4} \quad \text{or} \quad h = \left[\frac{15\pi^2 m_e^3 q^4}{4\varepsilon_0^2 \rho_{space} \Delta} K_h \right]^{1/4} \quad \text{or} \quad h = \left[\frac{15\pi^2 m_e^3 q^4}{4\varepsilon_0^2 \rho_{space} \Delta'} \right]^{1/4}$$

For the first two, K_h = 1.013533117. For the last one, the use of Δ' requires no correction.

Although the distance Δ' is very close to being Δ, we shall be careful in rushing to any conclusions, as the excellent match might be no more than just a coincidence. We need to find the reason why Δ/Δ' = 1.013533117 instead of 1.00000. To achieve this, we shall search for at least one more property that yields about the same distance – something that is fully independent of what we found above. We shall now see that there is something that "fits the bill", and extremely well so.

2.2.4 The quantized space

The scenario presented above for what represents the smallest possible angular momentum gives a physical meaning to the Planck constant h. The smallest amount of quantized energy equals the angular momentum of the volume of space energy, as enveloped by the electron's Bohr orbital. By saying this, we recall that h is energy for a frequency of 1 Hz. Only after multiplying momentum with the actual frequency does the expression become the energy of the photon.

By this we also see that the Planck's constant, which is the very building block of the quantum nature of reality, is in full accord with basic Newtonian principles.

A distance of Δ cannot be the smallest dimension, not even the smallest in the material world. If we imagine an electron or any other particle "built of cubes" of sides Δ, it would appear rather jagged! The very much smaller neutrino couldn't even be built that way. Therefore, we have to conclude that there exist some very much shorter distances in the space medium.

With no direct evidence so far that space itself is quantized, a deeper analysis of this possibility will in the following suggest the same, but from a completely independent point of view. Our "toolbox" for saying anything about the properties of empty space may be limited, but a few things can be stated with considerable certainty or postulated until some solid evidence appears.

- A state of minimum energy will always overrule everything else.
- The space energy is the source of particle energy and thus the mass of all particles.
- Because the energy density of space shows local variations due to the presence of matter, there must be some finer structure that ensures the making of identical and stable particles.
- This finer structure must be everywhere and it must be granular (spherical) in order to allow the largest possible density to make a state of minimum energy. More on this below.
- Granules might group to make larger structures, as also seen in the world of matter.
- These larger groups are held together by being in a state of lowest potential energy, not by any principle believed to operate in the domain of matter, like exchange forces.
- We postulate that there is no friction in the space medium because there are no binding forces between the spherical granules. Friction is a phenomenon between molecules only.
- The granular structure will allow the propagation of energy by exchanging momentum in a mechanical sense, like in a 3D Newton's cradle.
- As the spheres themselves represent energy in the form of standing waves, they must be free to allow for individual spin. Thus, there must be some clearance between them.
- As photons have both energy and momentum, the granules will allow the flow of photons.

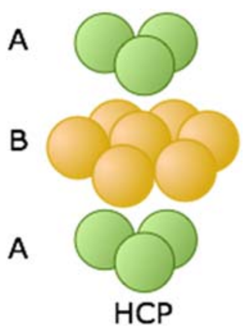
2.2.5 Properties of the energy of space

The principal difference between a matter particle and a photon is that the pair of standing waves in space form closed loops, so that the incoming wave is the same as the outgoing wave. This is what makes a particle, because the pair of standing waves are also in mutual resonance, giving the lowest possible energy and hence a very robust structure. For a photon, there is an interaction between a longitudinal wave and a transversal wave. They exchange kinetic energy and momentum, just like a pendulum exchanges kinetic and potential energy during its cycle. As these are open-ended waves, a photon will always propagate in the forward direction, where its momentum vector is heading.

2.2.5.1 The geometry of the Hexagonal Closest Packing (HCP) lattice

With the theoretical tools listed above, we begin this analysis by considering the way a number of spheres of identical radius can be stacked in order to achieve the highest possible stacking density. This has already been done with stacks of solid spheres [6 -7] and the results are directly applicable to our problem. The configuration known as HCP – Hexagonal Closest Packing is what gives the highest packing density, and in this sense also the highest energy density. This will also represent a state of lowest possible energy, because the structure has no potential energy that will be released by reconfiguring the spheres. Their surfaces are only just touching, as there are no gaps in between the surfaces at the point of contact.

The densest packing of equal spheres when measured over a large volume uses approximately 74 % of the volume, whereas random packing generally has a density of around 64 %.



From the theory of crystalline solids; densely packed spheres of uniform size in HCP mode gives the densest packing possible because the spheres from the level above and below will fit inside the 3 recesses formed by the 7 spheres shown in yellow. The granules will favour a structure in which as many granules as possible can be in direct contact. In this stacking mode, each granule has 12 nearest neighbours: six in its own layer and three in each layer above and below. This hexagonal arrangement gives the maximum amount of interaction between granules, leading to more stable structures. Such lattice geometries are also seen in metallic, atomic, and simple ionic crystals.

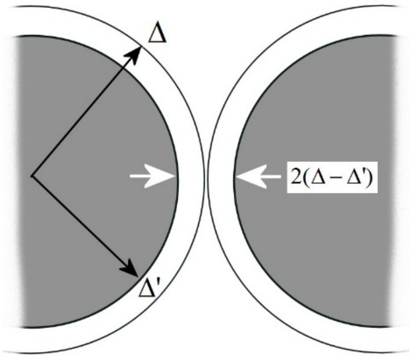
What is it that makes the space granules - their physical composition? Nobody knows, and their existence is so far only a postulate. But it is energy and as such forming standing waves. As for all standing waves, the waves making a granule require an integer number of wavelengths and hence no losses over time to be sustainable.

2.2.5.2 The lattice dimensions of the HCP structure

The height of one hexagonal element or cell can be expressed as: $4\sqrt{2/3}\,r_{HCP} = 3.2659863237 \cdot r_{HCP}$. The detailed derivation of this can be found in [8]. The height of the HCP structure is given relative to r_{HCP} and not as a dimension. Also note that there is no spacing between the granules.

This raises the question: What is the length of the radius r_{HCP} ? Since we are faced with the problem of giving meaning to the length Δ', might it actually be that these two lengths represent the same thing, so that: $r_{HCP} = \Delta'$?

Between the individual granules of the physical HCP structure there has to be a small clearance to allow some individual freedom of motion. Since the length $4\sqrt{2/3}\,r_{HCP}$ does not include any gap between the granules, the effective *physical* length of r_{HCP} will be slightly longer than we found. We therefore suspect that the gap between the granules might be due to the difference $\Delta - \Delta'$, or (1.375780678807 - 1.357302256233) $\cdot 10^{-19}$ m = 1.8369998081 $\cdot 10^{-21}$ m. Thus, each granule will have this gap "wrapped all around", as shown.



But why does the expression for h give precisely the measured value when using Δ' instead of Δ? The reason seems to be that the clearance is not part of the standing wave associated with the granule and as such does not contribute to its momentum nor energy. The expression for h involves only a quantum of real momentum and real energy. As the spacing between the granules is a void, it contributes nothing to the length factor of the expression for momentum and the correction factor reduces to K_h = 1.000 when using Δ'. This void is the white ring.

Thus, we can conclude that the correction factor K_h expresses the necessary clearance between the granules to allow them to vibrate - however slightly. Being firmly locked in a grid-like structure of recesses that gives the lowest possible energy, they cannot move or shuffle around and their tiny motion can be compared with that of the spheres of a Newton's cradle. The spheres do not move more than a miniscule length, but energy and momentum are nevertheless propagated at no losses. Besides, the clearance allows the space medium to have a certain amount of spread in its density.

2.2.6 What makes the space granules spin in synchronism with the orbiting electron?

In the expression 0.4$\cdot mvr$ for angular momentum of a sphere, we ascribed orbital motion to the mass m. The total angular momentum is the sum of the contributions from a huge number of granules, in full synchronism with the position and speed of the electron in its orbital. Having now gained some insight into the physical meaning of this mass, it remains to explain how come the granules will spin as a result of the electron's orbital speed.

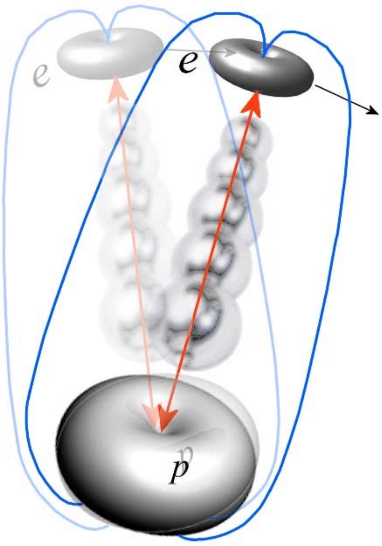
This is easier to understand if we consider their angular velocity rather than their (surface) speed.

At the ground (Bohr) level, the orbital speed is: $v_1 = \left(\dfrac{q^2}{4\pi m_e \varepsilon_0 a_0} \right)^{0.5}$ = 2.18769126 $\cdot 10^{6}$ m/s.

With an orbital length of $2\pi a_0$ = 3.32491853 $\cdot 10^{-10}$ m, this allows 6.57968382 $\cdot 10^{15}$ rotations per second; each of 2π radians, giving the electron an angular velocity of: 4.13413727 $\cdot 10^{16}$ rad/s.

In this scenario, the angular velocity of the granules will be that of the electron. But how can this be possible? The standard answer for most such questions is that it gives the lowest possible energy. The granules are free to rotate due to the small clearance we calculated. The granules will align with the electron in its orbital at all times because the granules will align with the lines of force between the electron and proton. This force is due to the closed loop of energy flow shared between the two, represented by the blue lines in the figure below. A state of lowest possible energy is achieved when the string (of granules) representing the loop of shared energy flow is the shortest possible. This length will be balanced against the centrifugal force of the orbiting electron.

The flow can be understood by this: The two particles have a core opening that are exactly the same, with a radius Δ. Besides, with our theory for the Coulomb force, they will be aligned face to face at all times, as shown. Note: This illustration is not to scale. The proton p shall be a lot bigger and the granules somewhat smaller, allowing the granules to fit inside the core of the torus-shaped particles.



As we have just found, their core openings are slightly wider than the 2 Δ' diameter of the granules, allowing a free energy flow through both particles. The granules can be seen as the actual conveyor of the force of attraction (the red arrow) and hence the angular velocity of the electron will be imparted on the granules in a way that ensures full alignment of their angular velocities.

Note that we are not talking about a physical flow as such. What is moving is their energies and momenta, precisely as we can imagine taking place in a 3D Newton's cradle. The granules are actually phase-locked to the electron, in a way that can be likened with the Moon's bound rotation relative to the Earth. Being phase-locked, the volume of granules will have completed one full cycle at the same time that the electron has done one orbit.

Note that all this takes place without any mechanical-like friction.

With the granules spinning around their own axis and in synchronism with the orbiting electron, we understand that the angular momentum of granules has some commonalities with the *intrinsic* spin of particles. We emphasize that the granules are not orbiting the proton as the electron does and hence the granules do not have any orbital angular momentum. In our document [11], we calculated the intrinsic spin of both the electron and the proton. For the electron we found:

Spin ang. mom. L_e'	$5.272858586434 \cdot 10^{-35}$	$\mathrm{kg \cdot m^2/s}$	$L_e' = \mu_e' m_e / (q g_e')$
Spin ang. mom. L_e'	$5.272858586434 \cdot 10^{-35}$	$\mathrm{kg \cdot m^2/s}$	$L_e' = \pi h \omega_{eR} m_e / (q c^{2}{}' g_e')$
Measured value L_e	$5.272859088231 \cdot 10^{-35}$	$\mathrm{kg \cdot m^2/s}$	$\hbar/2$
Difference from $\hbar/2$	- 0.000010	%	Discrepancy from $\hbar/2$ in %

We see that the rotation ω_{eR} is a factor here, as this is the angular velocity at which the particle's body is spinning around its axis. As is well known, standard theory cannot explain spin in terms of rotation of a particle, as this would violate the speed limit c of its surface velocity by a great factor. But in our theory the particles have the shape of a torus and are not point particles.

With the granules doing one rotation for each orbital period of the electron, they will have a surface velocity given by: $v = \omega_{eR} r_{granule} = \omega_{eR} \Delta'$. Inserting values gives:

v = $4.13413727 \cdot 10^{16} \cdot 1.3574106807 \cdot 10^{-19}$ m/s = $5.6117 \cdot 10^{-3}$ m/s. This is of course $\ll c$. It is reasonable to assume that with no friction involved, the granules will continue spinning as long as the electron is orbiting at that level. Should the electron be excited and occupy a higher orbital level given by $n > 1$, then its orbital velocity will decrease by the factor n and so also the granules.

2.3 Discussion

What has been suggested here not only gives substance to our calculation for the Planck constant; it also gives substance to our postulate that space itself is quantized. We have found the shape and physical dimension of the quantized element of space energy, which we refer to as granules.

Consider again the initial expression: $h = 0.4 \cdot 4/3 \cdot \pi a_0^3 \rho_{space} \dfrac{q}{(4\pi\varepsilon_0 m_e a_0)^{1/2}} \Delta' K_h^{-1}$. The fact that the value we found for h agrees so very well with the shape and spin of spherical granules makes us convinced that the granules of space are indeed spherical and have the radial dimension Δ'.

The HCP lattice structure makes the space grid of granules extremely stiff and robust. This can be illustrated by an egg carton, with the eggs representing a layer of granules and the top and bottom part of the carton being the layer of granules above and below. With the eggs placed in the recesses of the carton and closing the lid, the overall structure becomes very rigid. This dense packing also ensures a state of the lowest possible energy and highest density. With the very small clearance between the granules, a force acting on a certain granule will be opposed by a huge number of adjacent granules as these themselves are locked in the grid.

The expression above raises the question whether Planck's constant is a *fundamental* constant in the true meaning of the word. Our calculation reveals that it is not. What might be an absolute fundamental constant is Δ, as this length is the link between matter particles and the energy of the space medium. With the length Δ and hence also Δ', we see that there is a connection between the granularity of space and the dimensions of particles. We recall that the large and the small radii for the electron are 4Δ and 3Δ respectively. For the proton they are 6308Δ and 6307Δ. That such a connection exists is not the least surprising when having accepted that there is a space medium of energy, out of which particles are made from standing waves in this medium.

A very interesting conclusion is that the Planck's constant; being the very basis of the quantum nature of reality, seems to be in full accord with Newtonian principles. Angular momentum, whether it is orbital or spin, are based on mechanical principles and is hence Newtonian. There is no conflict here if we consider what the quantization of spin actually implies. It is all given in the way we derived Planck's constant - a volume of space energy in the form of spherical granules contained within the lowest possible orbital of the lightest atom, with the granules being in phase-lock with the orbiting electron.

Although not considered in this document, we postulate that the relativistic mass increase of a fast-moving particle is embedded as kinetic energy in the space medium and not within the particle itself. Moving fast through space at a speed near c, there will be a time lag until the granules trailing the particle have managed to recover a state of equilibrium. There will be what can be likened with a wake in the space energy immediately behind the particle, creating the *illusion* that the particle itself has increased its mass because the relativistic mass follows right behind it. The faster the speed, the more granules will be agitated and the more energy will be contained in the particle's wake.

This view might explain how charged particles can retain their unit of charge even when accelerated close to the speed of light and gaining a mass that in the extreme can be many times its rest mass. This can only be understood if the kinetic energy is *external* to the fast-moving particle. Admittedly, this is merely a postulate, but nevertheless an idea that connects some dots.

3 Future studies

3.1 More on the relativistic mass embedded in space

In our earlier work [4], we could conclude that the frequency and hence the energy of the emitted photon equals the energy that the electron acquired in the radial direction during its descent. But this is also the same energy as represented by its relativistic increase in mass. Although the orbital velocity at the excited level is considerable, its velocity in the vertical direction is zero until the descent gets started. But from there onwards it increases speed really fast, building up a certain amount of relativistic mass. When reaching the ground level and its radial speed once again is zero, we contend that it is the relativistic mass increase which creates the photon, not the electron itself. This strengthens the view that relativistic mass energy is located in space and not in the motion of the particle itself. In other words, the energy and hence also the frequency of the emitted photon equals the relativistic mass that the electron acquired during its descent in the radial direction.

3.2 Is particle motion also quantized?

If the energy of space is quantized, it might very well be that even motion itself is quantized. Thus, instead of a smooth, continuous motion with time, it might be a sequence of tiny quantized steps, making motion a fast-repeating "stop and go" process. With the mass energy of the particle being propagated from one granule over to the next, we can understand how a particle can seemingly move freely in a rigid sea of granules without forcing its way as would a corpuscle.

In light of this, we postulate that the length Δ is also the step size (pitch) in the quantized motion of matter. An identical particle will be "rebuilt" at the next step, and so it continues until an external force either accelerates or decelerates it, in accord with Newton's 2nd law of motion.

The motion itself is free of any friction and can in theory continue for an unlimited period of time, all in accord with Newton's 1st law of motion.

A "stop and go" process is actually intuitive when considering motion as being propagation of energy through some grid-like structure of space energy. If this grid is likened with a 3-dimensional Newton's cradle, then we can understand how particle speeds can be arbitrarily slow and not instantly rush off at the speed governed by the chain of spheres. Thus, the maximum speed can be governed by the space grid, but this speed is limited to the instants of time when there is "go". Between each such "go" there is a "stop" period, the length of which is given by the amount of energy imparted on the particle. The more energetic, the shorter the "stop" periods will be. Thus, more energy means longer leaps between stops. These steps will be so minute and repeated so often that the motion is perceived as perfectly smooth. At the speed of light there will be no stops.

3.3 The quantization of light and the making of a photon

The electron has a component of linear momentum and hence kinetic energy when moving from an excited level down towards a lower and stable orbital. The alignment of the granules will follow the electron, whether the electron's motion is a Fibonacci-like trajectory [9] or a circular orbit.

Consider what is happening when the electron reaches ground level and delivers its acquired kinetic energy back to space – energy creating a photon of (near) exactly that energy. The spinning motion of the granules is then no longer linked to the motion of the electron, and their joint energy is fully disconnected from the electron, meaning that it is free to move in the direction their momentum vector is heading. This amount of energy will act like a spearhead in the medium of space. With this, we postulate that the released energy will create a shock wave in the space medium. The leading compaction will be followed by a rarefaction and vice versa. However, in an effort to maintain a state of equilibrium and the lowest possible energy, the granules will be slightly drawn in from the sides where the energy is rarefied and pushed away from where there is compaction. This creates a transversal wave, also known as a photon. We believe that a photon also has a longitudinal wave component and that there is a continuous exchange of energy between these two. In addition, the transversal wave has two components and there is a continuous energy exchange between these, the frequency of which - together with Planck's constant, gives the energy of the wave.

Why is it that a higher frequency means a proportionally higher energy? Besides, where is the wave amplitude in all this? This can be fully understood if we realize that the energy of a photon is actually embedded in the gradient (steepness or slope) of its sinusoidal waveform. The steeper the flanks of the wave, the more periods of the wave can be accommodated within a certain period of time. But this in itself is the very definition of frequency. Thus, the two views amount to exactly the same and is at the core of the Planck expression. All this is explained in more detail in the appendix 4.1.

3.4 More on the properties of the vacuum of space

The fact that the clearances between the granules do not contribute to the value of h, this tells us that there are countless little "pockets" in space that are not included in any standing waves. These pockets fill the volume in between the spherical granules. We cannot accept the idea that there exists any basic element in space having the volume of tiny cubes. Thus, it is given by geometry that regardless how small the granules might be, there will always be a leftover volume because of the spherical shapes.

Although Δ is a minute length in its own right, it is way too large to define the finer details of even the largest of particles. So, what gives the lower limit of resolution? With no proof given for the time being, we suggest that the same hexagonal structure suggested above can be repeated for each of the 12 granules of an HCP cell. And it does not have to end there, as each of these 144 granules might in turn give room to another hexagonal structure. For each deeper level and thus correspondingly higher frequency of the associated standing waves, the volume of space not being included in any standing wave gets smaller and smaller. Thus, with approximately 74 % of the volume taken by the upper level of the hexagonal structure of granules, then a certain percentage of the remaining emptiness might be occupied by the next lower level and so on. But the volume represented by all the clearances between granules will remain a complete void.

Is it possible to say how many such nested levels n_{HCP} there might be in the vacuum of space? This is for further studies.

3.5 Deriving an expression for the electron's mass

From the expression of h we can also extract an expression for the electron's mass m_e. Thus:

$$m_e = \left[\frac{4h^4 \varepsilon_0^2 \rho_{space} \Delta'}{15\pi^2 q^4} \right]^{1/3} = 9.10938355946 \cdot 10^{-31} \text{ kg}$$

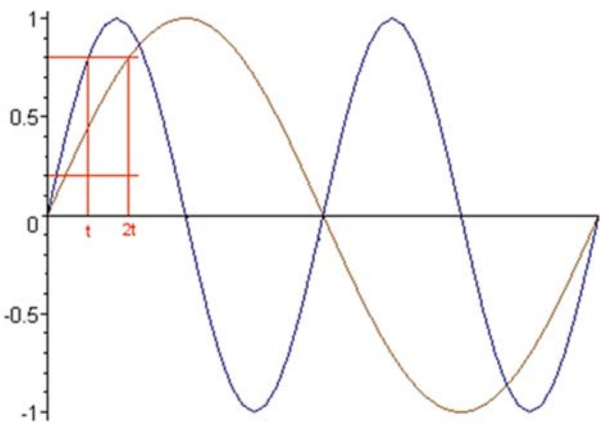
4 Appendix

4.1 Considerations on the wave energy

If the Planck expression $E = hf$ is compared with the expression for mechanical energy, which is proportional to *two* separate entities - these being force and the distance over which this force is acting, this might seem rather odd. Besides, where is the wave amplitude in the Planck expression? We shall now see that the wave amplitude is indeed present, although somewhat hidden.

This idea can be visualized by using terminology borrowed from high-speed electronics, namely rise and fall times of a signal waveform. The illustration below presents two sinusoidal waves, with time plotted along the x-axis. They have the same amplitude, but the dark blue line has a wavelength just half that of the one in brown. Over the range 20 % to 80 % of the amplitude, we see that the slopes are almost linear. This range is between the two red lines. The rise (or fall) time from 20 % to 80 % of peak amplitude is exactly half for the waveform of lowest wavelength. Thus, the steepness of the wave (its slope) can be expressed as the ratio of two variables, or m/s.

In electronics, the amplitude is measured in volts rather than in metres and the rise time is commonly given as ns over the 20 % to 80 % range of the amplitude.



The shorter the time to reach a certain level or the higher the level is reached after a certain time; the steeper is the slope of the curve. The steeper it is, the more periods of the waveform can be accommodated within a certain time interval. Or in other words; for a fixed amplitude level - the shorter the rise time t, the shorter is the wavelength and hence the higher the frequency. The wave amplitude is therefore embedded in the ratio m/s.

Effectively, for a given wave amplitude, the inverse of the rise time works out the same as frequency. Note that the number of periods does not increase the energy, as just one slope of the waveform – whether rising or falling, contains all the energy there is in the wave.

On basis of this, we can conclude that the energy resides in the slope and its steepness (or gradient).

By this we have shown that the energy $E \propto \frac{1}{rise\ time}$, which in practice equates to $E \propto f$.

The Planck's constant h is the associated proportionality factor, giving the correct frequency for a specific amount of energy. And by this we have derived the Planck's law: $E = hf$.

As seen in a context of mechanics, the slope containing all the energy can be likened with the stroke of a hammer. The steeper the slope, the harder the hammer hits. This is the crux of the photo-electric effect.

4.2 Some important notes on physical constants

Coulomb's law expresses the force between electric charges. The electrical constant ε_0, having the dimensions of Farads per meter, relates the units for electric charge to mechanical quantities such as length and force. But what is the physical meaning of the electrical constant, sometimes also referred to as the vacuum permittivity? It is said to be the capability of an electric field to permeate a vacuum – whatever this might mean. But this phrase does allude to some properties of empty space – some properties that really shouldn't exist if space were a complete void in all respects.

In the new SI system as of 2019 [10], the permittivity of vacuum will not be a fundamental constant anymore, but instead a measured quantity, related to the measured (dimensionless) fine structure constant α. Consequently, ε_0 is not exact. As before, it is defined by the equation $\varepsilon_0 = 1/(\mu_0 c^2)$. However, as c is taken to be an exact constant, then ε_0 is determined by the magnetic vacuum permeability μ_0, which in turn is given by the experimentally determined value of α.

The method of allocating a value to μ_0 is a consequence of the result that Maxwell's equations predicted that in free space, electromagnetic waves move with the speed of light. Understanding why ε_0 has the value it has requires a brief understanding of the history behind it.

If starting with no constraints for the Coulomb constant k_e, then the value of $k_e = 1/(4\pi\varepsilon_0)$ may be chosen arbitrarily. For each choice of k_e there will be a different value ascribed for q.

The idea subsequently developed that it would be better to include a factor 4π in equations like Coulomb's law. It was reasoned that a particle might possibly be spherical and that electric charge was some sort of surface phenomenon or substance. Whatever charge might be, a surface phenomenon would require a factor 4π in equations where it appeared.

The next step was to treat the quantity representing a unit amount of electricity as a fundamental quantity in its own right, denoted by the symbol q and to write Coulomb's law in its present form:

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{r^2}$$

Next, the requirement was added to make force be measured in Newtons, distance in metres and charge to be measured in some convenient unit named the Coulomb C; this being defined as the charge accumulated when a current of 1 ampere flows for one second. When this is used for the Coulomb's force law, then in order to balance the dimensions to make it a force expressed in Newtons N, the dimensions $C^2 \cdot N^{-1} \cdot m^{-2}$ were required for the parameter ε_0. Arbitrarily taking the dimensions of the Farad F as $C^2 \cdot N^{-1} \cdot m^{-1}$, the dimensions of ε_0 became F/m.

The numerical value of ε_0 is determined by the values of c and μ_0, as given by: $\varepsilon_0 = 1/(\mu_0 c^2)$.

The physical constant μ_0 is commonly called the magnetic constant. Alternatively, it may be referred to as the permeability of free space, the permeability of vacuum or the vacuum permeability. Whatever its name says about it, its physical meaning is as nebulous as ε_0, as it alludes to something that should not exist if the vacuum of space is the total void.

The system of equations thus generated is known as the rationalized metre–kilogram–second (rmks) equation system, or “metre–kilogram–second–ampere (mksa)” equation system. This is the system used to define the SI units.

Since the redefinition of SI units in 2019, the vacuum permeability μ_0 is no longer a defined constant (per the former definition of the SI ampere), but rather needs to be determined experimentally. It is proportional to the fine-structure constant, with no other dependencies.

μ_0 = 1.25663706212·10^{-6} H/m. 1 Henry per metre ≡ 1 Newton per square Ampere.

Before this, μ_0 had an *exact* defined value of: μ_0 = $4\pi\cdot 10^{-7}$ H/m = 1.2566370614·10^{-6} N/A^2. The difference appears at the 9th decimal place. As regards its numerical value, this modification is hence not significant.

But where did the factor $4\pi\cdot 10^{-7}$ come from? The 4π balances out the $1/4\pi$ from the expression for ε_0 to make $c^2=1/(\mu_0\varepsilon_0)$. The factor 10^{-7} makes it more in line with ε_0.

On the whole, everything involving the dimensions and numerical values of ε_0 and μ_0 seems to be rather loosely specified. The thing is that it is c - the square root of their inverted *product* that is considered a fundamental constant. Their individual values and dimensions can really be anything as long as the square root of their inverted product has the dimensions of speed and a numerical value exactly as that measured.

With our interpretation of k_e as a density ρ_{space} with dimensions kg/m^3 and charge as kg/s rather than Coulomb because it represents a flow of mass energy and not a substance smeared over the particle’s surface, there is no longer any affiliation to the electric constant through the relationship $k_e=1/(4\pi\varepsilon_0)$. But having given $1/(4\pi\varepsilon_0)$ a different meaning, there is no longer a constant to balance Coulomb’s force law to make it have the dimension of a force. A new constant would have the numerical value of 1 because we have retained the numerical values of q and also $1/(4\pi\varepsilon_0)$. Because of that we have decided to just ignore it, but being aware that the use of our dimensions for Coulomb’s force equation does not express the dimensions of force unless a new constant is added.

But then what are the dimensions of ε_0 and μ_0 in our theory? The updated Farad is s^4·A^2/(kg·m^2). As A has the dimensions C/s, then with our definition of C as kg, the dimensions of ε_0 as F/m will be:

$$\varepsilon_0 = \frac{s^4 A^2}{kg\cdot m^2\cdot m} = \frac{s^4 kg^2/s^2}{kg\cdot m^3} = \frac{kg\cdot s^2}{m^3}$$

From this follows that μ_0 must have the dimensions m/kg in order to make c a velocity of m/s.

This reordering of dimensions is merely the result of our redefinition of the dimensions of Coulomb’s constant and electric charge. As the dimensions of ε_0 and μ_0 were so arbitrary in the first place, re-defining their dimensions once more has no consequences as long as their values are retained.

With these changes, the dimensions for magnetic field (or magnetic flux density) B become:

$B = \frac{\mu_0 I}{2\pi r} = \frac{m/kg}{m}\cdot kg/s = \frac{1}{s}$. Finally, the magnetic field strength: $H = B/\mu_0 = A/m = \frac{kg}{s\cdot m}$.

5 References

1. Milo Wolff: Exploring the physics of the unknown Universe
   ISBN 0-9627787-1-0 Published by Technotran Press, CA, USA.

2. https://youtu.be/MxCdjMHD5jc

3. How to derive the moment of inertia of a solid, uniform sphere
   https://www.miniphysics.com/uy1-calculation-of-moment-of-inertia-of-solid-sphere.html

4. https://www.researchgate.net/publication/344059306_Generation_of_a_photon_through_spontaneous_emission

5. https://en.wikipedia.org/wiki/Planck_constant

6. https://en.wikipedia.org/wiki/Sphere_packing

7. https://chem.libretexts.org/Bookshelves/General_Chemistry/Book%3A_Chem1_(Lower)/07%3A_Solids_and_Liquids/7.08%3A_Cubic_Lattices_and_Close_Packing

8. https://chemistry.stackexchange.com/questions/74233/how-to-calculate-the-height-of-an-hcp-lattice

9. https://www.researchgate.net/publication/354382120_Plotting_the_relaxation_track_of_an_excited_electron_in_the_hydrogen_atom

10. https://en.wikipedia.org/wiki/2019_redefinition_of_the_SI_base_units

11. https://www.researchgate.net/publication/350568006_Explaining_and_calculating_the_magnetic_dipole_moment_and_intrinsic_spin_of_particles_v3