The Origin of the Fundamental Constants

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Abstract In this work, the hypothesis that the universe is made up of 4-dimensional spheres of space, whose diameter is the Planck length, allows us to calculate most of the constants used in current physical theories. Calculated constants include: elementary charge, fine structure constant, electron mass, Planck constant, gravitational constant, electrical constant, Boltzmann constant, mass and charge of up and down quarks, muon mass, and Higgs boson. All of these depend on the speed of light and the Planck length, which shows that all the constants are related and not due to chance.

Keywords: Fundamental Constants, Planck length, Discrete Space-Time

1. Introduction

A physical constant is a physical magnitude whose value remains unchanged over time, for a given physical process. The fundamental constants form the basis of the most widely accepted physical theories, relativity, quantum mechanics, and the standard model. According to Duff et al. *"... we defined as fundamental those constants which cannot be calculated at our present level of fundamental knowledge (or rather ignorance)."* [1]

The fundamental constants appear in the descriptions of natural phenomena. For example, Newton's law of gravitation says that the force between two masses is directly proportional to the product of the masses and inversely proportional to the square of the distance between them, with G being the constant of proportionality. The speed of light c appears in the special and general theory of relativity and in Maxwell's equations, which are the basis of electromagnetic waves. Planck's constant h appears in quantum mechanics and the mass of elementary particles in the standard model of particle physics.

In the standard model, elementary particles are classified into two groups: bosons and fermions. Bosons have integer spin (0, 1 or 2) and are the particles that interact with matter, while fermions have half-integer spin (1/2 or 3/2) and are the particles that make up matter. Fermions are divided into two groups: quarks that are always in the presence of other quarks, and leptons that can exist in isolation. In the standard model there are three types of massive leptons: electron, muon and tau; all have the same negative charge, each with its corresponding neutrino. There are also six types of quarks, three of them with a positive charge of +2/3 of the charge of the electron and three with a negative charge of -1/3 of the charge of the electron: up and down; charm and strange; top and bottom. The masses of these 12 leptons cannot be calculated, which gives rise to 12 fundamental constants. The W and Z bosons also have

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their masses. Finally, there is the Higgs boson, which gives mass to the other particles and, therefore, is a very important part of the theory, by which we obtain another mass or fundamental constant.

The fundamental constants have been measured with great precision and are therefore suitable for defining the units. However, the constants remain enigmatic. For example, the fine structure constant has baffled physicists since its discovery 100 years ago. In general, the values of the fundamental constants are unexplained. *"Of course, no one had any idea why they took the particular numerical value that they did."* [2]

"The launch in 2019 of the new international system of units is an opportunity to highlight the key role that the fundamental laws of physics and chemistry play in our lives and in all the processes of basic research, industry and commerce." [3] In this way, all base units are associated with the rules of nature to create our measurement rules.

If we used different units, the numerical values would be different and, therefore, although they provide us with information about nature, they are actually human artifacts that have nothing to do with the universe. Put another way, the universe only needs two constants: the speed of light and the Planck length. All the other constants are necessary for applied physics or for technological development, but they are not necessary to understand the workings of the universe.

The dimensional constants are used to relate the different constants to each other. For example, the speed of light can be used to convert units of time (such as years) to units of length (such as light years) or vice versa. It also relates the electric (ε_0) and magnetic (μ_0) field constants in a vacuum. Therefore, of the three constants, only two are independent.

According to Baez, "*but most physicists would prefer to have none. The goal is to come up with a theory that lets you calculate all these constants, so they wouldn't be "fundamental" any more. However, right now this is merely a dream,"* [4]. In the standard model, there is no way to calculate these constants because it starts from the observation of the phenomena and, therefore, its values are known by measuring them over and over again in different physical phenomena.

"Some physicists believe that at least some of the fundamental constants are just cosmic accidents, fixed by the dynamics of the Big Bang. Thus the constants are arbitrary, depending on details of the Big Bang. Obviously in this case there is no way to calculate the fundamental constants." [5]

"*The multiplicity and variety of fundamental constants are esthetic and conceptual shortcomings in our present understanding of foundational physics."* [6]

"Despite their perceived fundamental nature, however, there is no theory of the constants as such. For example, there is no generally accepted formalism that tells us how the constants originate, how they relate to one another, their relative sizes, or how many of them are necessary to describe physics." [7]

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For Duff, the dimensional constants, such as *ħ, c, G, e, k*, are human constructions that do not vary with time. *"Dimensional constants, on the other hand, such as ¯h, c, G, e, k. . . , are merely human constructs whose number and values differ from one choice of units to the next. In this sense only dimensionless constants are "fundamental". Similarly, the possible time variation of dimensionless fundamental "constants" of nature is operationally well-defined and a legitimate subject of physical enquiry. By contrast, the time variation of dimensional constants such as c or G on which a good many (in my opinion, confusing) papers have been written, is a unit-dependent phenomenon on which different observers might disagree depending on their apparatus."* [8]

2 Discrete Space-Time

One of the main objections to discrete space-time is that the existence of a discrete space-time atom is incompatible with the contraction of its length and the time dilation of special relativity. However, it must be borne in mind that, for lengths and times close to the Planck scale, the Pythagorean theorem is not verified. Therefore, some authors use a modified distance formula [9-12]. Specifically, Crouse and Skufca derive the relativistic phenomena of the Lorentz-Fitzgerald contraction and time dilation using a modified distance formula that is appropriate for discrete spaces. They "*show that length contraction of the atom of space does not occur for any relative velocity of two reference frames. It is also shown that time dilation of the atom of time does not occur". "... It was shown that when applied to distances near the Planck scale, the new formula yields distances much different than those predicted by the Pythagorean theorem. But for larger length scales, the distances calculated with the new formula converge to those calculated using the Pythagorean theorem. When using the new distance formula in the otherwise typical derivations of time dilation and length contraction, one sees that the atom of space and atom of time are indeed immutable - true constants of nature and independent of the speed of any observer*." [13]

According to general relativity, space-time is continuous. However, there is no experimental evidence for this. Are space and time a continuum or are they composed of indivisible discrete units? Our education probably convinces us of its continuity but, in recent years, both physicists and mathematicians have asked if it is possible that space and time are discrete? Smolin states that space is formed from atoms of space: *"If we could probe to size scales that were small enough, would we see atoms of space, irreducible pieces of volume that cannot be broken into anything smaller?"* that he calls "Atoms of Space and Time." [14].

For Heisenberg, the mass of the particles must be derived from a fundamental length, together with the Planck h constant and the speed of light [15-16].

For some physicists, such as Hawking and Motz, Planck particles could be micro-black holes [17-19]. The mass of Planck has also been proposed as being responsible for dark matter. [20,21]

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The Planck scale appears to combine gravity (G), quantum mechanics (h), and special relativity (c) [22]. According to Padmanabhan, the Planck length is the minimum length in any spacetime. Padmanabhan showed that the Planck length provides a lower limit of length in any suitable physical space-time [23]. "*It is impossible to construct an apparatus which will measure length scales smaller than Planck length. These effects exist even in flat space-time because of vacuum fluctuations of gravity."* [24]

Planck's length can be considered as being the shortest distance having any physical meaning. "*…a fundamental (minimal) length scale naturally emerges in any quantum theory in the presence of gravitational effects that accounts for a limited resolution of space-time. As there is only one natural length scale we can obtain by combining gravity (G), quantum mechanics (~) and special relativity (c), this minimal length is expected to appear at the Planck scale.*" [25]

Haug proposed different methods of measuring the Planck length independently of the gravitational constant *G*. The Planck length is both a physical measurement and the diameter of the true fundamental particle: "*The gravitational constant is a composite (derived) constant, while the Planck length represents something physical; it is the shortest reduced Compton wavelength possible. According to recent developments in mathematical atomism, there are also strong indications that the Planck length is the diameter of the only truly fundamental particle, namely an indivisible particle that together with void is making up all matter and energy.*" [26]

On the other hand, Haug raises the hypothesis that Hesisenberg's uncertainty principle collapses on the Planck scale [27,28]. The search for a quantum theory of gravity leads to a generalisation of the Heisenberg uncertainty principle (GUP) on the Planck scale. Adler uses Newtonian and general relativistic gravity and modifies the uncertainty principle with an additional term: *"In both theories it is clear that the extra term must be proportional to the energy or momentum of the photon, so on purely dimensional grounds the order of magnitude of the extra term is uniquely determined. As a consequence there is an absolute minimum uncertainty in the position of any particle such as an electron. Not surprisingly the minimum is of order of the Planck distance. In view of the absolute minimum position uncertainty one may plausibly question whether any theory based on shorter distances, such as a space-time continuum, really makes sense."* [29] Other authors also conclude that on the Planck scale the fluctuations are of the same order of magnitude as the distances involved [30,31].

For Santilli, space must be a solid and incompressible medium, as it is also the means of transmission of waves and forces. Matter is a dynamic modification of space. "*Space, that must transmit waves and forces, must be full, and matter, which must be a dynamic state of this space – because it interferes and generates forces – must be 'empty in relation to common concepts'. If we could stop all its movements for a moment, matter would disappear completely, as it actually does, whenever corpuscular radiation interferes.*" [32]

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3 Four-Dimensional (4D) Discrete Space-Time

The starting hypothesis is that the universe is made up of spheres with four spatial dimensions whose diameter is the Planck length. Of the four spatial dimensions, three of them are observed as space and the fourth spatial dimension is observed as time ($u=ct$). This is due to the fact that we lack references for the fourth dimension as a consequence of the expansion of the universe. Of the four dimensions, three are observed as space (x, y, z) and the fourth ($u = ct$) spatial dimension is observed as time. Planck's four-dimensional spheres are atoms of space and time which Smolin comments on. [14] To simplify the drawing in Figure 1, only three dimensions are considered: $r(x,y)$ and u.

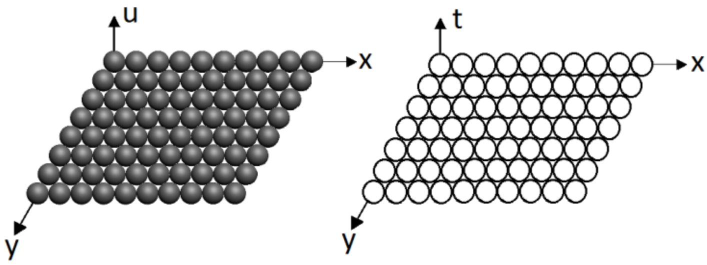

Figure 1. An expanding flat 3D universe is seen as 2D and t

If space is made up of 4D Planck-sized spheres, each Planck sphere can only be at rest or spinning on itself. Furthermore, the 4D Planck sphere has two possible rotations, one from the three-dimensional space and one from the fourth dimension. Rotation of the fourth dimension (ω_u) rotates the u-axis and another spatial axis about any two axes. For example, the u-y axes rotate around the x-z axes. In the rotation of space, (ω_e) is rotated around the axis u and another spatial axis. For example, the x-z axes rotate around the u-y axes. Therefore the 4D Planck sphere can rotate both 3D space and the fourth dimension ($u = ct$, Figure 2), which results in the following combinations:

- Zero rotations. Vacuum space;
- One spatial rotation, ω_e . Photons;
- One rotation of the fourth dimension ω_u. Gives rise to neutrinos;
- Two rotations, one of space ω_e and another of the fourth dimension ω_u. Electron, positron and quarks up and down.

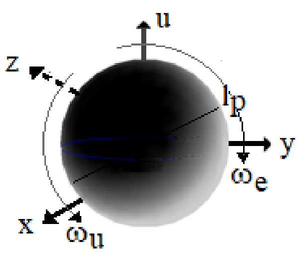

Figure 2. Rotations of a 4D Planck sphere

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The static spheres of space are not observed, it is what we call empty space. The spinning spheres are observed as elementary particles, such as electrons, photons, first generation quarks and neutrinos. The 4D Planck sphere is only determined by two constants: Planck length and the speed of light.

These spheres constitute a solid and incompressible space that transmits the waves. *"Since space transmits waves and forces, it is absurd to assume that it is empty, whereas it must be a solid, incompressible medium. And the elementary particles, since they interfere and generate forces, can by no means have a ponderable nature, but must be active energy states determined by a dynamic state of space points."* [32] Those spheres are the fundamentally grainy nature of space commented on by Das et al. *"We again arrive at quantization of box length, area and volume and an indication of the fundamentally grainy nature of space."* [33]

In causal set theory, space-time is made up of identical space-time atoms with no internal structure [34-37]. "*According to this proposal, spacetime is comprised of discrete "spacetime atoms" at the Planck scale*" [34]. Also T. Padmanabhan describes gravity from atoms of space-time. [38]

Sing proposes a New Quantum Theory of Gravity based on space-time atoms in such a way that each atom has its own matter content. "*In our theory, the universe is made up of enormously many such atoms of space-time matter (STM). We do not know at this stage as to what determines the total number of such STM atoms in the universe, and whether this total number is finite or infinite. Each STM atom carries its own space-time and its own matter content."* [39] It also uses the Planck length and speed of light as fundamental constants. "*The theory is in fact a classical matrix dynamics with only two fundamental constants – the square of the Planck length and the speed of light, along with the two string tensions as parameters.*" [39]

4 Speed of Light c

The speed of light depends on two parameters: length and time. The unit of length is the metre and it is defined as one ten-thousandth of the distance between the North Pole and the Equator. The unit of time is the second, which is defined as a fraction of the day. Therefore, the numerical value of the speed of light depends on the arbitrariness of the definitions of length and time. Currently the metre is defined as the distance that light travels in a vacuum in an interval of 1/299792458 s. In this way, the speed of light becomes a fundamental constant that cannot be calculated, but is defined exactly and its value is c = 299792458 m/s [40].

If we make $c = 1$, then:

$$299\ 792\ 458\ \text{ m/s} = 1 \quad (1)$$

Thus,

$$1\ \text{s} = 299\ 792\ 458\ \text{ m} \quad (2)$$

A light second is the distance light travels in one second. Therefore, we can use the second as a unit of distance or time.

5 The Origin of the Constants

In current physics, space-time is continuous, which implies that, in principle, the constants are arbitrary and due to chance. However, in a discrete space-time, the sphere of 4D space will have a certain size and its diameter will be a function of the unit of length. That sphere is the one which will determine the origin of the constants.

5.1 The Origin of the Gravitational Constant *G*

The universal gravitational constant G determines the intensity of the force of gravitational attraction between objects. It is a physical constant obtained empirically and whose value is $G = 6.67430 \times 10^{-11}$ $m^3/$ kg s^2 . [40]

If we make $G = 1$, then:

$$6.67430 \times 10^{-11} \text{ m}^3/\text{ kg s}^2 = 1 \qquad (3)$$

From where,

$$1 \text{ kg} = 6.67430 \times 10^{-11} \text{ m}^3/\text{ s}^2 \qquad (4)$$

It must be remembered that in 1795, during the French Revolution, the gram was used as the mass of one cubic centimeter of distilled water at one atmosphere of pressure and at a temperature of 3.98ºC, corresponding to the melting point of ice. The basic unit of mass in the International System of Units is the kilogram, which corresponds to one litre of water. However, because the density of water varies with atmospheric pressure, a standard mass is used as a reference. This standard mass is made up of a cylinder of platinum and iridium (90% and 10%, respectively), which is kept at the International Bureau of Weights and Measures (BIPM) in Sèvres, near Paris.

A volume of water is arbitrarily chosen and the unit of mass is assigned to it but the same volume of water can also be assigned the value of 6.674×10^{-11} kg. In this way it transpires that $G = 1$ $m^3/$ kg s^2. Also, if we assign the value of 6.674×10^{-11} m^3/s^2 to that litre of water, the gravitational constant and the kilogram of the international system disappear.

Volume of water	Mass	Units of mass	Value of G	Units of G
1 litre	1	kg	6.67430×10^{-11}	$m^3/$ kg s^2
1 litre	1	m^3/s^2	6.67430×10^{-11}	------
1 litre	6.67430×10^{-11}	kg	1	$m^3/$ kg s^2
1 litre	6.67430×10^{-11}	m^3/s^2	-----	------

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If we had assigned a value of 1 kg to a litre of oil, the gravitational constant would have a slightly different value. Therefore, the value of the gravitational constant is determined by our arbitrary choice of the units of length, mass, and time. By fixing the metre as the unit of length, the value of the Planck length (l_p) is also fixed. By setting the second as the unit of time, the value of the speed of light (c) is determined. This results in:

$$l_p\, c^2 = 1.453 \times 10^{-18}\ \mathrm{m^3/s^2} \qquad (5)$$

By creating the concept of mass from 1 litre of water, the value of the Planck mass (m_p) is determined and the product $l_p\, c^2$ is separated into two constants.

$$(l_p\, c^2/m_p)\, m_p = G\, m_p \qquad (6)$$

This also creates the Gravitation constant, which is dependent on the speed of light and Planck units of length and mass.

$$G = l_p\, c^2/m_p \qquad (7)$$

A litre of water is the volume that we observe. Today we know that not all the volume is occupied. We also know that the particles that make up that volume move, and so,

$$1\ dm^3 de\ water = 6.674 \times 10^{-11} m^3/s^2 \qquad (8)$$

If we now make that litre of water equal to 1 Kg, we have created the value of G. In short, G is a human construction.

International System	Symbol	Value	Units	Dimensions
Mass	m	*1*	*kg*	M
Gravitation Constant	G	6.67430×10^{-11}	$m^3\, kg^{-1}\, s^{-2}$	$L^3\, M^{-1}\, T^{-2}$
Force	F	*1*	$kg\, m\, s^{-2}$	$L\, M\, T^{-2}$

L = length; M = mass, T= time, kg = kilograms, m = metres and s = seconds

For Matsas et al., [41] there are only two fundamental constants: length and time. To do this, the mass and Planck's constant are multiplied by G. Thus, G plays the role of a conversion factor (from grams to $\mathrm{cm^3/s^2}$) in the same way as Boltzmann's constant k (from ergs to Kelvin). We can make the following changes:

$$m' = G\, m \qquad (9)$$

$$F' = G\, F \qquad (10)$$

$$h' = G\, h \qquad (11)$$

The gravitational constant G is no longer necessary and the kilogram disappears from the International System of Units. By fixing the metre as the unit of length, the value of the Planck length (l_p) is also fixed. By setting the second as the unit of time, the value of the speed of light (c) is determined, which results in: $m'_p = l_p\, c^2$. If now, we

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make that litre of water equal to 1 Kg, the value of the Planck mass (m_p) is fixed in such a way that the natural unit of mass $m'_p = l_p c^2$, is separated into two constants, namely: the gravitational constant G and Planck mass m_p.

$$G = l_p c^2/m_p \quad (12)$$

This brings up the kilogram and the gravitational constant. If we use m' $(m'= Gm)$ instead of m, all measurements in physics reduce to measurements of space and time. In this way, G disappears from all physical equations, thus reducing the number of dimensional fundamental constants.

"One can use M' = GM instead of M in order to reduce all measurements in physics to measurements of space and time intervals and exorcise G from all equations of physics, thus reducing the number of fundamental dimensionful constants." [42]

Januz Kowalski, on the other hand, came to a similar conclusion and deduced the mass as being a function of the Planck length .[43]

In the same way that mass is a form of energy, the new definition of mass, m', is also a form of energy, governed by the same equation, but only with units of length L and time T.

$$E' = GE = Gmc^2 = m'c^2 \ [L^5, T^{-4}] \quad (13)$$

5.2 The Origin of Planck's Constant *h*

Planck's constant was proposed as a proportionality constant between the frequency of the electromagnetic wave associated with the photon and its energy. It depends on the units of length, mass and time chosen, its value being h = 6.62607015×10^{-34} kg m^2/s [40]. In the Planck units of length, mass and time, the reduced Planck constant is used, hence:

$$\hbar = m_p l_p c = 1{,}0545718171 \times 10^{-34} kg\ m^2/s \quad (14)$$

For Duff [44] and Volovik [45] $\hbar$ is a fundamental constant and, therefore, can be used as an energy-to-frequency conversion factor.

If we express mass as a function of length and time (Eq. (4)), the new value of Planck's natural constant turns out to be:

$$\hbar' = G\ \hbar = l_p^2 c^3 = 7{,}038 \times 10^{-45} m^5/s^3 \quad (15)$$

This depends only on the Planck length and the speed of light and is, therefore, determined. Applying the same force to objects with the same volume produces different accelerations. To distinguish some objects from others, the concept of mass was created (Newton's second law). This results in the product $l_p c^2$ splitting into two new constants G and m_p. In turn, the product $l_p^2 c^3$ is also separated into two constants: the gravitational constant and Planck's reduced constant.

$$\hbar' = l_p^2 c^3 = (l_p c^2/m_p)(m_p l_p c) = G\ \hbar \quad (16)$$

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The (m_p l_p c) gives rise to Planck's reduced constant or angular momentum. Since all particles rotate (m^3/t^2), the energy in a period will be an integer or half-integer multiple of Planck's constant. That is, we have converted the turn into a constant. However, the spin of the particles is not observed, due to our technological limitations. What is observed is the period or wavelength and the energy will be:

$$E^{'} = GE = G\hbar\omega \ = \hbar^{'}\omega \qquad (17)$$

As before, if we use $\hbar' = G\,\hbar$ instead of $\hbar$, all measurements in physics reduce to measurements of space and time. In this way, $\hbar$ also disappears from all physical equations, thus reducing the number of dimensional fundamental constants. In short, the units of $\hbar$ will depend on the unit chosen for the mass, in addition to the units of length and time.

Like the constant of gravitation, it is the arbitrary definition of the kilogram that prevents the calculation of Planck's constant $\hbar$, unless a boundary condition is imposed.

5.3 The Origin of the Electric ε_0 and Magnetic μ_0 Constants

Two and a half thousand years ago, the Greeks already knew that rubbing an amber stone attracts small objects such as feathers and straw. To differentiate this force from the gravitational force, the concept of electric charge was created. Since the force can be attractive or repulsive, then the electric charge must be positive or negative. The unit of electric charge is the coulomb, which was derived from the ampere and is defined as the amount of charge transported in one second by an electric current of one ampere of intensity. Therefore, the intensity (I) of electric current can be expressed as the number of coulombs (Q) per unit of time (t), $I = Q / t$. Thus, the constant of Coulomb's law is equal to K=9.98755179 × 10^9 m^3kg/s^2C^2.

If we make K = 1, then:

$$K = 9.98755179 \times 10^{9} \ m^{3}kg/s^{2}C^{2} = 1 \qquad (18)$$

Thus,

$$1\ C = \sqrt{9.98755179 \times 10^{9} \ m^{3}kg/s^{2}} \qquad (19)$$

Therefore, the coulomb depends on the units of length, mass, and time. Taking into account Eq. (4), then:

$$1\ C = \sqrt{8.98755179 \times 10^{9} \ \times \ 6{,}67430 \times 10^{-11}} = 7.74503 \times 10^{-1}\ m^3/s^2 \qquad (20)$$

This indicates that Coulomb's law constant is simply a conversion factor, which needs to be introduced into the equation to preserve the units on both sides of the equation. Therefore, the coulomb, like the kilogram, can be expressed in units of length and time. On the other hand, in the same way that we have multiplied the mass by the gravitational constant, which is equivalent to multiplying the gravitational force by G, we multiply the Coulomb force by G.

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$$F_C^{'} = GF_C = GK\frac{q^2}{r^2} \qquad (21)$$

Under Planck conditions, the gravitational force and the Coulomb force are equal. Therefore,

$$F_P^{'} = GF_P = G^2\frac{m_p^2}{l_P^2} = GK\frac{q_p^2}{l_P^2} \qquad (22)$$

K is the constant of Coulomb's law and q_p is the Planck charge, and so:

$$Gm_p = \sqrt{GK}\,q_p = l_p c^2 \qquad (23)$$

When defining the electrical charge from the current of one ampere, the value of the Planck charge (q_p) is fixed, so that the product $l_p c^2$ is separated into two new variables: q_p and $(GK)^{1/}$. Since the value of G is already defined, the new constant can be presented as:

$$K = \frac{l_p^2 c^4}{Gq_p^2} \qquad (24)$$

Taking into account Eq. (7) gives:

$$K = \frac{l_p c^2}{q_p^2} m_p \qquad (25)$$

Where the values of Planck mass (m_p) and Planck charge (q_p) depend on the definition of mass and electric charge, respectively. The electric field constant will be:

$$\varepsilon_0 = \frac{1}{4\pi}\frac{q_p^2}{m_p l_p c^2} \qquad (26)$$

Or as a function of Planck's constant,

$$\varepsilon_0 = \frac{1}{4\pi}\frac{q_p^2}{\hbar c} \qquad (27)$$

The electric and magnetic field constants are related by the speed of light:

$$\varepsilon_0 \mu_0 = \frac{1}{c^2} \qquad (28)$$

Thus:

$$\mu_0 = 4\pi\frac{m_p l_p}{q_p^2} \qquad (29)$$

Therefore, of the three constants, only one is actually necessary.

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6 Units of Mass and Charge

Both mass and charge, as well as space and time, are fundamental or basic concepts that are difficult to understand. Physicists do not know what mass is. They simply define different ways of measuring something that they call 'mass'. In current physics, mass is defined as the amount of matter in a body. Mass is a fundamental physical quantity that expresses the inertia or resistance to change in the movement of a body. It is an intrinsic property of particles.

Current physics does not explain what electric charge is either, but simply establishes a unit of charge for reference, corresponding to the electric charge of the electron. If we make the following change:

$$m' = \frac{Gm}{c^2} \qquad (30)$$

mass now has units of length [L]. However, this way of proceeding changes the numerical values to which we are accustomed. In order not to change the numerical values and to be able to calculate the fundamental constants [46,47], the following change can be made:

$$m' = \frac{G_1}{c_1^2} m \qquad (31)$$

where $G_1 = 1\ m^3/\ kg\ s^2$ y $c_1 = 1\ m/s$. In this way, the unit constant $G_1/c_1^2 = 1\ m/kg$ transforms kilograms into metres and vice versa. In this way, the mass retains its numerical value, however the unit of measurement changes. The force will now have speed units squared, that is:

$$F' = \frac{G_1}{c_1^2} F \ \ \mathrm{m^2/s^2} \qquad (32)$$

The gravitational constant retains its numerical value, but its units change.

$$G' = \frac{c_1^2}{G_1} G \ \ \mathrm{m^2/s^2} \qquad (33)$$

Planck's constant will be:

$$h' = \frac{G_1}{c_1^2} h \ \ \mathrm{m^3/s} \qquad (34)$$

where h' has units of length squared multiplied by the speed or area in movement. Therefore, the unit of mass can be the kilogram, the metre, the cubic metre/second squared, or any other combination of space and time. In any case, a constant is necessary so that the units of force in Newton's second law and in the law of universal gravitation coincide.

The arbitrary definition of the kilogram is what prevents the calculation of the gravitational constant, unless a boundary condition is imposed. In addition, when defining the kilogram as a unit of mass, the gravitational constant and Planck's constant are generated, depending on the unit of mass, in addition to the units of space and time.

For the electric charge, we can make the same change and express the electric charge in metres. However, it should be kept in mind that, for a current of one ampere ($I = 1$ C/s), we can express the coulombs in seconds. This is equivalent to making the change:

$$q' = \frac{\sqrt{K_1 G_1}}{c_1^3} q \ \text{seconds} \qquad (35)$$

where K_1 = 1 kg m^3 / s^2 C^2. In this way, the unitary constant $\sqrt{G_1 K_1}/c_1^3 = 1\ s/C$ transforms coulombs (q) into seconds (q') and the charge retains its numerical value. This is an identical equation to Stoney's time: [48]

$$t_S = \frac{\sqrt{KG}}{c^3} e \qquad (36)$$

where e is the charge of the electron. It should be noted that the inverse of this unit constant is what we call amps. Coulomb's constant will now have units of speed raised to the fourth power.

$$K' = \frac{c_1^4}{K_1} K \ (metres/seconds)^4 \qquad (37)$$

And the Coulomb force will be:

$$F_C' = \frac{G_1}{c_1^2} F_C = \frac{G_1}{c_1^2} K \frac{q^2}{r^2} (metres/seconds)^2 \qquad (38)$$

The units of the electric field will be:

$$E' = K' \frac{e'}{r^2} \ metres^2/seconds^3 \qquad (39)$$

which correspond to the units of frequency, multiplied by a speed squared. The intensity of the current, in amperes, becomes dimensionless. Therefore, the load can be expressed in m^3/s^2 according to the equation (1 C = 24.508 m^3/ s^2) or in seconds for the current of one ampere, if the corresponding change of variables is made (Eq. (35)). Ultimately, all constants can be expressed in units of length and time.

7 Relationship Between Mass and Charge of Electron

Suppose we have a particle of mass m, which rotates at speed ω_e, the potential of the gravitational field at distance r will be:

$$\frac{Gm}{r} = v^2 \qquad (40)$$

where G is the gravitational constant and v is the linear speed of rotation of the particle.

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The Planck sphere rotates one complete revolution in three-dimensional space (ω_e) at the same time that it rotates the fourth dimension (ω_u), so that the particle is upside down ($\omega_e = 2\ \omega_u$), which we see as a half spin. [49]

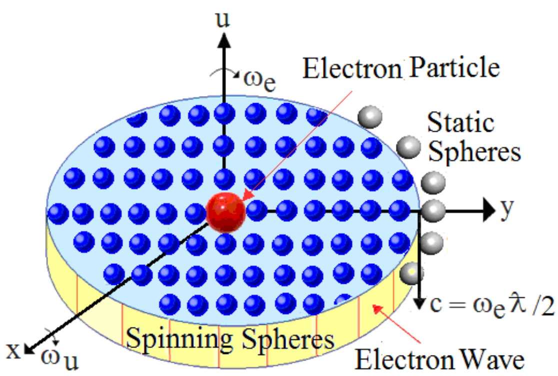

Figure 3. Two-dimensional representation of the electron

The 4D Planck spheres are linked by the Planck force, so rotating one of them will drag it to the adjacent spheres. The linear speed of rotation (Figure 3) will increase as we move away from the rotating sphere, until the speed of light *c* is reached at a distance *r*, then

$$v = \omega_u l_p \qquad c = \omega_u r \qquad (41)$$

The 'rest mass' is due to rotation in the fourth dimension (ω_u), while the wave is due to rotation in space (ω_e) or disturbance in a medium. Said medium is formed by the static 4D Planck spheres that constitute empty space.

Assuming that the gravitational field potential (Eq. (40)) of a particle of mass *m* is equal to the square of the linear velocity of rotation ($v = \omega_u l_p$) of a Planck sphere, as shown in (Figure 4), then:

$$\frac{Gm}{r} = v^2 = (\omega_u l_p)^2 \qquad (42)$$

By substituting $c = \omega_u r = \omega_u ƛ$ in Eq. (42), and taking into account the Planck length $l_p = \sqrt{G\hbar / c^3}$, we obtain:

$$E = mc^2 = \frac{1}{2}\hbar\omega_e = \hbar\omega_u = \frac{\hbar c}{r} = \frac{\hbar c}{ƛ} \qquad (43)$$

where $\hbar$ is the reduced Planck constant, and *r* is the distance in the fourth dimension that adjacent spheres of space and time rotate at the speed of light and coincide with the wavelength of the electron $ƛ = \lambda / 2\pi$. Therefore, the energy ($\hbar\omega_u$) of the rotation of the Planck sphere in the fourth dimension (ω_u) is what we call mass, and the square of the linear speed of rotation of the Planck sphere is what we call the potential of the gravitational field [50,51].

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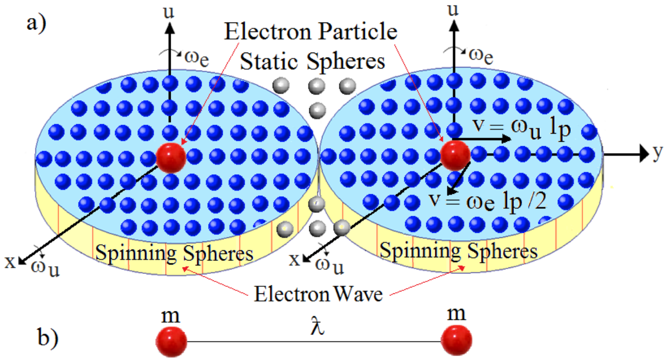

Figure 4 a) Discrete space. b) Continuous space.

On the other hand, suppose we have a circular loop carrying an electric current *I* and we gradually reduce the loop until we reach the Planck size ($lp \approx 10^{-35}$ m) and the electric current flowing is equal to 1A. Under these conditions, the coulomb, which is the arbitrary unit of electric charge, coincides with the time (in seconds) that it takes for the particle to make one revolution.

Under these conditions, the period of rotation in the fourth dimension gives rise to the electric charge. The mass will be due to the rotational energy of the 4D Planck sphere. This allows us to relate the mass and electric charge of the electron by applying the Heisenberg uncertainty principle [49-52] as a certainty principle.

$$E = mc^2 = \frac{1}{2}\hbar\omega_e = \hbar\omega_u \qquad (44)$$

The mass *m* is what we call rest mass or inertial mass. Equation (43) can be expressed in terms of the period ($\omega_u = 2\pi/T_u$), in which:

$$E = mc^2 = \frac{1}{2}\frac{h}{T_e} = \frac{h}{T_u} \qquad (45)$$

The electric charge will be due to the rotation ω_u (one of the three possible rotations). Therefore, the electric charge can be expressed as:

$$q = \frac{1}{cr^2}\frac{\partial V_{4D}}{\delta u} = 2\pi^2 T_u \qquad (46)$$

Substituting the period for the electric charge in Eq. (45) gives:

$$E = mc^2 = \frac{2\pi^2 h}{q} \qquad (47)$$

where *m* is the rest mass of the electron and the electric charge *q* is in seconds. If we want to preserve the units we are used to, simply undo the change (Eq. (35)) or multiply the current by one ampere (I = 1 A).

$$E = mc^2 = \frac{2\pi^2 h}{q} I \qquad (48)$$

Therefore, Planck's constant relates the mass and charge of the electron.

8 Calculation of the Fundamental Constants

Both mass and electric charge can be expressed in units of space and time. Therefore, the fundamental units are two: length and time. On the other hand, this paper's hypothesis is that the universe is made up of four-dimensional spheres of space, whose diameter is the Planck length. Therefore, the fundamental units would be Planck length and Planck time. However, the Planck length has not yet been measured but is calculated from other constants ($l_p = \sqrt{G\hbar / c^3}$), among which is the Gravitation constant *G*.

Since *G* is extremely small and is measured with very little precision, it is convenient to choose the reduced Compton wavelength of the electron as the constant linked to the unit length. On the other hand, we can link the speed of light c to the unit of time, instead of the Planck time, because the speed of light relates space and time and the Planck time has not been measured either.

Since mass and electric charge can be put in units of space and time, they can be calculated fairly accurately, by establishing a boundary condition, from the speed of light and the Compton wavelength of the electron. In short, taking into account Eq. (31) and (35), we can express and calculate the mass in metres and the load in seconds.

8.1 Calculation of the Elemental Charge

Electric charge is an electromagnetic constant and is measured in coulombs in honor of Charles-Augustin de Coulomb, for his mathematical description of the law of attraction between electric charges. Its value is: 1.021766208 × 10^{-19} C. [40]

It has been shown that the electric charge is due to the period of rotation of the fourth dimension ω_u (one of the three possible rotations). Therefore, the electric charge can be expressed as:

$$q = \frac{1}{cr^2} \frac{\partial V_{4D}}{\delta u} = 2\pi^2 T_u \qquad (49)$$

The period can be expressed as a function of wavelength, as:

$$\lambda = cT_u \qquad (50)$$

Substituting T_u in Eq. (49) gives:

$$q = 2\pi^2 \frac{\lambda}{c} = 1.59755 \times 10^{-19} \text{ s} \qquad (51)$$

where the electric charge is in seconds, according to the change made (Eq. (35)). The charge in coulombs is obtained by undoing the change (or multiplying the above equation by one amp (I = 1). [49]

$$q = 2\pi^2 \frac{\lambda}{c} I = 1.59755 \times 10^{-19} \text{ C} \qquad (52)$$

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The relative error is 2.89 10^{-03}. It seems appropriate to state that current physics does not know what electric charge is or why it has that value. A coulomb is an arbitrary unit of electric charge. Current theory allows electric charge to be measured but not explained. Put simply, electric charge is defined as an intrinsic or fundamental property of matter.

8.2 Calculation of the Fine Structure Constant

The fine structure constant was introduced by Arnold Sommerfeld in 1920, to explain the hyperfine splitting of atomic spectral lines. Since then there have been many attempts to find approximate equations based on purely algebraic relationships. Since the fine structure constant relates the electric charge, Planck's constant, the electric field constant and the speed of light, it will be necessary to calculate these constants.

The fine structure constant characterises the electromagnetic interaction, included in the atomic and nuclear category. Its value is: $\alpha = 7.2973525664 \times 10^{-3}$. [40]

The charge is the period or time it takes for the particle to make one revolution. Mathematically, this would be:

$$q = \pi T_e = \pi \frac{T_u}{2} \ (segundos) \qquad (53)$$

The energy of this rotation can be calculated by simply applying Heisenberg's uncertainty principle as a certainty principle.

$$E_J = \frac{1}{2}\frac{\hbar}{T_e} \qquad (54)$$

where T_e is the period of rotation around the fourth dimension. In the quantum model, the standing wave that constitutes the electron is given by the De Broglie wavelength, however, if we take the wavelength as a function of Planck's reduced constant, which is the one involved in the principle of Heisenberg uncertainty, it becomes:

$$\lambdabar_B = \frac{1}{\alpha}\frac{\hbar c}{mc^2} \qquad (55)$$

and taking into account Eq. (47) results in:

$$\lambdabar_B = \frac{1}{2\pi\alpha}\frac{qc}{2\pi^2} \qquad (56)$$

Depending on the rotation period (53):

$$\lambdabar_B = \frac{cT_e}{4\pi^2\alpha} \qquad (57)$$

and substituting in Eq. (54), results in:

$$E_J = \frac{1}{8\pi^2\alpha}\frac{\hbar c}{\lambdabar_B} \qquad (58)$$

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Imposing the condition that the Planck energy at distance $r = \lambda_B$ is equal to the spin energy in that direction, yields:

$$E_{J,r} = \frac{E_J}{\sqrt{3}} = \frac{\hbar c}{\lambda_B} \qquad (59)$$

From where,

$$\alpha = \frac{1}{8\pi^2\sqrt{3}} = 7{,}312\times 10^{-3} \qquad (60)$$

The geometric interpretation is as follows: the 4π is due to the surface of the three-dimensional sphere that is observed. The 2π is due to the rotation of that sphere in three-dimensional space, i.e. 2π radians. Finally, the √3 is due to the diagonal of the unit cube in Cartesian coordinates.

Dănescu obtained the same expression and a similar geometric interpretation through dimensional analysis. Three of the 16 relations analysed by Danescu, lead to the same expression of the fine structure constant, only as a function of the geometric constants analysed .[53,54]

Feynman wrote about the fine structure constant. "*It has been a mystery ever since it was discovered over fifty years ago, and all good theoretical physicists put this number on their wall and worry about it.*

Inmmediately you would like to know where this number for a coupling comes from: is it related to π or perhaps to the base of the natural logarithms? Nobody knows. It's one of the greatest damn mysteries of physics: a magic number that comes to us without understanding by man." [55]

8.3 Calculation of Planck Length

Although the Planck length is not a properly fundamental constant, but derived from other fundamental constants, it will be necessary to calculate the mass of the electron (in metres) and the Gravitation constant. The Planck length is given by:

$$l_P = \sqrt{\frac{G\hbar}{c^3}} \qquad (61)$$

The Planck length can be calculated since there is a relation with the reduced Compton wavelength of the electron, which we have taken as the length constant. However, it is necessary to establish a boundary condition, or unitary element. We start from a 4D Planck sphere that rotates at the Planck speed of rotation. Said Planck sphere reduces its speed of rotation until it reaches the minimum value of rotation, which gives rise to the electron. The minimum acceleration corresponds to the rotating central sphere and then:

$$a_{\min} = \omega_e^2 \frac{\lambda_p}{2} \qquad (62)$$

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On the other hand, the speed of the electron in a free state is αc [49] and the acceleration corresponding to that speed will be:

$$a = 4\pi \frac{\alpha c}{\sqrt{2t}} \qquad (63)$$

The 4π is due to the two turns that the electron must make to return to the initial state (spin ½). The $\sqrt{2}$ is due to the diagonal of the square of a unit side (t = 1 s), whose sides are the three-dimensional space *r(x,y,z)* and the fourth dimension u.

Taking into account the value of the fine structure constant already calculated (Eq. (60)), results in:

$$\frac{4\pi c}{8\pi^2\sqrt{3}}\frac{1}{\sqrt{2t}} = \omega_e^2 \frac{\lambda\!\!\!^{-}_p}{2} \qquad (64)$$

From where:

$$\lambda\!\!\!^{-}_p = \frac{1}{\pi\sqrt{6}}\frac{c}{\omega_e^2 t} = 1.61595 \times 10^{-35}\ \text{m} \qquad (65)$$

8.4 Calculation of Electron Mass

If we express the mass in metres (Eq. (31)) and the charge in seconds (Eq. (35)), then the speed of rotation of the electron relates the mass to the charge ($m \equiv q\ v$). On the other hand, under the Planck conditions, it is verified that

$$Kq_p^2 = Gm_p^2 \qquad (66)$$

where K is the Coulomb constant, G is the constant of gravitation, q_p is the Planck electric charge and m_p is the Planck mass. Thus**,**

$$m_p = \sqrt{\frac{K}{G}}q_p = \sqrt{\frac{K}{Gc^2}}q_p c = \frac{1}{\sqrt{4\pi}}\sqrt{\frac{\mu_0}{G}}q_p c = \frac{1}{\sqrt{4\pi}}\frac{q_p c}{\alpha} \qquad (67)$$

So α can only be the fine structure constant. The mass of the electron can be put as a function of the Planck mass, through the reduced Compton wavelength of the electron and the reduced Planck constant. Thus:

$$m = \frac{\hbar}{\lambda\!\!\!^{-} c} = \frac{m_p l_p}{\lambda\!\!\!^{-}} \qquad (68)$$

By substituting the Planck mass (Eq. (67)) and taking into account the fact that the fine structure constant relates the electric charges of the electron and Planck ($\sqrt{\alpha}=q/q_p$), we obtain the following expression for the mass of the electron:

$$m = \frac{1}{\sqrt{4\pi}}\frac{q_p c}{\alpha}\frac{l_p}{\lambda\!\!\!^{-}} == \frac{1}{\sqrt{4\pi}}\frac{qc}{\alpha\sqrt{\alpha}}\frac{l_p}{\lambda\!\!\!^{-}} \qquad (69)$$

where the mass of the electron (m) is in metres and the charge of the electron (q) is in seconds. The wavelength of the electron can be expressed in terms of the electric charge (Eq. (50)), as follows:

$$\lambda = \frac{qc}{2\pi^2} = 2\pi ƛ \qquad (70)$$

Substituting into Eq. (69), we obtain the mass of the electron in metres:

$$m = 2\pi^2 \sqrt{\frac{\pi}{\alpha}\frac{l_p}{\alpha}} = 9.086\,10^{-31} m \qquad (71)$$

The mass is the space in the fourth dimension of the 4D Planck sphere, projected onto the 3D sphere that we observe as a particle. In a universe made only of space and rotating 4D Planck spheres, if the electric charge is time, the rest mass can only be space.

8.5 Calculation of Planck's Constant

Planck's constant is a universal physical constant, its value being: 6.63607015 10^{-34} kg m^2/s. [40] It represents the elemental quantum of action and relates the amount of energy to the frequency associated with a particle. To calculate Planck's constant we can use the relationship between the mass and charge of the electron, as in Eq. (48).

$$h = \frac{1}{I}\frac{qmc^2}{2\pi^2} = 6.6452 \times 10^{-34} \text{ kg m}^2\text{/s} \qquad (72)$$

In 1963, Paul Dirac wrote: *"The physics of the future, of course, cannot have the three quantities h e and c all as fundamental quantities. Only two of them can be fundamental, and the third must be derived from those two. It is almost certain that c will be one of the two fundamental ones. The velocity of light, c, is so important in the four-dimensional picture, and it plays such a fundamental role in the special theory of relativity, correlating our units of space and time, that it has to be fundamental.* [56] In fact, the Planck constant has been obtained as a function of e and c, since c and l_p determine the initial conditions of the 4D Planck sphere. Planck's constant ħ can also be calculated based on the speed of light, Planck length and fine structure constant. [47]

8.6 Calculation of the Gravitational Constant

The gravitational constant G depends on the speed of light, the reduced Planck constant and the Planck length, therefore we need the value of the Planck length. The value has been calculated previously, based on the reduced Compton wavelength of the electron, which we have taken as the length constant. So the gravitational constant will be:

$$G = \frac{ƛ_P^2}{\hbar} c^3 = 6.67174\,10^{-11}\ m^3 kg^{-1} s^{-2} \qquad (73)$$

This value is within the 14 measured values of the Newtonian constant of gravitation G of interest in the 2014 fit. [40]

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8.7 Calculation of the Electric Constant

The electrical constant is related to the already calculated constants of: fine structure (Eq. (60)), charge of the electron (Eq. (52)), Planck's constant (Eq. (72)) and the speed of light.

$$\varepsilon_0 = \frac{1}{4\pi\alpha}\frac{q^2}{\hbar c} \qquad (74)$$

where the electric charge is in seconds. This needs to be multiplied by the current of one ampere, to convert it to coulombs. Therefore**:**

$$\varepsilon_0 = \frac{1}{4\pi\alpha}\frac{q^2}{\hbar c}I^2 = 8{,}80168\times 10^{-12} \qquad (75)$$

which gives a relative error of 5.93×10^{-03}.

8.8 Calculation of the Boltzmann Constant

Boltzmann's constant relates absolute temperature and energy. Its value is 1.38064852(79) $\times 10^{-23}$ JK^{-1}, with a standard uncertainty of 5.7 $\times 10^{-7}$. [40]

It has been seen that the energy of the electron is due to the rotation of the fourth dimension. This rotation will have to be projected onto the three spatial dimensions that are observed. The energy can be put as a function of the Compton wavelength. This energy will have to be equal to the energy given by the temperature.

$$E = \frac{1}{2\pi^2}\frac{hc}{\lambda} = kT \qquad (76)$$

The temperature will be due to the rotation of the electron c = 1 m/s y T=1 K, then:

$$K = \frac{1}{2\pi^2}\frac{h}{\lambda}\frac{c}{T} = 1.3835\times 10^{-23}\ \ JK^{-1} \qquad (77)$$

where: h=6,626 070 040(81) × 10^{-34} Js and λ= 2,426 310 2367(11) × 10^{-12} m. This gives a relative error of 0.21%.

8.9 Calculation of Mass and Charge of Down and Up Quarks

The developed model is based on the fact that both the universe and the particles verify Heisenberg's uncertainty principle, as a certainty principle. Therefore, the equation to take into account is Heisenberg's uncertainty principle and, obviously, not to modify it.

Equation (47) establishes a relationship, through Planck's constant, between the mass (m) and the charge of the electron (q) [54]. This equation can be put as:

$$\frac{1}{2\pi^2}n^2 mc^2\frac{q}{n} = nh \qquad (78)$$

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where n and l are positive integers or half-integers, h is the Planck constant, and m and q are the mass and charge of the electron, respectively. The mass m_n and the electric charge q_n of the particles will be given by:

$$m_n = n^2 m \qquad q_n = \frac{q}{n} \qquad (79)$$

For n = 1, we obtain the mass and the electron electric charge.

Quark Down

For n = 3:

$$m_d = 9m = 4.59 Mev \qquad (80)$$

This value falls within the limits recommended by Particle Data Group (PDG), between 4.50 and 5.15 MeV [58]. The electric charge will be:

$$q_d = \frac{1}{3} q \qquad (81)$$

Quark Up

For n = 3/2:

$$m_u = 2n^2 m = \frac{9}{4} m = 2.30 Mev \qquad (82)$$

This value falls within the limits recommended by PDG, between 1.90 and 2.65 MeV [58]. The '2' is due to the fact that two down quarks (modulus of electric charge) are needed to obtain an up quark. The electrical charge will be:

$$q_u = \frac{2}{3} q \qquad (83)$$

8.10 Calculation of the Mass of the Second Generation Quarks

First generation quarks are stable, whereas second and third generation quarks decay into other quarks through the weak interaction. However, they have not been observed in the free state, but confined to groups of 2, 3, 4, and even combinations of 5 quarks (figure 5). The quark-antiquark combination is called a meson. The protons and neutrons that make up the atomic nucleus are combinations of three quarks or baryons**.**

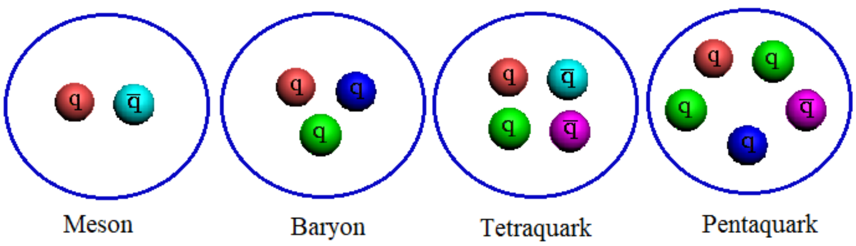

Figure 5. Combinations of 2, 3, 4 and 5 quarks

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There are several 21st century particle physics experiments reporting the existence of tetraquarks, formed by the combination of two quarks and two antiquarks. The particle X(3872), is one of the first tetraquark candidates [59-61]. The diquark-antidiquark structure explains the properties of particle X(3872) well. [62]. *"If the X(3872) is not a pure* $c\bar{c}$ *state, the simplest explanation would appear to be that it is composed of two quark and two antiquarks (* $c\bar{c}u\bar{u}$ *) and produced in B+ decay"* [63].

The Z(4430) particle discovered in 2014 could also be a tetraquark. *"It therefore seems clear that the Z (4430) must be exotic with a minimal quark content of* $c\bar{c}u\bar{d}$ *, but as before there is a major open question as to its internal structure"* [63].

There is also experimental evidence requiring a minimum of five quarks [64, 65]. "*It can be interpreted as a molecular meson-baryon resonance or alternatively as an exotic 5-quark state (uudds¯) that decays into a K+ and a neutron*" [66]. Evidence for the positive strangeness pentaquark is seen in the photoproduction of kaons with the SAPHIR detector at the Bonn ELectron Stretcher Accelerator ELSA [67]. On the other hand, for other authors, the experimental evidence of pentaquarks is very weak [68].

Baryons are combinations of 3 quarks, however combinations of two quarks with one antiquark are missing (Figure 6), such as down-anti-down higher or up-anti-up lower

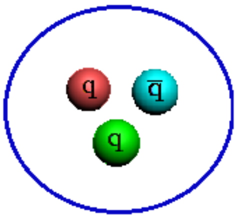

Figure 6. Combinations 2 quarks with antiquark

Strange quark

The strange quark, according to the standard model, is an elementary particle, which belongs to the second generation of quarks. Its electric charge is equal to -1/3 of the elementary charge and a with spin of 1/2. The mass of the strange quark recommended by PDG [58], is:

$$m_S = 93^{+11}_{-5}\ MeV \qquad (84)$$

According to the developed model, the strange quark must be a particle composed of an up antiquark quark plus a down quark.

$$s = u\bar{u}d(J = 1/2) \qquad (85)$$

The energy of the strange quark due to the up-anti-up combination will be the energy of the electromagnetic field at a distance equal to its Compton wavelength:

$$E_S = K\frac{q_u^+ q_{\bar{u}}^-}{\lambda_s} = K\frac{4}{9}\frac{q_e^- q_e^-}{\lambda_s} \qquad (86)$$

In addition, we must take into account the coupling of the down quark with the up antiquark equals one electron. Therefore, the coupling will be between the electron and the up quark.

$$\alpha_u = \frac{q_e}{q_u/2} = 3 \qquad (87)$$

With what:

$$\alpha_u K\frac{q_u^+ q_{\bar{u}}^-}{\lambda_s} = 3K\frac{4}{9}\frac{q_e^- q_e^-}{\lambda_s} = m_e c^2 \qquad (88)$$

From where:

$$m_s = \frac{4}{3\alpha} m_e c^2 = 93{,}4 \ MeV/c^2 \qquad (89)$$

Where m_e = 0.51099895 MeV/c^2 and α=0.0072973525693. Depending on the method used to calculate the mass of the strange quark, it varies from 87.6 ± 6.0 MeV/c^2 to 119.5 ± 9.3 MeV/c^2 [58].

8.11 Calculation of Muon Mass

According to the Standard Model of Particle Physics, the electron, the muon and the tau are point particles, with the same charge and spin that basically differ in that:

- the electron is stable, while the other two particles decay; and
- the masses are different.

The measured muon mass is 155.658 MeV. [58] If we assume that the muon is a particle composed of a quark-antiquark plus an electron, then we have two types of muons:

- d-type muon: $\mu_d^- = d\bar{d}e^-(J = 1/2)$
- u-type muon: $\mu_u^- = u\bar{u}e^-(J = 1/2)$

The mass will be due to the rotation of the particles that constitute the muon and the rotation is related to the charge of said particles. Therefore, the mass will be due to the energy of the electromagnetic field at a distance r equal to its wavelength λ_μ. Equating said energy to the energy of the electron E_e results in:

$$E(r) = E(\lambda_\mu) = E_e \qquad (90)$$

$$K\frac{q_{\bar{e}}q_{\bar{d}}}{r}+K\frac{q_{\bar{e}}q_{\bar{d}}}{r}=2K\frac{q_{\bar{e}}q_{\bar{d}}}{r}=\frac{2}{3}K\frac{q_{\bar{e}}q_{\bar{e}}}{r} \qquad (91)$$

for $r=\bar{\lambda}_{\mu}$

$$\frac{2}{3}\frac{Kq^2}{\lambda_\mu}=\frac{2}{3}\frac{Kq^2}{\hbar c}m_\mu c^2=m_e c^2 \qquad (92)$$

It will be necessary to take into account other energies, such as the magnetic, kinetic and potential of the quarks and the proper mass of the electron. Of all of these, the most important seems to be the mass of the electron and, therefore:

$$m_\mu=\frac{3}{2\alpha}m_e+m_e=\ 105{,}549\text{ MeV} \qquad (93)$$

For the combination $\mu^-=u\bar{u}e^-(J=1/2)$, the mass will be given by:

$$K\frac{q_{\bar{e}}q_{\bar{u}}}{r}+K\frac{q_{\bar{e}}q_{\bar{u}}}{r}=2K\frac{q_{\bar{e}}q_{\bar{u}}}{r}=\frac{4}{3}K\frac{q_{\bar{e}}q_{\bar{e}}}{2r} \qquad (94)$$

The ‘2’ in the denominator is due to the fact that two quarks are obtained above three positrons. [57]

8.12 Calculation of the Mass of the Higgs Boson

The Higgs boson is the particle responsible for giving mass to other particles and to itself. The Higgs mechanism was formulated by Brout and Englerty in 1964, and later by Higgs. According to this idea, the universe is made up of an invisible field, called the Higgs field. The friction of the particles within this field reduces their speed, so that the greater the resistance, the greater the mass. *“The idea represents a great intellectual leap that, in a way, recovers the old notion of the ether, albeit in a completely new way”* [50].

The mathematical development of quantum field theory predicts that all fundamental bosons, responsible for interactions between particles, are not massive. However, the W (Weak) boson that carries the weak interaction has a non-zero mass. This was seen as a major flaw in quantum field theory. In 1964, Higgs developed a mathematical mechanism by which electroweak symmetry is broken locally. This is what is called ‘spontaneous symmetry breaking’. Due to this rupture, the Higgs bosons appear that give mass to the electroweak bosons and, in fact, interact more intensely, the greater the mass of the particle.

The Higgs Boson generates the Higgs field that permeates all of space so that the elementary particles that interact with it acquire mass. However, the standard model does not predict the Higgs mass, which has to be measured experimentally. Nor does it predict the value of the mass of fermions, bosons and quarks, nor the value of some parameters that depend on the mass of the Higgs boson.

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In short, 60 years after Higgs and two other groups of physicists independently developed the theory, all we have is a mathematical equation, which says that the mass of particles is proportional to a given mass, called the value of expectation. However, neither the expectation value, nor the proportionality constant, nor the mass of the particles can be calculated.

To calculate the mass of the Higgs boson, it is necessary to know its structure. To do this, some of its decays need to be known. At the LHC, the Higgs boson cannot be observed directly, but rather through its decay products. One possible decay is to two photons. It can also decay to two Z particles. The Z decays into a muon-antimuon pair. If both Z's decay in this way, then this creates four muons (Figure 8).

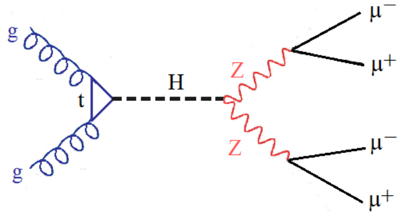

Figure 8. Higgs boson decay.

The muon, in the model developed in this paper, is a particle composed of a down quark-antiquark plus an electron and whose mass is given by Eq. (90).

In the same way, the mass of the Higgs boson will be given for $r = \lambda_H/2\pi$.

$$E_H = \frac{2}{3} K \frac{q_{\bar{e}} q_{\bar{e}}}{\lambda_H} \qquad (95)$$

In addition, it will be necessary to take into account the coupling of the quarks of the other muon, which will be:

$$\alpha_d = K \frac{q_{\bar{e}} q_{\bar{d}}}{\hbar c} + K \frac{q_{\bar{e}} q_{\bar{d}}}{\hbar c} = 2K \frac{q_{\bar{e}} q_{\bar{d}}}{\hbar c} = \frac{2}{3} K \frac{q_{\bar{e}} q_{\bar{e}}}{\hbar c} = \frac{2}{3}\alpha \qquad (96)$$

We must also take into account the coupling of the electron, which will be:

$$\alpha_e = \frac{q_{\bar{e}}}{q_p} = \sqrt{K \frac{q_{\bar{e}} q_{\bar{e}}}{\hbar c}} = \sqrt{\alpha} \qquad (97)$$

where q_p is the Planck charge. Finally, as we have two Z particles, then:

$$E_H = 2\alpha_e \alpha_d \frac{2}{3} K \frac{q_{\bar{e}} q_{\bar{e}}}{\lambda_H} = m_e c^2 \qquad (98)$$

and so

$$m_H = \frac{1}{2\sqrt{\alpha}} \frac{3}{2\alpha} \frac{3}{2\alpha} m_e = 126{,}37 \ GeV/c^2 \qquad (99)$$

Where m_e = 0,51099895 MeV/c^2 is the mass of the electron and α=0.00729735256 is the fine structure constant. This value falls within the limits of

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mass given by the ‘PDG’, i.e. between 122 ±7 and 126.8 ±0.2 ±0.7 GeV/c2. The value recommended by the ‘Particle Data Group’ is: *m* = 125.10 ±0.14 GeV/c^2 [58].

8.13 Calculation of the Z Boson Mass

If the Higgs boson decays into two Z particles, in principle, the mass of each Z boson should be half the mass of the Higgs. However, it must be taken into account that since the Z particle is neutral, the two Z particles join due to the gravitational force, as occurs with neutrons. Therefore, there will be a loss of mass, because the union of two neutral particles decreases the volume of the whole and therefore, the energy of the electromagnetic field of the two Z bosons, which form the Higgs boson, is lower that the sum of the masses of the two Z bosons.

$$m_H = 2m_Z - \Delta m \qquad (100)$$

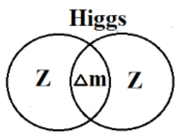

Figure 9. Mass defect as the Higgs decays in two Z bosons

On the other hand, if the Z boson decays into muon-antimuon, the simplest thing is that it is formed by these two particles (figure 10)

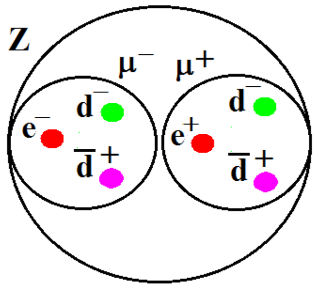

Figure 10. The two muons interact to form a boson

In this case, since the muons are charged particles, they interact with each other, so that

$$2\alpha_d \alpha_e K \frac{q_\mu^- q_\mu^+}{\lambda_Z} = m_e c^2 \qquad (101)$$

Where, α_d is due to the coupling of the quarks of each muon, α_e is due to the coupling of the electron of each muon and the 2 is due to the 2 muons.

$$m_Z = \frac{1}{2\alpha\sqrt{\alpha}} \frac{3}{2\alpha} m_e = 84{,}25 \ GeV/c^2 \qquad (102)$$

Where m_e = 0.51099895 MeV/c^2 and α=0.0072973525693. The value given by PDG, Γ(μ + μ) = 83.99 ± 0.18 GeV /c^2 [58].

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9 Errors and Measurements

Most of the fundamental constants are measured very precisely. For example, the mass of the electron is measured with a relative standard uncertainty of 3.0×10^{-10}. In this work, for the calculation of the relative error of the electron, the following formula was used:

$$Error\% = \frac{|V_m - V_c|}{V_m} 100 \qquad (103)$$

where V_m is the measured value and V_c is the calculated value, which gives a mass of the electron an error of:

$$Error = \frac{9.1093837015 \text{ x } 10^{-31} - 9.086 \text{ x } 10^{-31}}{9.1093837015 \text{ x } 10^{-31}} = 2.57 \times 10^{-3} \qquad (104)$$

This is seven orders of magnitude greater than the relative standard uncertainty, which may seem very large for the calculation of a fundamental magnitude but consider, for example, the mass of the up quark, which does not exist freely in nature and, therefore, has to be calculated from other parameters. In this case, different calculation methods are used, from which PDG recommends a certain value. A couple of measures can be considered:

- *Dominguez determined the quark mass from a QCD finite energy sum rule for the divergence of the axial current* [58]. This gives a value of 2.6 ± 04.
- *Deandrea determined $m_u - m_d$ from $\eta \rightarrow 3\pi^0$ and combined it with the PDG 06 lattice average value of $m_u + m_d = 7.6 \pm 1.6$ to determine m_u and m_d* [58]. This gives a value of 2.9 ± 08.

If the maximum value measured (3.02 ± 0.33) is taken into account and compared with the minimum value (1.70 ± 0.3), the relative error between the maximum and minimum values would be:

$$Error = \frac{3.03 - 1.7}{3.03} = 4.39 \times 10^{-1} \qquad (105)$$

The difference between the maximum and minimum value is 43.9%, i.e. the standard model only allows the fundamental constants to be calculated roughly.

10 Conclusion

Many of the constants are due to the mass of the various fermions and bosons, which the Standard Model does not predict but simply measures using different methods. After measuring the different values, Particle Data Group recommends a certain value. In addition, it assigns the value of the mass to the interaction of the particles with the Higgs field, produced by the Higgs boson, whose mass the standard model is also unable to predict.

Instead, as we have seen, if the particles are assumed to be rotating 4D spheres, the charge can be attributed to the period of that rotation. Therefore, the mass will be due to the rotation of the particles or to the energy of the electromagnetic field, with which the mass of most particles can be easily calculated.

On the other hand, the speed of light is fixed by defining the metre as a unit of length and the second as a unit of time. At the same time, the values of the Planck length and time corresponding to the 4D sphere of Planck are fixed. With this, the constants $l_p\, c$, $l_p\, c^2$ and the product of both $l_p\, c \times l_p\, c^2$ are determined.

The value of the Planck mass (m_p) is determined by defining the kilogram as the unit of mass, with which the constant $l_p\, c^2$ is separated into two: Planck mass and Gravitation constant, $G = l_p\, c^2/ m_p$. Also, the product $l_p\, c \times l_p\, c^2$ separates into two: the Planck's constant and Gravitation constant: $m_p\, l_p\, c \times l_p\, c^2/m_p = \hbar \times G$.

By defining the coulomb as the unit of electric charge, the value of Planck's electric charge (q_p) and that of Coulomb's law constant, which depends on the constant $l_p\, c^2$ and on the mass and electric charge of Planck, are fixed. $K = l_p\, c^2\, m_p\, /q_p^2$.

On the other hand, on the 4D Planck sphere the gravitational and Coulomb forces are equal but Planck's 4D sphere decreases its rotation until it reaches electron conditions so that Coulomb's law, under Planck's conditions, verifies $F_q = \alpha F_p$, where F_p is the Planck force.

The negative charge of electrons and the positive charge of positrons are determined by the direction of rotation of the 4D Planck sphere. Electrons and positrons combine in such a way that three electrons make one down quark and three positrons make two up quarks. The quarks combine to give rise to the second and third generation particles, as well as the rest of the compound particles. In turn, the compound particles decay, giving rise to photons and neutrinos. So, it all comes down to space in movement.

When comparing the calculated values of the fundamental constants carried out in this work, with the values calculated by the standard model, it is observed that, only two constants are enough to determine the values of the remaining fundamental constants. The only constants in nature, independent of the speed of any observer, are the Planck length and the Planck time, which can also be referred to as the Planck length and the speed of light.

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