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On the nature of electric charge

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A few hundred years have passed since the discovery of electricity and electromagnetic fields, formulating them as Maxwell's equations, but the nature of an electric charge remains unknown. Why do particles with the same charge repel and opposing charges attract? Is the electric charge a primary intrinsic property of a particle? These questions cannot be answered until the nature of the electric charge is identified. The present study provides an explicit description of the gravitational constant G and the origin of electric charge will be inferred using generalized dimensional analysis.

Key words: Electric charge, gravitational constant, dimensional analysis, particle mass change.

INTRODUCTION

The universe is composed of three basic elements; mass-energy (M), length (L), and time (T). Intrinsic properties are assigned to particles, including mass, electric charge, and spin, and their effects are applied in the form of physical formulas that explicitly address physical phenomena. The meaning of some particle properties remains opaque. For example, there is no intelligible explanation of an electric charge. What is known of electric charge is its ability to generate force and an electromagnetic field and its attractive and repulsive reactions to other charged particles. It is known that an electric charge obeys the law of conservation and quantization. Constants have been identified, such as h (Planck constant), v_c (speed of light), and G (gravitational constant). Meaningful interpretations of mass-energy, length, and time in relation to these constants are also necessary. Attempts have been made to clarify the nature of electric charge, but none are comprehensive because they fail to provide explicit general formulas for the relation between electric charge and known physical parameters. The present study provides a new approach to this problem and an explicit formula that addresses the relation between electric charge and known physical parameters. This approach is of great generality and mathematical simplicity that simply and directly postulates a hypothesis for the nature of the electric charge. Although the final formula is a guesswork based on dimensional analysis of electric charges, it shows the existence of consistency between the final formula and proven physical facts.

The explanation begins with a brief introduction to dimensional analysis and how it is used. The new method is then applied to develop a formula to describe G in terms of known physical universal parameters. The new formula will be shown to be almost identical to the solution of the Friedmann equation. The guideline will be proposed to formulate an explicit definition of the nature of an electric charge. It will be shown that electric charge is equivalent to mass change in a particle. To overcome deficiencies in the new approach, the results will be compared to current proven knowledge. No contradictions or inconsistencies will be raised and excellent compatibility will be confirmed. Practically, any ambiguity in knowledge may unexpectedly produce multiple unknowns. The main purpose of this study is to eliminate obscurity about the origin of the electric charge.

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DIMENSIONAL ANALYSIS

Almost all physical parameters (constants and variables) have a combination of the dimensions of mass, length, and time. The present study did not employ basic units for absolute temperature (Θ), amount of substance (N) and luminous intensity (J), and other parameters related to them. Because physical parameters are addressed, the gravitational constant and electric charge can be sufficiently expressed using a combination of M, L, and T. Constants without dimensions express values such as angle or proportions such as the ratio of particle speed to light speed. Some constants merely establish equality in the system of measurement. Some physical constants and variables do not have clear dimensions of a combination of M, L, and T. For example, the dimension of linear momentum is ML/T. This is an explicit combination of mass, length and time. The dimension of electric charge $\sqrt{4\pi\varepsilon_0 \frac{ML^3}{T^2}}$ is more complicated. The vacuum permittivity constant is ε_0, but it is not explicitly defined in terms of M, L, and T. One can easily decompose ML/T into, e.g., mass (M) and velocity of a particle (L/T), and find a formula for the linear momentum of a particle. This has not been accomplished for electric charge.

Dimensional analysis is a simple tool for understanding the relationship between physical parameters and equations based on their dimensions, but it is not used to explore and formulate unknown phenomena. It is often used to check the accuracy of calculations and equations and to express physical parameters based on their associations with other types of parameters.

The present study uses a slight generalization of this tool to find a meaningful and explicit description of the obscure physical parameter of electric charge. This method parses the dimension of an unintelligible parameter into separate parts and performs a simple mathematical manipulation on each part to convert it into a real physical parameter. Finally, the physical parameters derived for each part, keeping the final composition, will be used to present a precise definition of the relationship between the combination of M, L, and T and the original unknown parameter.

Crediting a physical parameter to a specific dimension must be based on logic and known physical facts. This method avoids any decomposition of a dimension or assigning a physical parameter to each part that promotes ambiguity in the meaning of a part. This constraint appears as a lemma that should be studied and developed. This method may not work in all cases, but gives good results for gravitational constant and electric charge.

It should be emphasized that this method and its related restrictions will not sufficiently support the final results. Each equation obtained from this method is guesswork, although dimensions for both sides of the equation are established. Experiments, measurement, and mathematical calculations based on pre-established relationships and equations confirm the conjecture; however, it is good practice to compare these results withproven physical facts.

First, the symbols [] and $[]^{-1}$ should be defined in relation to the dimensions of the physical parameters:

Definition 1: $[y] = M^{\alpha}L^{\beta}T^{\gamma}$

In this equation, $M^{\alpha}L^{\beta}T^{\gamma}$ is the dimension of physical quantity *y*. In fact, the units of any physical quantity can be expressed using a power law (Sedov, 1993).

Definition 2: $y = [M^{\alpha}L^{\beta}T^{\gamma}]^{-1}$

where a physical quantity y governs the dimension combination $M^{\alpha}L^{\beta}T^{\gamma}$.

NATURE OF THE GRAVITATIONAL CONSTANT G

Gravitational constant (G) is a constant parameter that appears in the equation of gravity:

$$F = G\,\frac{m_1 m_2}{r^2} \qquad (1)$$

This equation itself does not provide a tangible interpretation of the nature of G. This formula does not define its source, amount, or relation to other actual parameters in the universe. To discover this relationship, the dimensions of both sides of Equation (1) for M, L and T are:

$$\frac{ML}{T^2} = [G]\frac{M^2}{L^2} \qquad (2)$$

Therefore:

$$[G] = \frac{L^3}{MT^2}\,\frac{M}{M} \qquad (3)$$

Equation (3) represents the dimension of G and states that physical parameters exist in the universe whose integration (as a formula with the above final dimension) gives the value of G. To fit this into an equation to determine the value of G in terms of physical parameters, the right side of Equation (3) is parsed into two parts and multiplied by dimensionless parameter β on the right side, obtaining:

$$G = \beta\,[\frac{L^3}{M}]^{-1}[\frac{1}{T^2}]^{-1} \qquad (4)$$

The fraction *M/M* should not be omitted, but should encompass in β for simplicity. This can be rewritten as:

$$G = \beta \left[\frac{4\pi/_3 L^3}{4\pi/_3 M}\right]^{-1}\left[\frac{1}{T^2}\right]^{-1} \tag{5}$$

If L is assumed to be the dimension of the radius of a sphere, the numerator of $\frac{4\pi/_3 L^3}{4\pi/_3 M}$ is the volume of that sphere:

$$G = \beta \left[\frac{V}{4\pi/_3 M}\right]^{-1}\left[\frac{1}{T^2}\right]^{-1} \tag{6}$$

Obtaining:

$$G = \frac{3}{4\pi}\beta \left[\frac{1}{\left(\frac{M}{V}\right)}\right]^{-1}\left[\frac{1}{T^2}\right]^{-1} \tag{7}$$

The mass-to-volume ratio represents the mass density (ρ). Assuming that $\frac{1}{\rho}$ and $\frac{1}{T^2}$ are real physical parameters that govern dimensions $\frac{1}{\left(\frac{M}{V}\right)}$ and $\frac{1}{T^2}$, respectively, produces:

$$G = \beta \frac{3}{4\pi\rho T^2} \tag{8}$$

Because G is a universal constant independent of any particle and reference system, the parameters of Equation (8) should be relevant to the whole universe. Therefore, let the supposed sphere be the entire universe and *M* its mass; consequently, ρ is the mass density of the universe. Also let T be the age of the universe. Now, choosing constant β gives an equation that expresses the value and nature of gravitational constant G. Regardless of the value of constant β, Equation (8) states that G is inversely proportional to the squared age and matter density of the universe. That is, if G is constant, ρ must decline steadily because of the continual increase in the value of T. Therefore, *V* (the volume of the universe) increases steadily because of the law of mass-energy conservation. Now, we compare the derived formula for G (Equation (8)), with what has been obtained, using Einstein field equations. In the matter-dominant universe, solving the Friedmann equation leads to (Komissarov, 2012):

$$G = \frac{3\Omega_m H_0^2}{8\pi\,\rho_m} \tag{9}$$

In this equation, the Hubble constant (H_0) is approximately the inverse of the age of universe and Ω_m is the ratio of mass density of the universe to the critical mass density. This Ω_m may be related to *M/M* in Equation (3) that was canceled and temporarily included in β.

Therefore, if we substitute β with $\frac{\Omega_m}{2}$, there will be no difference between Equations (8) and (9).

Using dimensional analysis, plus guess and intuitive analysis based on physical realities, obtains an equation to determine the physical parameters defining G. Although, this process began with a good guesswork, evaluating it using the Friedmann equation confirmed the strength of new method and correctness of its result.

NATURE OF ELECTRIC CHARGE

The question remains about the nature of electric charge and why there is no comprehensible interpretation of electric charge based on M, L and T, or a combination of known parameters of particles, such as spin and velocity. It is not known why same-charged particles repel and oppositely-charged particles attract or if electric charge is really an intrinsic property of a particle. The complicated dimension of electric charge $\sqrt{4\pi\varepsilon_0 \frac{ML^3}{T^2}}$ makes it difficult to accept it as an intrinsic property of particles, when compared with simple and explicit properties like mass and spin.

Electric charge seems to be an abstract of other basic properties and physical constants. If this is true, how can an electric charge and electromagnetic field be directly measured and formulated? The answer is that the style that mass-space-time exerts its characteristic of the primary intrinsic property (related to the electric charge) leads to an observable, measurable, and summarized physical parameter known as electric charge. The reason that the main intrinsic property cannot be identified is that value is beyond current accurate measurement. It must be emphasized that this study does not refute current knowledge on electric charges and electromagnetic fields. Electric charge is certainly a known, observable, and measurable parameter of the universe. Accepted knowledge, especially Maxwell's equations, that has been subjected to countless experimentation based on the current definition of electric charge is definitely correct; however, it is necessary to overcome the obscurity about the nature of electric charge. Physics currently face unresolved problems and opened line research on the subjects such as the unified field theory, baryon asymmetry, and magnetic monopoles (Christianto et al., 2007). Defining the nature of an electric charge may also shed light on these unknown areas in physics.

Previous attempts to find the origin of electric charge include work by Shpenkov and Kreidik (2004), who developed a hypothesis based on new definition of elementary particles and their exchange in the matter-space-time field. Their theory that an electric charge is a mass change rate seems to be consistent with the results of the present study. Shpenkov ("What the Electric Charge is") stated, "The erroneous form of the Coulomb law gave rise to a phenomenological system of notions with measures having fractional powers of base units that are really senseless. Cognition of the nature of electric charges has become impossible". This notion is the opposite of the conclusion of this study.

Olah (2009) proposed a hypothesis that is in contrast with the current proven model of electric charges and fields. It is difficult to accept such theories. Tiwari (2006) suggested the origin of an electric charge in terms of fractional spin. Sasso (On Primary Physical Transformations of Elementary Particles: the Origin of Electric Charge) proposed a hypothesis based on relation between electric charge and spin. Nguyen (2013) discussed the change in electron charge in an external magnetic field. He stated: "the variability (or the constancy) of the mass and the electric charge of the electron still remains as a foundational problem in modern physics, awaiting to be justified". Krasnoholovets (2003) and McArthur (1999) also discussed this.

None of these works provides an explicit formula for the exact value and the nature of electric charge based on proven facts. There are two remarkable points among these discussions: there is a possible relation between electric charge and mass change, and variability of electric charge is possible. The strength of the new approach is: (1) it utilizes current proven physical equations to develop a solution; (2) a simple novel method of dimension analysis is proposed; and (3) an explicit formula for an electric charge is provided. No previously mentioned research encompasses all three benefits. A new theory is not proposed, but a different way of looking at previous hypotheses is advanced.

Using the successful dimensional analysis from the previous section, the same procedure is followed to discover the nature of electric charge beginning with Coulomb's law:

$$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2} \tag{10}$$

Replacing the dimensions of the parameters leads to:

$$[q^2] = 4\pi\varepsilon_0 \frac{ML^3}{T^2} \tag{11}$$

Assuming dimensionless parameter (γ) and multiplying it by the right side of Equation (11) produces the following:

$$q^2 = 4\gamma\pi\varepsilon_0 [\frac{ML^3}{T^2}]^{-1} \tag{12}$$

Up to this point, the equation represents the dimension of electric charge. It also states that there must be physical parameters and constants that are integrated as a formula (with this final dimension) that equals q. The next point is to assign meaningful parameters to the components of the q dimension, beginning by decomposing $\frac{ML^3}{T^2}$. Clearly, $\frac{ML^3}{T^2}$ can be categorized in different ways using parameters with proper and valid physical interpretations. One solution is:

$$[\frac{ML^3}{T^2}]^{-1} = [\frac{ML^2}{T}]^{-1} [\frac{L}{T}]^{-1} \tag{13}$$

In this equation, $\frac{ML^2}{T}$ is the dimension of angular momentum, and $\frac{L}{T}$ is the dimension of linear velocity. Since q is the intrinsic property of the particle, angular momentum should be interpreted as particle spin. It is known that particles with non-zero spin have zero electric charge (such as electron-neutrinos). This inconsistency is troubling. In addition, in Equation (12), the roots of the parameters of angular momentum and linear velocity describe electric charge, but the root of the parameters is senseless and physically meaningless. Guesswork in this method should not conflict with known principles, although the dimension relationship is true. Slight manipulation of Equation (12) produces:

$$q^2 = 3\gamma\varepsilon_0 [\frac{4\pi L^3}{3M}]^{-1} [\frac{M^2}{T^2}]^{-1} \tag{14}$$

As in Equations (5) and (6):

$$q^2 = 3\gamma\varepsilon_0 [\frac{1}{(\frac{M}{V})}]^{-1} [\frac{M^2}{T^2}]^{-1} \tag{15}$$

Producing:

$$q^2 = 3\gamma\varepsilon_0 [\frac{1}{\rho}]^{-1} [\frac{M^2}{T^2}]^{-1} \tag{16}$$

In this equation, ρ (mass density) should be interpreted as the ρ of the particle, or a known ρ. The former produces the same problem mentioned above, which is that the root of ρ is a meaningless physical parameter. If the ρ of space is considered to be where the particle is (e.g. mass density of the universe), the problem is resolved. Using Equation (8) in Equation (16) produces:

$$q^2 = (4\pi\varepsilon_0 \alpha G T^2) [\frac{M^2}{T^2}]^{-1} \tag{17}$$

By applying final guess that governs $\frac{dm}{dt}$ to $\frac{M}{T}$ dimension produces:

$$q = \sqrt{4\pi\varepsilon_0 \alpha G}\, T \frac{dm}{dt} \tag{18}$$

In this equation, α is a dimensionless parameter and is currently unknown; T is the age of universe; $\frac{dm}{dt}$ is the mass change in the particle over time (in the particle reference frame), and q is the electric charge. Here, $\frac{dm}{dt}$ was chosen to govern $\frac{M}{T}$ because it is more pertinent, simple and meaningful physical parameter.

Of the possible solutions for Equation (12), Equation (18) is unique and the most consistent with current proven facts and principles. When using this approach, it should be noted an independent formula for q was not proposed, but is concluded from existing formulas. Briefly, Equation (18) is an abstract of the law of gravity, Newton's 2nd law, Coulomb's law and the Freidmann equation.

Equation (18) says that the origin of an electric charge is the particle (rest-) mass change over time. In other words, mass creates a field of gravity and its change creates another field (electromagnetic). This is a surprising result because charged particles such as electrons and protons are inherently mass-variable; however, if $\left|\frac{dm}{dt}\right|$ (absolute value of $\frac{dm}{dt}$) is minuscule, it does not conflict with current proven facts. Note that Equation (18) establishes a two-way relationship between mass change and electric charge that any mass change (over time) in a particle (or physical system) will produce an electric charge (and electric field). The exact value of $\left|\frac{dm}{dt}\right|$ will be given based on experimentation to determine the exact value of α. It is possible to estimate values α and $\left|\frac{dm}{dt}\right|$ (for electrons), but should be kept in mind that they are not conclusive. Suppose there are two electrons separated by distance r (m). Equation (1) gives:

$$F_g = G\,\frac{m_e^2}{r^2} \tag{19}$$

where m_e is electron mass, and F_g is the gravitational force exerted on the two electrons. Equations (10) and (18) give:

$$F_e = \alpha G\, T^2\, \frac{\left|\frac{dm_e}{dt}\right|^2}{r^2} \tag{20}$$

Ratio $\frac{F_e}{F_g}$ is calculated as:

$$\frac{F_e}{F_g} = \alpha\, T^2\, \frac{\left|\frac{dm_e}{dt}\right|^2}{m_e^2} \tag{21}$$

If $\frac{F_e}{F_g}$ is alternately calculated using Equations (1) and (10), it produces:

$$\frac{F_e}{F_g} = \frac{1}{4\pi G\varepsilon_0} \times \frac{q_e^2}{m_e^2} \tag{22}$$

If the current values of Equation (22) are substituted:

$\varepsilon_0 = 8.854 \times 10^{-12}\ Fm^{-1}$
$G = 6.674 \times 10^{-11}\ m^3\,kg^{-1}sec^{-2}$
$q_e = -1.602 \times 10^{-19}$ coulomb
$m_e = 9.109 \times 10^{-31}\ kg$

This gives the following for the electron:

$$\frac{F_e}{F_g}(electron) = 4.165 \times 10^{42}$$

Equation (21) has two unknown parameters, α and $\left|\frac{dm_e}{dt}\right|$. Supposing $\frac{F_e}{F_g}(electron) = \alpha$, then $\left|\frac{dm_e}{dt}\right|$ will be:

$$\left|\frac{dm_e}{dt}\right| = \frac{m_e}{T} \tag{23}$$

Substituting the values in Equation (23) or Equation (18), gives:

$T = 4.350 \times 10^{17}\ sec$
$\left|\frac{dm_e}{dt}\right| = 2.094 \times 10^{-48}\ kg/sec$

With the proposed assumptions and estimations, the value of $\left|\frac{dm_e}{dt}\right|$ is outside of the apparatus accuracy range. The exact value of m_e is:

$$m_e = 9.10938291\,(40) \times 10^{-31}\ kg$$

Its relative standard uncertainty is 4.4×10^{-8}. Using the value calculated for $\left|\frac{dm_e}{dt}\right|$, it takes $10^9\ sec$ (~ 30 years) for a change to occur in the least significant digit of m_e.

Using the above assumptions and calculations that summarized in Equation (23), Equation (18) may be written as:

$$q = \left(\frac{e}{m_e}\right) T\,\frac{dm}{dt} \tag{24}$$

where $\frac{e}{m_e}$ is a well known physical constant (although e and m_e are both time variable) that can be directly measured by experimentation. Experimental or mathematical confirmation of Equation (18) produces the following results:

(i) A change in particle mass is the source of the electric charge and electric field. A charged particle keeps its structure during mass change. There is a definite threshold for mass change in each particle; thereafter, the particle decays or annihilates.
(ii) A change in particle mass increases or decreases, making the electric charge positive or negative.
(iii) It is necessary to investigate how the mass of a

charged particle changes and the role of photon particles in this process. Two overall scenarios exist: (1) mass (energy) exchange directly between charged particles; (2) mass (energy) exchange independently between each charged particle and space. In any case, the mass of negatively charged particle increases and, for positively-charged particles, it decreases, regarding Equation (24). A justification for attractive and repulsive characteristics of charged particles must be found based on their mass change.

(iv) If $\left|\frac{dm}{dt}\right|$ is constant, for each charged particle:

$$m_0(t) = \pm \left|\frac{dm}{dt}\right| \times t + m_0(t=0) \tag{25}$$

where t is the age of the particle, m_0 is the rest mass of the particle, $m_0(t=0)$ is the initial mass of the particle and $t=0$ is the time at which the particle began to act as a charged particle (continuous mass change).

(v) If $\left|\frac{dm}{dt}\right|$ is constant, then $\frac{d^2m}{dt^2}$ will be zero, since:

$$T = t + \tau \ ; \ \tau \geq 0 \tag{26}$$

where T is the age of universe, t is the age of the charged particle; thus, τ is the difference between them. Equation (18) gives:

$$\frac{dq}{dt} = \pm \sqrt{4\pi\varepsilon_0 \alpha G} \left|\frac{dm}{dt}\right| \ C/sec \tag{27}$$

where $\frac{dq}{dt}$ is constant and non-zero for all charged particles. Because the magnetic field is proportional to $I = \frac{dq}{dt}$, this means that charged particles necessarily create the magnetic field (Biot-Savart law). Today, it is believed that there is inherent magnetism in charged particles such as electrons. This agrees with the proposed conclusion.

There is currently no approved experiment or mathematical calculation that directly assesses the conjecture about the nature of electric charge, but the present results do not create any contradiction with current knowledge about the electric charge and its effects. The validity of the results is supported by the law of gravity, Newton's 2nd law, Coulomb's law and the Freidmann equation.

DISCUSSION

Utilizing dimensional analysis to govern physical parameters to combinations of basic dimensions to identify unknown physical phenomena provides weaker mathematical support for the derived equation. This is the inherent deficiency of the approach. To overcome this deficiency, two further steps should be taken; comparing the final result with known and proved physical facts and conducting experiments to directly evaluate the results. This section compares the proposed hypothesis on the nature of electric charge with proven facts.

(a) The possibility of a charged particle without mass continues to be advanced by some parties. A similar question arises in the Reissner-Nordstrom solution of Einstein's field equations. The Reissner-Nordstrom metric (for a black hole with mass M and charge q) is:

$$ds^2 = \left(1 - \frac{r_s}{r} + \frac{r_q^2}{r^2}\right) dt^2 - \left(1 - \frac{r_s}{r} + \frac{r_q^2}{r^2}\right)^{-1} dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta \ d\varphi^2 \tag{28}$$

where $r_s = \frac{2GM}{c^2}$ (Schwarzschild radius) and $r_q^2 = \frac{Gq^2}{4\pi\varepsilon_0 c^4}$. It is possible to show that it is physically impossible to make the mass M in the Reissner-Nordstrom solution vanish, because the charge itself generates an electromagnetic mass that is part of M or constitutes all of mass M. The electromagnetic mass vanishes only when the charge vanishes (Pekeris, 1982). In agreement with this result, in Equation (18), the electric charge will be zero; if the mass of particle is constant (zero or nonzero value), and electric charge exists if and only if the mass of the particle is variable (and definitely exists). However, there is no restriction for the mass of a charged particle to become zero instantaneously. Ibohal and Kapil (Charged black holes in Vaidya backgrounds: Hawking's Radiation, Department of Mathematics, Manipur University, India) discussed a similar case for the Reissner-Nordstrom solution.

(b) It is more realistic to consider the Reissner-Nordstrom metric for a black hole in a non-flat background Friedman-Robertson-Walker universe. It can be shown that the mass and charge of the black hole both vary with the evolution of the universe (Chang and Shuang, 2004; Ibohal, 2002). The variability of mass and charge of charged particles is the pivotal result of Equation (18).

(c) The influence of cosmological expansion on local systems is still a subject of research. Some authors support the view that cosmic expansion affects only systems larger than a certain spatial scale and that there is no effect below that scale. Others believe that all systems are subject to the effect of cosmic expansion, although this effect is numerically negligible for small systems (like atoms) and stronger for larger objects. This expands the validity of the Friedmann-Lemaitre-Robertson-Walker metric down to small scale (Bochicchio et al., 2013; Jose J. Arenas: The effect of the cosmological expansion on local systems: Post-Newtonian approximation). In Equation (18), factor T is $\frac{1}{H_0}$ (where H_0 is the Hubble constant). This result strongly supports the latter idea and vice versa.

(d) Based on Equation (18), particles have an absolute equal electric charge if and only if they have an equal $\left|\frac{dm}{dt}\right|$. Thus, the amount of electric charge is independent of the amount of mass. This has been seen for charged particles, such as electron and proton, yet it continues to be expected that charge is dependent on mass (e.g. mass change).
(e) All stars, black holes, and planets experience eras during which they experience mass-energy exchange with space. According to Equation (18), all of them should be considered to be charged particles for this period. Thus, they have an electromagnetic field surrounding them. This was proven in nature of electric charge.
(f) Equation (18) states that charged particles with decreasing mass (e.g., positive charge) have finite life times because of their finite mass; thus, charged particles are not fundamentally stable. This provides a good explanation of proton decay as proposed by GUTs and is still a matter of subject and observation (Senjanovi´c, 2009).
(g) Experiments show that electric charge is quantized; the q of every charged particle is an integer multiple of elementary charge e. Equation (24) clearly shows that each charged particle is a multiple of e, although it cannot singly guarantees that the coefficient is integral.

This discussion shows the excellent consistency of Equation (18) with currently-accepted physical facts. It sufficiently supports the hypothesis offered herein to describe the nature of electric charge, and adequately eliminates the weakness of the method applied to formulate the electric charge in terms of known physical parameters.

CONCLUSION

This study introduced a generalization of dimensional analysis of the physical equations and parameters and utilized this method to identify an explicit relation between gravitational constant G, and two universe parameters (age and mass density). Also, It was found that the origin of an electric charge (and electromagnetic field) is mass change of particle(s) over time. Therefore, mass change should be considered as the primary intrinsic property of charged particle rather than electric charge. It is a surprising result that, if experimentally or mathematically proven, will significantly influences some areas of physics and our view of the universe. It appears that dimensional analysis is not only a reliable method for assessing the validity of equations, but also it can help to find a meaningful interpretation for a category of unknown physical parameters. This method effectively uses speculation and intuition that is founded on proven facts and logic.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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