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Research Article

The Universe Creation by Electron Quantum Black Holes

Omid Akhavan*

Department of Physics, Sharif University of Technology, P.O. Box 11155–9161, Tehran, Islamic Republic of Iran

***Corresponding Author:** Omid Akhavan, Department of Physics, Sharif University of Technology, P.O. Box 11155–9161, Tehran, Islamic Republic of Iran.

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Abstract

Some of the most fundamental questions of physicists are what the universe is constructed by, or why the building blocks of our universe (i.e., the elementary particles) present so particular characteristics (e.g., particular mass, electrical charge, and/or spin). In this work, for the first time, we have demonstrated that all properties of electron (as the most fundamental spin-1/2 elementary particle having the smallest allowed electrical charge/mass of our universe) are correlated to each other and would be automatically created, just by assuming the black hole and quantum physics principles, along with an improvement for the Newtonian gravitational field at Planck scales. This assumption results in considering an internal structure, including a closed string-like form with a radius of Planck length, light speed rotational velocity, and more charge dispersion against mass aggregation, for an electron black hole having energetic jets (the nomination for spin). Based on this internal structure, the other spin-1/2 elementary particles (i.e., muon and tau leptons from one side and quarks and neutrinos from another side) are the other transformations of Planck-scale electron black hole (i.e., a dramatically unification in physics). Consistent with the standard model of elementary particles, our proposed model can also predict the allowed numbers of particles at each spin. Surprisingly, it was found that only one spin-2 particle without any electrical charge and/or mass (a nomination for graviton) can satisfy the Planck-scale black hole conditions, after spin-1/2 electron. We strongly believe that the use of the Planck-scale black hole concept in elementary particle physics can shed light on various open questions in physics, and further develop our knowledge about the universe.

Keywords: Planck Particles; Hawking Radiation; Micro Black Holes; Elementary Particles; Standard Model

Introduction

One of the most dreams of a thoughtful human is achieving a complete comprehension of the physical mechanism of universe creation, especially through mechanism approaching a grand unification. Despite many achievements in physics, there have still been many open questions (e.g., what the universe is constructed by, or why the universe possesses such a special structure), indicating the human incomplete understanding of the universe. One of the most fundamental problems raised in modern physics is the origin of the essential characteristics (including electric charge, spin, and mass) of building blocks in the universe. For example, there has not been any self-consistent mechanism by which one can explain why an electron would be possessed such particular amounts of charge, spin, and mass. All of these fundamental properties must be inserted into the theories (e.g., the standard model [1] and string theory [2]) by hand, instead of automatically appearing in the heart of the theory itself.

One of the preliminary attempts for understanding the electron structure was firstly developed by Einstein through assigning a Schwarzschild radius to the electron as a black hole, in the middle of the 20th century. But in this manner, the radius of the electron would collapse down to $\sim 1.35 \times 10^{-57}$ m, inconsistent with both quantum physics (if the Plank length with the value of $\sim 1.61 \times 10^{-35}$ m is considered as the minimum length to guarantee the Euclidean geometry of our observable universe [3]) and theory of relativity (the essential spin of an electron can result in violation of the light speed limitation at its radius). On the other hand, considering zero-radius for an electron (a point-like electron) results from serious problems relating to the tendency of the electron self-energy into infinity [4]. Nevertheless, based on our present knowledge, electrons would not seemingly possess any known internal structure [5,6]. Hence, it is strangely considered as a point-like spin-1/2 particle having a point-like electric charge without any spatial extension, even in the quantum theory models prefer a classical-based viewpoint, such as Bohmian quantum theory [7,8]. Indeed, the problem of electron size (or, more importantly, the electron internal structure) seems like a contradictory issue in modern physics. In this situation, the idea of assigning the black hole property to an electron has also been discarded.

In 2010, some new exciting investigations regarding the possibility of production of microscopic black holes (infinitesimal versions of black holes) were managed through the collision of protons with a total energy of $\sim 7\ \mathrm{TeV}$ (after that upgraded up to $\sim 14\ \mathrm{TeV}$), in the world's biggest particle collider i.e., Large Hadron Collider (LHC) at CERN [9,10]. Meantime, some ambiguities along with anxieties about the performance of the produced microscopic black holes, and also the fate of materials around the black hole, particularly our planet, were raised [11-13]. In this regard, CERN physicists tried to reassure the scientific and even public community that the microscopic black holes not only can exist but also cannot cause any danger for our planet [14]. Meanwhile, there have been some theories that predict the existence of at least one additional spatial dimension in our universe, in addition to the well-known four-dimensional space-time (e.g., some extensions of the standard model). Surprisingly, one of the results of the existence of such additional dimensions is the creation of microscopic black holes in our universe [15-18]. In this regard, Einstein's electron black hole idea can also be restored to life, if the inconsistencies with relativity and quantum physics can be elaborately resolved. Meanwhile, if microscopic black holes exist, then the concept of black hole-based elementary particles can be developed further. Such perspective can inevitably change our understanding of the universe, thoroughly.

In this work, we have tried to extract all fundamental characteristics of an electron (i.e., its unique electric charge, spin, and mass) by using an electron black hole model satisfying the quantum physics principles (called a quantum black hole), for the first time. This model results in a closed string-like form of the internal structure for an electron with a radius of Planck length, light speed rotational velocity, more electric charge dispersion against mass aggregation, and a black hole energetic jet. Surprisingly, based on the quantum black hole model, all of the other spin-1/2 elementary particles (i.e., muon (μ) and tau (τ) leptons from one side and quarks and neutrinos from another side) can be imagined as the other generations of electrons. In addition, the permitted numbers of particles at each spin are predictable, consistent with the number of spin-0, 1, and 3/2 particles in the standard model of elementary particles. Finally, the quantum black hole model can predict the existence of a stable spin-2 particle having no electrical charge and mass, as a nomination for the graviton.

Self-construction of charge, spin, and mass of elementary particles in a Planck black hole

In quantum gravity, Planck length is known as the length at which the ground state quantum oscillations of the gravitational field would completely distort the usual Euclidean geometry [3]. Hence, if we still prefer to talk about the observable phenomena in a universe having Euclidean characteristics, then the minimum quantum length should be considered as the Planck length, which is given by

$$\ell_p = \sqrt{\frac{\hbar G}{c^3}} \quad \text{---------------} (1)$$

Where $\hbar$ is the reduced Planck constant ($\hbar = h/2\pi$), G is the gravitational constant and c is the light speed in a vacuum. Now, based on Heisenberg's uncertainty principle $\Delta(m)\Delta r \geq \hbar/2$, one can obtain

$$\Delta(\frac{2Gm}{c^2})\Delta r \geq \ell_p^{\ 2} \quad \text{-----------------}(2)$$

In which the term within the parenthesis is known as Schwarzschild radius (r_s) of mass m. It Δr is replaced with the minimum quantum length ℓ_p, then the minimum r_s of a black hole would be ℓ_p. In this regard, the minimum mass required for the creation of a black hole (M_0) with a radius of ℓ_p is

$$M_0 = \frac{\ell_p c^2}{2G} = \frac{1}{2} m_p \quad \text{--------}(3)$$

In which

$$m_p = \sqrt{\hbar c / G} \quad \text{---------------(4)}$$

Is a mass of a Planck particle or Planck mass. Now, self-collapse of mass M_0 results in releasing gravitational potential energy (U_g) in the frame of $E_0 = U_g + m^2$, in which E_0 is the initially available energy ($\sim M_0c^2$) and m is the total mass remained after completion of the collapse. Now, among the various methods for gravitational energy transformation, we are interested in the mechanism concentrated on electrical charge creation. The charge creation can be happened through a mechanism similar to the Hawking radiation mechanism [19], based on which a quantum fluctuation results in the creation of a negative-positive (matter-antimatter) pair particle near the horizon of a black hole. Then, falling one of the particles into the black hole causes the escape of another particle outside the horizon [20,21]. In this work, if the first particle fallen into the center of mass collapse possesses a negative (positive) charge (this charge can even be assumed very smaller than e, in a continuous process), then the released gravitational energy can be consumed to compensate further creation and accumulation of further negative (positive) charges within r_e radius for creation of electron (positron), based on the following equation

$$U_g = U_e \quad \text{---------- (5)}$$

Now, if we assume that our particle model possesses a spherical form with uniform mass and charge distribution (the simple and first approximation which can be used), then $U_g(r) = GM^2/2r$ and $U_e(r) = e^2/8\pi\varepsilon_0 r$ in general. Hence, one can write Eq. 5 in the form of

$$\frac{GM^2}{2r_e} - \frac{GM^2}{2R_0} = \frac{e^2}{8\pi\varepsilon_0 r_e} - \frac{e^2}{8\pi\varepsilon_0 R_0} \quad \text{---------------- (6)}$$

In which R_0 is the radius of the initial mass distribution (the initial soup of the particle with the total mass of M_0) and M is the mass contributed to the charge creation. Now, by supposing $r_e < R_0$ (which is reasonable for an initial mass distribution with constituents located far from each other), the following simplified relation is achieved

$$GM^2 = \frac{e^2}{4\pi\varepsilon_0} \quad \text{----------(7)}$$

Which is interestingly a relation independent from the radius of the particle remained after completion of the black hole burning (r_e). In addition, Eq. 7 shows a balanced (see-saw) mechanism between the electrical and gravitational properties of the initial constituents of an electron in our ancient universe. This balanced mechanism yields

$$e = \sqrt{4\pi\varepsilon_0 G}M \quad \text{-------------(8)}$$

In which M is a portion of the initial mass contributed in the charge creation. Based on the Maxwell-Boltzmann energy equipartition theorem, each degree of freedom of a thermal equilibrium system has been associated (in average) with an equal amount of energy. Since a black hole formation essentially accompanies rotation (as a degree of freedom), the initial mass contributed in charge creation (as another degree of freedom) is half of the total initial mass, i.e., $M = M_0/2 = m_p/4$. This results in a preliminary (while unique) relation for the charge, based on the physical fundamental constants, as follows:

$$e = \frac{1}{2}\sqrt{\pi\varepsilon_0\hbar c} \quad \text{------------- (9)}$$

Surprisingly, this relation yields the value of $e = 4.68\times10^{-19}$ C, which is an excellent amount for our first approximation (note that the order of magnitude is exactly right). However, the digits are not still completely consistent with the real values measured for the charge. This deviation can be assigned to our first simple approximation about the uniform distribution of e charge as well as a mass on the surface of a sphere. According to quantum mechanics, the minimum realizable length in our universe is Planck length. Since the elementary particles possess spin, the radius of rotation cannot be also decreased down to Planck-scale. The simplest rotating condensed structure in quantum physics (achieved after full completion of a gravitational collapse) is a ring with a radius of ℓ_p (see Figure 1). Hence, the balances of self-energies of Planck particle collapsing into a ring structure black hole can better result from the relation between charge creation and mass evaporation. In this regard, the electrical self-energy of a ring with radius R and N_e discrete charges can be evaluated by the following method:

$$U_e(r) = 2\times\frac{N_e}{2}\sum_{n=1}^{N_e-1}\frac{1}{4\pi\varepsilon_0}\frac{(e/N_e)^2}{2R\sin(n\pi/N_e)} \quad \text{-------------(10)}$$

This discrete summation can be calculated by its transforming into an integral continuous summation as follows:

$$U_e(r) \cong \frac{e^2}{8\pi\varepsilon_0 N_e R}\frac{N_e}{\pi}\int_{\pi/2N_e}^{(2N_e-1)\pi/2N_e}\frac{d\theta}{\sin\theta} = \frac{e^2}{8\pi^2\varepsilon_0 R}\ln\left(\frac{1}{\tan^2(\pi/4N_e)}\right) \quad (11)$$

Which can be simplified into

$$U_e(r) \cong \frac{e^2}{4\pi^2 \varepsilon_0 R} \ln(\frac{4N_e}{\pi}) \quad \text{----------(12)}$$

For $N_e > 1$. The gravitational self-energy of such ring can also be calculated similarly, so that, one can obtain

$$U_g(r) \cong \frac{GM^2}{\pi R} \ln(\frac{4N_m}{\pi}) \quad \text{--------(13)}$$

For $N_m > 1$. Now, by applying Eq. 12 and Eq. 13 in Eq. 5, and assuming $M = M_0 / 2 = m_p / 4$, the total electric charge created by evaporation of the ring Planck particle can be written as

$$e = \frac{1}{2}\sqrt{\pi \varepsilon_0 \hbar c \times \log_{(4N_e/\pi)}(4N_m / \pi)} \quad \text{------------(14)}$$

Which is a relation independent from R. However, by completion of the collapsing, the R should be reduced into $\sim \ell_p$. Meantime, the fundamental laws of our universe would be resulted in further aggregation of mass elements (i.e., reduction of N_m into n_m) and further dispersion of electric charges (i.e., the evolution of N_e into n_e), while the following relation is satisfied:

$$\log_{(4N_e/\pi)}(4N_m / \pi) = \log_{(4n_e/\pi)}(4n_m / \pi) \quad \text{-------(15)}$$

By imagining the completion of collapsing, the extreme dispersion of the electric charges restricted on a Planck-scale ring is realizable, when their minimum separation length on the ring is considered $\sim \ell_p$. This assumption corresponds to $n_e \cong 2\pi\ell_p / \ell_p = 2\pi$. A finalized gravitational collapsing is also corresponds to $n_m = 1$. Since the minimum value of n_m corresponds to a minimum value of electrical charge created by mass evaporation, this method surprisingly expresses the minimum fundamental electric charge of our universe as

$$e = \frac{1}{2}\sqrt{\pi \varepsilon_0 \hbar c \times \log_8(4/\pi)} = 1.60 \times 10^{-19}\ \text{C} \quad \text{------------(16)}$$

With only ~0.2% deviation from its experimental value. This highly interesting result implies that the internal structure of the electron can be modeled as a closed string object with more charge distribution (at least 2π times further) than its mass distribution. This internal structure can be imagined as 6 centers of electrical charge with the charge of e/6 and a mass center on the Planck ring (see Figure 1). Now, assume that one of these charge centers was formed as an anti-charge center during the gravitational collapse. Surprisingly, this results in the appearance of a 2e/3 net charge for the final black hole particle (consistent with the electrical charges of up (u), charm (c), and top (t) quarks, as other spin-1/2 elementary particles of the standard model). The necessity of the appearance of the color property of quarks can be preliminary understood here, because it can compensate for the perturbation induced by the anti-charges in the attractive-repulsive mass-charge balance of the Planck back hole. Similarly, if we consider the formation of 2 anti-charges during the collapse, the net charge would be e/3 (corresponding to the charges of down (d), strange (s), and bottom (b) quarks). Finally, if we assume the formation of 3 anti-charges during the collapse, the net charge would be zero, and so, there is no net agent to resist against the gravitational collapse of the Planck-scale black hole (the charges and anti-charges themselves can balance the ring structure). This corresponds to complete evaporation of the residual mass, while the jet spin can still exist. These fantastic properties cause us to remember the characteristics of neutrinos, as the other spin-1/2 particles of the standard model have no mass. Now, it is time to express that all elementary electric charges of our universe are automatically achievable by just a combination of black holes and quantum physics principles. In addition, all leptons and quarks are the other transformations of electrons, as the most elementary particle of our universe (see Table 1).

Now it turns to consider the essential rotation of an electron black hole. Since angular momentum (spin) would be conserved during the collapse, one can calculate it at special states of collapsing. For instance, if electron structure can be imagined based on the rotation of a ring, then one can write

$$S = I_0\omega_0 = M_0 R_0 v \quad \text{-------------(17)}$$

In which I_0, ω_0, M_0, R_0 and v are total rotational inertia (the rotational inertia of total mass/energy), angular velocity, total mass (total mass/energy i.e., M_0), the radius of such mass/energy soup at its extreme rotational energy state as well as the extreme linear speed of the soup at its orbit, respectively. This extreme condition corresponds to assigning the maximum light speed c (as a maximum physical limit) to the linear motion of the whole electron soup concentrated at the last possible orbit, that is, ℓ_p. In this case, the total spin of an electron (S), i.e., the angular momentum of all ingredients (with the mass of $M_0 = m_p / 2$) that contributed to the formation of an electron, can be calculated as

$$S = \frac{m_p}{2} \ell_p c = \frac{1}{2} \hbar \quad (18)$$

In which the last term is obtained by using Eq. 1 and Eq. 4. It should be noted that during the creation of an electron black hole, all mass/energy contributed in its formation are confined in a Planck length scale, as we will show in the following. Since in quantum mechanics the spin of an electron is defined by $S = n\hbar$, Eq. 18 surprisingly indicates that the minimum (but, nonzero) spin quantum number of an electron black hole must be exactly 1/2. Note that this interesting result has been achieved just by assigning the most miniaturized black hole structure to achieve the extreme rotational energy to the electron. This result can also be repeated for another special state of electron black hole, i.e., when all the possible gravitational collapses terminated, that is, $N_m \to n_m = 1$ in Eq. 15. In this case, the electron behaves as a Planck-scale particle whose center is rotating around a Planck orbit with light speed (as seen in more details in the following; see, e.g., Eq. 27). Then, for the total mass/energy devoted to the rotational degree of freedom (i.e., $m_p/4$), one can write

$$S = I\omega = I\frac{c}{\ell_p} = [2(\frac{m_p}{4})\ell_p^{\,2}]\frac{c}{\ell_p} = \frac{m_p}{2}\ell_p c = \frac{\hbar}{2} \quad \text{-----(19)}$$

In which I (with the form of $2(m_p/4)\ell_p^{\,2}$ is written based on the Planck-scale geometry shown in Figure 1b) and ω are the total rotational inertia and angular velocity of all total mass/energy entities involved in a rotational degree of freedom (i.e., total mass/energy of $m_p/4$). It is worthy to note that, although the jets of huge black holes in space are still strange phenomena, their existences were approved by researchers. Similarly, the magnetic dipole moment (or in other words, the spin) of an electron originated from its possible maximum rotational energy in the universe can be considered as the energy jet of an electron black hole which its effects (e.g., electromagnetically energetic effects) would be distributed throughout the universe (see Figure 1). The spin concept proposed here (i.e., the spin constraint in Eq. 18), is also able to predict the allowed number of particles at each spin (consistent with the standard model and also beyond it). For example, the allowed number of spin-1/2 particles having charge e is just three (see Table 1). The spin constraint also results in explaining the other characteristics of the e-charged spin-1/2 particles (such as mass and lifetime), as shown in the following for electron, muon, and tau (see also Table 2). Surprisingly, only one spin-2 particle without any electrical charge and/or mass (a nomination for graviton) can satisfy the Planck-scale black hole conditions, after spin-1/2 electron (see Table 3).

We have found that the electron spin is an essential parameter of a light-speed rotating electron soup, including both mass and energy, concentrated in the Planck scale. But, as a key point, the constant nature of spin can adjust the contribution of energy and mass, separately. If we assume that the mass remained for an electron soup after completion of collapsing/burning the initial black hole is m_e (the mass contribution), then the relativistic rotational energy (the energy contribution) can be written as the following form

$$E_{rot} = \frac{S^2}{I_e} = \frac{(\hbar/2)^2}{2m_e r_e^{\,2}} \quad \text{-----------(20)}$$

Where I_e is the rotational inertia of just the mass remained for electron (the present observable electron mass) in the Plank-scale region. If we assume that there is no length scale smaller than r_e (i.e., electron structure is considered as the smallest entity in the universe), then I_e would be written as $2m_e\ell_p^{\,2}$ similar to the rotational inertia of a closed circular string rotates around an axis passed perpendicular to its surface and tangential to its perimeter (see Figure 1b). But, the question arising here is where this energy was provided from because the Newtonian gravitational energy (U_g) and the electrical energy (U_e) were already compensated by each other (see Eq. 5). One may suppose that at the beginning of our universe the available energy was infinite, and so, the energy required for the rotational motion was supplied by that energy. But this is not a reasonable answer, because based on our model this energy should progressively be produced during the collapsing process of the electron black hole, and consequently, it would continuously be supplied from the electron's constituents themselves. Hence, it seems that there is another kind of attractive field between the constituents of electron soup, besides the known Newtonian gravitational field, especially when the distance between them is very small (i.e., at Planck scale). This situation can be considered more reasonable when we think about another gravitational collapse on the ℓ_p orbit to form $N_m \to n_m = 1$

in Eq. 15 (as a collapse perpendicular to either the conventional Newtonian collapse or the known spatial dimensions (as an extra dimension), at Planck scale). If we prefer to avoid introducing any new field in physics, then the only gravitational field should compensate for this energy, based on the following relation:

$$E_0 = \delta U_g + U_g + mc^2 = U_e + K_{rot} + mc^2 \quad (21)$$

In which we have assumed

$$\delta U_g = \frac{G' M_0^2}{2 r_e^2} \quad \text{--------}(22)$$

Where G' can be called a quantum gravitational constant. This strategy corresponds to introducing a new term in a gravitational field with the form of

$$g'(r) = -\frac{G' M}{r^3} \quad \text{-----------}(23)$$

For any particle with mass M, in addition to the conventional Newtonian form of the gravitational field ($g(r) = -GM/r^2$) which is already used for U_g calculation. In the other words, now one can think about an improved gravitational field g_{imp} with the form of

$$g_{imp}(r) = -\frac{GM}{r^2}\left(1 + \frac{G'}{rG}\right) \quad \text{---------}(24)$$

However, no detectable deviation from the Newtonian gravitational field has been observed so far, from the large (e.g., galactic) to small (atomic) scales. Comparing Eq. 23 with the Newtonian g field shows that the effect of age should appear at length scales significantly lower than G'/G. Since no one does not expect to observe any deviation in the atomic phenomena due to adding the g's field effect, we should consider $G' \leq rG$ r atomic scale, i.e., $r \sim \alpha\, a_0$ with a_0 as the Bohr radius and α as the fine structure constant ($\alpha \cong 1/137$). This yields the maximum value of for G'. Now, $2.58 \times 10^{-23}\,\mathrm{m^4/s^2}$ by using Eq. 20 and Eq. 22, one can obtain the final residual mass of a completely burned black hole started with an initial mass of $M_0 = m_p/2$, as follows:

$$m_e = \frac{S^2}{G' M_0^2} = \frac{4(\hbar/2)^2}{G' m_p} = \frac{\hbar G}{cG'} = 9.11 \times 10^{-31}\ \mathrm{kg} \quad \text{--------------}(25)$$

Which is an exciting result for the electron mass (with only ~3.8×10^{-11} uncertainty for the experimental reports, which is even significantly smaller than the experimental uncertainty of electron mass, i.e., ~7.9×10^{-8}), just based on the fundamental constants. On the other hand, the presence of the g's field affects the Schwarzschild radius of electron (R_e). In fact, by using the conventional g field, one can obtain $R_e = 2Gm_e/c^2 = \sqrt{4G/\hbar c}\, m_e \ell_p = 8.3 \times 10^{-23}\ \ell_p$ which was first assigned to the electron by Einstein. However, by considering the go field, we obtain $R_e \sim \sqrt{G' m_e / c^2} \sim \ell_p$ (see Eq. 25), which is completely consistent with our quantum mechanical knowledge. Furthermore, by considering the go field for a rotating ring with residual mass m_e, one can consider the centripetal force providing condition as

$$\frac{G' m_e^2}{r^3} = \frac{m_e v_e^2}{r} \quad \text{------------}(26)$$

Which interestingly yields

$$v_e = \frac{\sqrt{m_e G'}}{\ell_p} = 2.99 \times 10^8\ \mathrm{m/s} \quad \text{------------}(27)$$

The relative dispersion of this value concerning c is as low as 1.9×10^{-11}. This means that an electron can be imagined as an object (e.g., like a closed string) rotating within a Planck-scale region (at its event horizon) with light speed or very near the light speed (see Figure 1b). This implies that I am an observable relativistic mass. Furthermore, the time elapsing (containing any kind of mass, charge, and spin evolution) is frozen for electrons, consistent with our universal observations (a lower limit for the mean lifetime of the electron is estimated $\sim 6 \times 10^{28}$ yr [22,23]). The required energy (E_e) for reaching the Planck scale is

$$E_e = \frac{\hbar c}{\ell_p} \sim 1.2 \times 10^{16}\ \mathrm{TeV} \quad \text{------------}(28)$$

Which is still very high and/or unavailable energy level. Although we tried to present an internal structure for electrons, such huge and seemingly unreachable energy can be considered as the reason why the electron is still known as an elementary particle with no internal structure. Some other useful evaluations are evaporation time (t) and temperature (T) of an electron black hole, which can be estimated based on the following relations [24,25]:

$$t(\mathrm{s}) \sim 2 \times 10^{-18} M^3(\mathrm{kg}) \quad \text{----------}(29)$$

and

$$T(\mathrm{K}) \sim 10^{23} / M(\mathrm{kg}) \quad \text{----------}(30)$$

Using these relations, one can obtain $t_e \sim 2 \times 10^{-42}$ s and $T_e \sim 9 \times 10^{31}$ K for electron black hole collapse time and temperature, by assuming M = $m_p/2$, respectively. It should be noted that due to assuming the go filed, the collapse time of the electron soup would be significantly less than t_e. Hence by considering, e.g. , $t_e \sim 10^{-43}$ s the length of the energy distribution of electron black hole through its electromagnetic jet would be $\delta l \sim ct_e \cong 3\times10^{-35}$ m $\sim \ell_p$, during the collapsing process. This shows that during the creation of an electron black hole, all mass and energy contributed to its formation should be constrained in Planck length (see Figure 1a). This finding can further confirm the assumptions considered in Eq. 18 for calculating the electron spin. Although a thermodynamic quantity such as temperature may seem unmeaningful for an elementary particle such as an electron, this high temperature (comparable with the Planck's temperature with $T_p \sim 1.4\times10^{32}$ K) and low collapse time (a little further than the Planck time, $t_p = \sqrt{G\hbar/c^5} \cong 5.3\times10^{-44}$ s) indicate the formation of an electron with the present properties (e charge, 1/2 spin and residual mass m_e) in the early universe conditions or at the beginning of Big Bang, in full consistency with the standard model which unsatisfiable inserts the electrons as one of the elementary particles at the beginning of the universe by hand, without mentioning any mechanism for their creation.

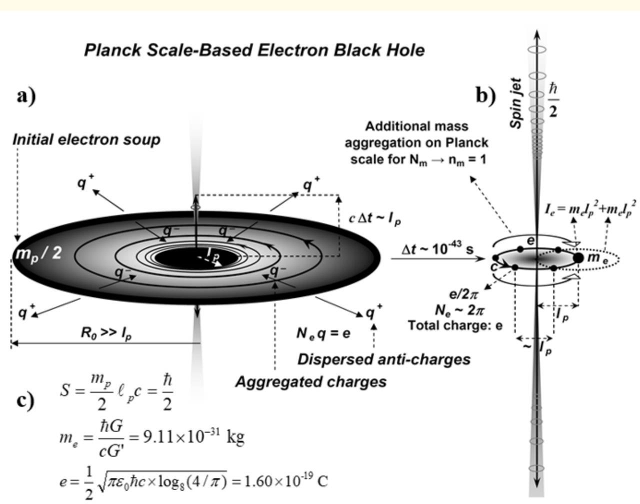

Figure 1: Schematic presentation for a) gravitational collapsing of an initial Planck mass ($m_p/2$) into a black hole formation (with a radius of ℓ_p) and b) creation of an electron black hole (with its closed string-like form internal structure) as the residual of the initial Planck mass. c) Shows the values of spins (S), residual mass (m_e), and electrical charge (e) of the electron black hole, based on the fundamental physical constants.

Extension of the model to other leptons

It is also interesting to study the capability of this strategy for explaining the other leptonic brothers of the electron, i.e., muon (μ) and tau (τ) leptons. In this regard, we prefer to start with the spin concept presented in Eq. 18. At this equation, we assumed that the minimum total mass/energy required for the electron black hole creation would be concentrated at Planck-scale (the Schwarzschild radius of mass $m_p/2$ is ℓ_p and no energy jet ejection appeared during the ultra-fast gravitational collapse) in a rotating state with the extreme linear velocity c, that is

$$S_e = (\frac{m_p}{2})(\ell_p)c = \frac{\hbar}{2} \text{ ------------(31)}$$

Since, based on quantum mechanics, the minimum assignable size to a particle (e.g., its diameter) is ℓ_p, the minimum de Broglie wavelength (λ_0) of the particle would satisfy $\lambda_0/2 = \ell_p = 2r_0$, in which r_0 is the smallest radius of the particle. Then, the next greater particle would possess a 2-fold size greater than that of the previous particle to satisfy $\lambda_1/2 = 2(\lambda_0/2) = 2\ell_p = 2r_1$, which $\lambda_1 = 2\lambda_0$ is the minimum wavelength of the new condition.yields

$$2r_n = \lambda_n/2 = 2^n\ell_p \text{ with n = 0, 1, 2, ... ----------(32)}$$

Now, for the minimum radius ($r_0 = \ell_p/2$), the spin-1/2 feature can be constructed by using the initial mass/energy m_p as follows:

$$S_\mu = (m_p)(\frac{\ell_p}{2})c = \frac{\hbar}{2} \text{ ----------------(33)}$$

Similarly, one can construct another spin-1/2 entity $r_1 = \ell_p$ which results in Eq. 31, and for $r_2 = 2\ell_p$ which yields

$$S_\tau = (\frac{m_p}{4})(2\ell_p)c = \frac{\hbar}{2} \text{ ---------------(34)}$$

It is interesting to note that there is not any way to construct other spin-1/2 entities, because the minimum mass required for a black hole formation is $m_p/4$ (see Eq. 3), as used in Eq. 34 as the final possible form. The conditions used in Eq. 31 exactly corresponds to the formation of a black hole, resulting in complete collapsing/burning of the initial mass $m_p/2$ into the residual mass m_e, as shown in Eq. 25. However, the conditions applied in Eq. 33 and Eq. 34 are not compatible with the formation of the black hole; the former needs a gradual mass/energy loss along with a size increase, while the latter needs to absorb further mass/energy, stopping it, and then, probably adjust it by some mass/energy desorption along with a size adjustment for transforming into a final stable black hole (i.e., electron black hole). Indeed, they are some kinds of disturbed Planck black hole (DBH) particles. Since these two features (shown in Eq. 33 and Eq. 34) are not consistent with the formation of a Planck-scale black hole, we cannot expect a rigorous collapse/burning similar to what was proposed for the particle described by Eq. 31 (i.e., the role of the go field in mass collapse and creation of electron would not effectively be considered, here). Hence, the common Newtonian gravitational field would be responsible for the mass collapsing to a particle size at which the go field would not work effectively. The lowest length scale in which the presence of age field would not certainly be sensed is the nucleic scale. Therefore, the mass/energy transformation of the spin-1/2 particles having charge e can be considered as follows:

$$\frac{1}{4}\frac{GM_0^{\ 2}}{r_n} \cong \frac{S^2}{mr_n^{\ 2}} \quad \text{---------(35)}$$

In which the left-hand side is one-half of the self-gravitational energy released during the collapse of the initial mass M_0 (the other one-half of the self-energy should be devoted to electric charge creation, as mentioned before) and the right-hand side is the rotational kinetic energy of the particle with the residual mass of m and radius r_n (the radius of a nucleon with the value of ~1.8×10^{-15} m). Based on Eq. 33 and Eq. 34, only two different values can be considered for M_0. This means that the two residual masses can be calculated by the following relation:

$$m_{\mu,\tau} \cong \frac{4S^2}{G(M_0^{\ 2})_{\mu,\tau}\, r_n} \quad \text{-------(36)}$$

Which yields

$$m_\mu \cong \frac{\hbar^2 c^2}{Gm_p^{\ 2} er_n} = \frac{\hbar c}{er_n} \cong 109.6\,\text{MeV} \quad \text{------------(37)}$$

For mass of muon (with ~3 % deviation from the experimental value) and

$$m_\tau \cong \frac{\hbar^2 c^2}{G(m_p/4)^2 er_n} = 16\frac{\hbar c}{er_n} \cong 1754\,\text{MeV} \quad \text{-----------(38)}$$

For mass of tau (with ~1% deviation from the experimental value).

If the muon and tau particles are considered as the rotating ring form objects with radius r_n (see Eq. 35), then the electromagnetic radiation power corresponding to this rotation can be written as follows:

$$P \cong \frac{e^2}{4\pi\varepsilon_0}\frac{2}{3c^3}\left(\frac{v^2}{r}\right)^2 / (1-(v/c))^5 \quad \text{--------(39)}$$

In which v is the linear speed of the rotation. The linear speed of rotation for muon and tau can be obtained

$$v_\mu \cong \frac{\hbar}{2m_\mu r_n} = 1.55\times10^8\ \text{m/s} \quad \text{------------(40)}$$

and

$$v_\tau \cong \frac{\hbar}{2m_\tau r_n} = 9.25\times10^6\ \text{m/s} \quad \text{---------------(41)}$$

The gravitational collapse of the ring from r_n into $\sim \ell_p$ (the region where the go filed is dominant) results in evaporation of mass δm into energy with a rate of

$$\frac{dE(r)}{dr} = \frac{G'\delta m^2}{r^3} \ \text{at}\ r_n < r \le \ell_p \quad \text{--------------(42)}$$

Based on Eq. 34, the smallest radius for collapsing a spin-1/2 particle (except electron, as the final stable particle) from r_n into $\sim \ell_p$ is $2\ell_p$. Hence the maximum rate of energy can be written as $G'\delta m^2\,(\,2\ell_p)^3$. Now, we can estimate the total energy by

$$\delta E \cong \frac{dE}{dr}\delta r = \frac{G'\delta m^2}{(2\ell_p)^3}\delta r \quad \text{----------------(43)}$$

In our proposed model, δr can give two extreme average values of $\sim \ell_p/2$ and $\sim r_n/2$ which can affect the magnitude of δE. For tau particle, the rotational velocity is in the borderline of the relativistic region ($v \sim 0.03c$), and collapsing into muon results in increasing the velocity up to ~0.5c. However, for the muon, the collapse would have resulted in the creation of electrons with rotational velocity highly approaching c (see Eq. 27). This means that the total energy/mass transformation during muon decay into electron would be significantly higher than the energy/mass transformation of tau decay into a muon (corresponding to assigning $\delta r \sim r_n/2$ to the former decay and $\delta r \sim \ell_p/2$ the latter one (consistent also with Eq. 34 for the latter)). Hence, for tau particle, the average total energy/mass transformation can be written as

$$\delta\overline{E}_\tau \cong \frac{G'(15/16\,m_\tau)^2}{(2\ell_p)^3}(\ell_p/2) \quad \text{--------------(44)}$$

In which δm is considered $\sim (15/16)m_\tau$ (the mass reduction from-to m_μ), and for muon particle, it can be written as

$$\delta\bar{E}_{\mu} \cong \frac{G'(205/206\, m_{\mu})^2}{(2\ell_p)^3}(r_n/2) \quad \text{--------------------(45)}$$

In which δm is considered $\sim (205/206)m_{\mu}$ (the mass reduction from m_{μ} to m_e). Now, by considering r = R_{av} = $r_n/2$ (as an average for the radius contributed in the τ collapsing) and $v \sim v_{\tau}$ in Eq. 39, one can obtain

$$\delta t_{\tau} \cong \frac{\delta\bar{E}_{\min}}{\bar{P}_{\tau}} \sim 9\times10^{-13}\,\text{s} \quad \text{---------------(46)}$$

As an upper limit estimation for the mean lifetime of the τ particle, in suitable consistency with the average experimental lifetime of τ (~2.9×10^{-13} s). In the same manner, by considering r_{aw} = $r_n/8$ (based on Eq. 33 and Eq. 34, the average radius of μ is 1/4 of the radius of τ) and $v \sim v_e$ in Eq. 39 and $v \sim 0.76c$ (as an average of v_{μ} and v_e) in the denominator, one can obtain

$$\delta t_{\mu} \cong \frac{\delta\bar{E}_{\max}}{\bar{P}_{\mu}} \sim 4\times10^{-5}\,\text{s} \quad \text{------------(47)}$$

As an upper limit estimation for the mean lifetime of μ the particle (with the average experimental lifetime of ~2.2×10^{-6} s). In fact, $\delta t_{\mu} < 4\times10^{-5}$ s, because in estimating the $\bar{P}_{\mu}$ value, the contributions of high energy radiations that occurred in the speeds approaching the c value have not been precisely considered. A brief overview of these results is presented in table 2.

Classification		Leptons	Quarks	Quarks	Neutrinos
$N_{\text{anti-charge}}$		0	1	2	3
Net charge (e)		1	2/3	1/3	0
	Spin formation				
Spin value		$\hbar/2$			
PBH particle	$(\frac{m_p}{2})(\ell_p)c$	e	u	d	ν_e
DBH particle	$(m_p)(\frac{\ell_p}{2})c$	μ	c	s	ν_{μ}
	$(\frac{m_p}{4})(2\ell_p)c$	τ	t	b	ν_{τ}

Table 1: A chart showing the characteristics of all allowed transformations of electron black hole (as the most fundamental spin-1/2 Planck-scale black hole (PBH) particle), based on the number of anti-charges involved in the Planck orbit ($N_{\text{anti-charge}}$), resulting in just three generations (the horizontal generations of e), and the other allowed spin formations, resulting in just two disturbing black holes (DBH) particles (the vertical generations of e).

Q(C)	ΔQ(%)	S	ΔS	N	Particle	mc^2(MeV)	Δm(%)	r(m)	δt(s)	v(c)
1.60×10^{-19}	~0.2	ħ/2	0	3	Tau	~1754	~1	~1.8×10^{-15}	<9×10^{-13}	0.03
					Muon	~109.6	~3	~1.8×10^{-15}	<4×10^{-5}	0.52
					Electron	0.511	3.8×10^{-9}	1.61×10^{-35}	∞	1

Table 2: Some characteristics of free massive spin-1/2 elementary particles (including charge (Q), spin (S), the allowed number (N), mass (m), radius (r), lifetime (Δt), and rotational velocity (v) of the particles) obtainable by using Planck-scale black hole concept. The deviations of the results concerning the real (experimental) values are shown by the Δ symbol.

The capability of prediction about the graviton

Finally, it is interesting to note that our proposed spin model predicts that the total numbers of spin-0 and spin-1 elementary particles in our universe would not be more than 1 and 4 (see Table 3), inconsistency with the standard model which predicts the existence of Higgs as the only spin-0 particle and $W^{\pm}$, Z^0, gluon (g) and photon (γ) as the spin-1 particles observed yet [1]. Since no one of these spin-1 particles can satisfy the condition of Planck-scale black hole formation, they would continue their collapse into either a final Planck-scale black hole particle with a residual mass (similar to the mechanism proposed for the collapse of μ and τ leptons into electrons) or complete mass evaporation. Among them, a photon can be considered as exceptional, because it moves with exactly light speed, and so, any time evolution would be frozen, unless it is stopped by an interaction. For the next particles with higher spin, Eq. 32 shows that no spin-3/2 elementary particle (not composite particles) would exist (consistent with the standard model). However, the formation of spin-2 Planck-scale black hole particle is again achievable via $S_g = (m_p)(2\ell_p)c$. This can preliminary suggest that the gravitons can be considered as Planck-scale black holes, albeit with zero residual mass. In fact, in the frame of our proposed model, the preliminary prediction for the residual mass of a spin-2 particle would be 4 times greater than min_e (see Eq. 25), while its total electrical charge would be less than e (because in Eq. 15 the N_e should be replaced by 4π). This results in domination of the attractive gravitational effect (against the repulsive electrical effect), and consequently, further collapsing/evaporating the particle into mass vanishing. Gravitons would be spin-2 massless elementary particles with zero net charge (similar to spin-1/2 mass fewer neutrinos). This method also predicts that there would be four other spin-2 particles in our universe, which cannot satisfy the Planck-scale black hole condition and consequently would show a finite lifetime (see Table 3). Interestingly, a generalized expression of this method can predict the possible spin value of Planck-scale black hole particles

$S = 2^{(2n-1)}\hbar$ with n = 0, 1, 2, ...-----------(48)

The number of particles satisfying the Planck-scale black hole condition at each spin is just 1. Such particles would possess a final residual mass (as shown for the electron in Eq. 25). However, it is expected that the probability of formation of high-spin particles is strongly reduced by increasing n.

S	N	N_{PBH}	R_h	Assigned name	Spin formation	BH	Assigned name	Spin formation
0	1	0	0	-	-	1	Higgs	$(\infty)(0)c$
1/2	3	1	ℓ_p	Electron	$(\frac{m_p}{2})(\ell_p)c$	2	Muon	$(m_p)(\frac{\ell_p}{2})c$
							Tau	$(\frac{m_p}{4})(2\ell_p)c$
1	4	0	-	-	-	4	g	$(\frac{m_p}{2^{n-1}})(2^{n-1}\ell_p)c$ $n = 0-3$
							γ	
							$W^{\pm}$	
							Z^0	
2	5	1	$2\ell_p$	Graviton	$(m_p)(2\ell_p)c$	4	unknown	$(\frac{m_p}{2^{n-2}})(2^{n-1}\ell_p)c$ $n = 0-4; n \neq 2$

Table 3: A chart showing the possible spins (up to 2) assignable to the elementary particles of our universe (S), the total number of particles at each spin (N), the number of Planck-scale black hole particles (N_{PBH}), the event horizon radius of each black hole (R_h) and the number of particles ready for continuing the mass evaporation down to final residual mass, such as μ and τ leptons, or complete mass disappearing, such as Higgs and Z^0, (N_{DBH}). The method of allowed spin formation of each particle along with its common name is also given.

Conclusions

It has been shown, for the first time that, the most extreme conditions of our universe inevitably results in the creation of the most miniaturized black hole having the most minimum electric charge, mass, and spin correlated entities, i.e. the electron, as the most fundamental particle of the universe. The correlated values of electron charge, mass, and spin were obtained based on the fundamental constants of the universe, just by assuming the validity of quantum physics for elementary particles (an expectable issue), the possibility of assigning a black hole structure to electron (a controversial issue) and activity of a special form of gravity at Planck scales (a new consistent idea). These hypotheses automatically yield the internal structure of an electron black hole as a light speed rotating ring with Planck length horizon, more charge dispersion against more mass aggregation on it, and spin jets. As a one-step into the grand unification in physics, all of the other spin-1/2 elementary particles, i.e., μ and τ leptons on one side, and quarks and neutrinos on another side can be obtained as the other transformations of the electron black hole, just by adjusting the spin constraint and charge distribution possibilities of the electron ring, respectively. In full consistency with the standard model, the spin formation possibility can also yield the allowed numbers of particles at each spin (e.g., spins of 0, 1, 3/2, and 2 which their allowed particle numbers are 1, 4, 0, and 5, respectively). Among these particles, only one of the spin-2 particles, which have to possess no electric charge and mass, behaves as a stable Planck-scale black hole, similar to neutrino as one of the transformations of electron black hole. Interestingly, the prediction of a spin-2 particle, as a nomination for graviton, does not require involving any extra dimensions into our common 3+1 space-time. As an experimental-based application, we believe that the concept of black hole-based elementary particles which provides a correlation between electric charge, spin, and mass of the particles can shed light on other various unanswered fields of the present physics from the prediction about the other realizable elementary particles such as graviton to the dark matter/energy dilemma, in the frame of a universal unified theory. This can be considered as one of our next highly exciting plans.

The Conflict of Interest Statement

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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