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Article

On a Conjecture on the Cosmological Origin of Quarks and Leptons by Spontaneous Fractionation of a Heavy Lepton Pair

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Abstract: A conjecture on the cosmological origin of the first generation of hadrons and leptons is proposed. In the theoretical framework of Bridge Theory, it is demonstrated that the direct interaction of a pair of heavy leptons with electric charge equal to that of a proton – antiproton pair, emitted in the decay of a balancing graviton predicted in the Multi-Bubble Universe model, leads to spontaneous fractionation of the pair into six elementary particles. Fractionation occurs through two equiprobable channels, resulting in the formation of hadronic and lepton particles. The results suggest possible explanations for the relative abundances of fundamental elementary particles, the existence of quarks and their fractional charge values, the presence of a small electric charge for neutrinos, and provide insights into the matter-antimatter asymmetry in the universe.

Keywords: Bridge Theory; cosmological origin of matter; matter-antimatter asymmetry; hadrons; leptons

1. Introduction

In 1964, Murray Gell-Mann and George Zweig, working independently on a theory of the strong interactions [1,2], proposed the existence of three fundamental subatomic particles. Within this framework, they suggested that hadrons, the strongly interacting particles, could be explained as composite object made up of smaller elementary constituents called quarks, a name coined by Gell-Mann.

As early as 1961 Gell-Mann had introduced a symmetry scheme known as the "Eightfold Way" [3], based on the mathematical structure of SU(3) symmetry. This scheme successfully classified hadrons into two fundamental groups: mesons and baryons. Independently, George Zweig arrived at a similar conclusion in 1964, suggesting that mesons and baryons could be described in terms of three fundamental particles. Their work demonstrated that certain properties of hadrons could be understood by treating them as triplets of constituent quarks. However, to this day, no theory fully explains how quarks formed in the early universe.

It is well known that all particles are created in pairs. However, the UP and DOWN quarks of the first generation in the Standard Model (SM) have never been observed to form independently in pairs. While high-energy collision of hadrons can produce a quark-gluon plasma, they not result in the independent creation of new quark pairs, unlike electron-positron or neutrino-antineutrino pairs that can emerge from a photon [4].

It is commonly assumed that in the immediate aftermath of the Big Bang, the universe was extremely hot and dense. As it cooled, conditions became favourable for the formation of the fundamental building blocks of matter, namely electrons and quarks, which later combined to form protons and neutrons. However, this scenario it does not explain how and way quarks formed in the first place, making their origin one of unresolved mysteries of nature.

This paper proposes a simple model based on the principles of the Bridge electromagnetic Theory (BT) [5,6], offering a physical framework that justifies the existence of quarks and other elementary particles of the first generation of the SM. To achieve this, a cosmological model compatible with the BT is required, one that addresses two fundamental questions: where do spacetime and primordial matter originate?

An answer is provided by the Multi-Bubble Universe model [7,8] (MBU) which describes the emergence of spacetime and primordial matter as a spontaneous process, without the need for a Big Bang, originating from field of nothingness. This field is initially characterised by the absence of both spacetime and the associated electromagnetic field. The MBU model aligns with various observational data related to the cosmic microwave background, gravitational interactions, and the anomalous rotational speeds of galactic halos, although many of its predictions remain to be tested.

In this paper, one will consider the working hypothesis of a currently unobserved charged particle emitted in pairs by the primordial decay of the balancing graviton predicted by the MBU model, with an energy 2.68 TeV (See Ref. [7] and [8]). The balancing graviton is homologous in certain properties to a Kaluza-Klein graviton [9,10], to which we will refer throughout this work. The decay of this graviton is proposed as the fundamental process from which spacetime and matter originate. The interaction of the aleph-antialeph pair is hypothesized to produce a space-time bubble. Given that graviton exists as a Bose-Einstein condensate below the spacetime threshold, it represents an additional fifth dimension. This five-dimensional topology $M^4 \times S^1$ envelops the graviton, rendering it unobservable while facilitating the creation of space-time bubble and the associated electromagnetic field (Cf. Ref. [5]). If, as suggested in this work, hadrons and leptons emerge as a consequence of this electromagnetic field's characteristics, then five dimensions are sufficient to describe all fundamental forces in nature.

As a first step, this work demonstrates that the direct electromagnetic interaction of a pair of particles, assumed to be aleph particles originating from the primordial decay of a KK-graviton in the MBU, results in the fractionation of the aleph pair into three pairs of fundamental particles compatible with the first generation of the Standard Model. This fractionation process, termed the X-process, may have occurred during the early phase of spacetime bubble formation, producing hadrons and leptons in sufficient quantities to form the observable universe.

The BT framework is based on the phenomenology of the Dipole Electromagnetic Source (DEMS) (See Ref. [5]) according to which any interacting pair of particles, regardless of their charge value of charge ($\pm q$), produce a DEMS. This DEMS localizes in its source zone an energy $h^* c/\lambda$ and a momentum h^*/λ in agreement with that one of a photon of wavelength λ (See Ref. [6]) whose value is equal to the minimum interaction distance reached by the particles. The action associated with such a direct interaction is $h^* = 2\pi\sigma q^2/c$, with $\sigma = 137.035950244954$ corresponding to the reciprocal value of the theoretical Sommerfeld constant calculated in Ref. [5], more recently re-calculated in the context of the hydrogen atom formation model [11].

Following the BT phenomenology, the present article proposes the possibility that a pair of fermions with appropriate characteristics, when they interact with each other, they spontaneously fractionate emulating the formation of the first generation of elementary particles described in the Standard Model of matter and existing in physical reality. Assuming that the pair of aleph particles produced by the decay of the KK graviton have a unit of electric charge equal to that of the proton $\left(Q = e^\dagger, \overline{Q} = -e^\dagger\right)$ necessarily greater than that in the electron, the cross on the top right of the electric charge in round parenthesis, distinguishes the charge of the proton from that of the electron, a DEMS is born as described in BT and on condition that the two particles have an interaction energy sufficient to give rise to a proton-antiproton pair, i.e., having an energy $E > 2m_p c^2$, the pair of aleph undergoes a spontaneous fractionation with two equiprobable channels, giving rise to two distinct groups of three pairs of elementary particles. The first group consists of three pairs of fractional charges in the quark-antiquark form $Q\overline{Q} \rightarrow d\overline{d} + 2u\overline{u}$ while the second group consists in three pairs of leptons, one pair electron-positron and two pairs of electronic neutrino-antineutrino in the

form $Q\overline{Q} \to e\overline{e} + 2\nu\overline{\nu}$. In this model, neutrinos are expected to have an extremely small but not zero electric charge because they must be able to interact electromagnetically even if weakly with other matter, so the electron and positron consequently have a lower charge value than that of the original unit from which they are derived. In the following, we will show how both fractional charge groups describe the particles in terms of charge in accordance with the first generation of elementary particles described in the Standard Model.

2. Structure Function of Two Interacting Charge Fragment

Starting from what has been demonstrated in BT that all DEMS produced by the direct electromagnetic interaction of a free pair of particles with elementary charge $e^{\pm}$ are associated with a Planck unit of action expressed in the Dirac form, to simplify we formally mark the process that gives rise to the DEMS as a formal operation which returns the action produced by the interaction between the charges with the binary symbolic operator giving the Planck action in Dirac form

$$\hbar = e \odot \overline{e} \equiv \sigma \frac{e^2}{c} \tag{1}$$

with c speed of light, e electron charge unit and $\sigma = \alpha^{-1}$ reciprocal value of the Sommerfeld constant, with the role of structure function theoretically expressed by the functional

$$\sigma = \left(\frac{4\pi}{3} \int_0^{\pi} \Theta_t(\rho,\theta)d\theta + \frac{1}{4\pi\rho^2} \right) \tag{2}$$

in which

$$\Theta_t(\rho,\theta) = 16 \sqrt{ \frac{1}{\left(4+\rho^2+4\rho\cos\theta\right)^2} + \frac{1}{\left(4+\rho^2-4\rho\cos\theta\right)^2} + \frac{2\left(4-\rho^2\right)}{\sqrt{\left[\left(4+\rho^2\right)^2-16\rho^2\cos^2\theta\right]^3}} }$$

$$\cdot \left| \frac{\left(2+\rho\cos\theta\right)}{\sqrt{\left(4+\rho^2+4\rho\cos\theta\right)^3}} + \frac{\left(2-\rho\cos\theta\right)}{\sqrt{\left(4+\rho^2-4\rho\cos\theta\right)^3}} \right| \tag{3}$$

is the transversal component of the Poynting vector of the electromagnetic field of the DEMS (Cf. Ref. [2]). Therefore, in Gauss units the theoretical value of action (1) for an interaction between a pair of charged elementary particles with proton-antiproton electric charge $e^{\dagger}\overline{e}^{\dagger}$ is analogously given by $\hbar^{\dagger} = e^{\dagger} \odot \overline{e}^{\dagger}$ where the numerical value of the action constant depends from the structure function (2) varying as a function of the ratio $\rho = R/\lambda$ between the dipole moment length per unit of charge R and the wavelength λ of the DEMS and of the emission angle θ.

For a free electromagnetic interaction between a pair of charged particles, i.e., without external constrains acting on the DEMS, the ratio has been calculated using a stochastic method described in Ref. [2] and [9] and its value is known exactly $\rho^* = 1.275556618599942$, but the value changes if the particles are subjected to the action of external forces. Using this ratio the value of the structure constant is $\sigma^* = 137.035989$ (See Ref. [2]) independently of the value of the charge of the pair of the interacting particles.

Each external constraint acting on the pair during their direct interaction produces a variation of the value of the ratio ρ and consequently of the structure constant as proven in Ref. [11] for an electron-proton capture.

Considering a pair $Q\overline{Q}$ one assumes that when the charges interact they produce a DEMS corresponding to a growing electromagnetic spherical bubble delimited by the emitted spherical wave of initial wavelength λ in which the spontaneous fragmentation of the pair occurs dividing the primitive electromagnetic bubble into three sub-DEMS produced by the interaction of pairs of fractional charges $C_i = \chi_i e^{\dagger}$ and $\overline{C}_i = \overline{\chi}_i e^{\dagger}$, where $\chi_i = |\chi_i|$ and $\overline{\chi}_i = -|\chi_i|$ with $i = 1,2,3$ are the

fractional dimensionless charges such a that $0 < \chi_i < 1$, with product of the pair of unitary charges generators $Q\bar{Q}$ given by

$$\left| Q\bar{Q} \right| = \sum_i \left| C_i \bar{C}_i \right| = e^{\dagger 2} \sum_i \left| \chi_i \bar{\chi}_i \right|.$$

(4)

Using the Equation (1) for the unit of charge $\left| e^\dagger \right|$, the absolute value of the Planck action is given by

$$h = 2\pi \sum_i C_i \odot \bar{C}_i = 2\pi \frac{e^{\dagger 2}}{c} \sum_i \sigma_{\bar{\chi}_i \chi_i},$$

(5)

with

$$\sigma_{\bar{\chi}_i \chi_i} = \left(\frac{4\pi}{3} \int_0^\pi \Theta_t(\rho,\theta) d\theta + \frac{1}{4\pi\rho^2} \right) \chi_i^2 = \sigma \chi_i^2.$$

(6)

that as the value of the ratio ρ yields the value of the structure constant of the single sub-DEMS is obtained under appropriate external conditions.

In general, for any possible interaction $C_i C_j$ even with different charge or anticharge values, the structure constant (6) acquires the form

$$\sigma_{\chi_i \chi_j} = \left(\frac{4\pi}{3} \int_0^\pi \Theta_t(\chi_i,\chi_j,\rho,\theta) d\theta - \frac{\chi_i \chi_j}{4\pi\rho^2} \right)$$

(7)

with field structure function associated to the transversal component of the of the Poynting vector

$$\Theta_t(\chi_i,\chi_j,\rho,\theta) = 16 \sqrt{ \frac{\chi_i^2}{\left(4+\rho^2+4\rho\cos\theta\right)^2} + \frac{\chi_j^2}{\left(4+\rho^2-4\rho\cos\theta\right)^2} + \frac{2\chi_i\chi_j\left(4-\rho^2\right)}{\sqrt{\left[\left(4+\rho^2\right)^2 - 16\rho^2\cos^2\theta\right]^3}} }$$

$$\cdot \left| \frac{\chi_i\left(2+\rho\cos\theta\right)}{\sqrt{\left(4+\rho^2+4\rho\cos\theta\right)^3}} + \frac{\chi_j\left(2-\rho\cos\theta\right)}{\sqrt{\left(4+\rho^2-4\rho\cos\theta\right)^3}} \right|$$

(8)

The application of Equation (7) allows to estimate the structure constants for each pair of integer or fractional charges existing in nature. In the (Figure 1a–d) are shown the structure functions (8) for some particular cases.
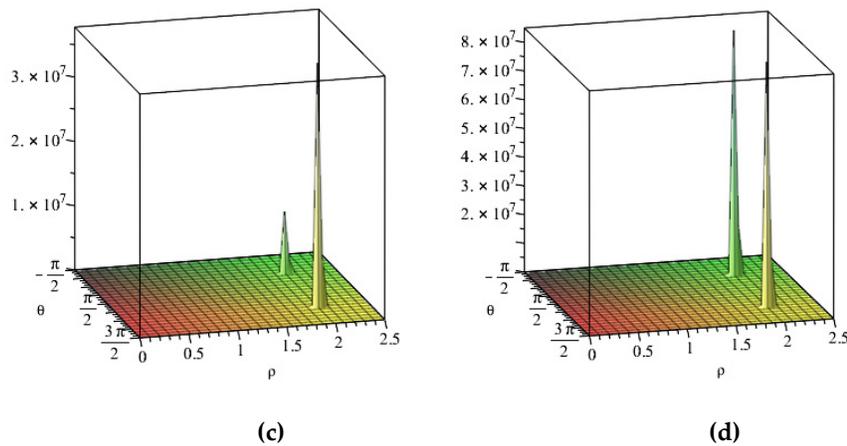

(a)

(b)

(c)   **(d)**
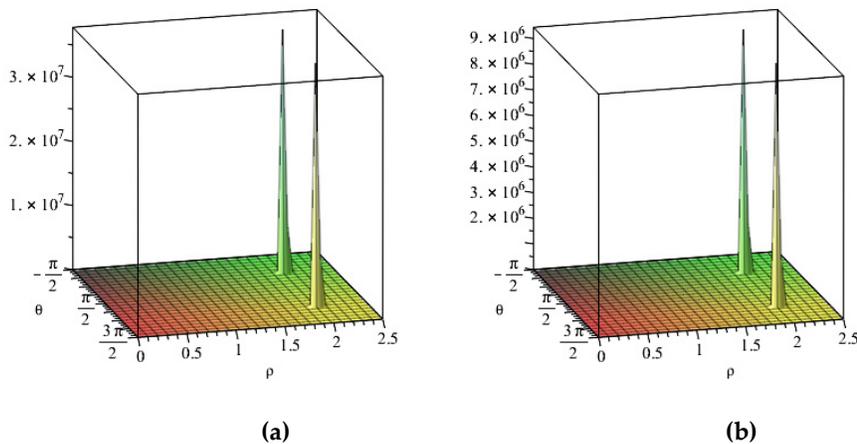
Figure 1. (a) structure function (8c) for the direct interaction of pairs $uu, u\overline{u}, \overline{uu}$; (b) structure function (8c) for the direct interaction of pairs $dd, d\overline{d}, \overline{dd}$; (c) structure function (8c) for the direct interaction of pairs $ud, \overline{ud}, u\overline{d}, \overline{ud}$; (d) structure function (8c) for the direct interaction of pairs $ee, e\overline{e}, \overline{ee}$.

3. Fragmentation of Unitary Electric Charges of a DEMS

Considering that a DEMS, when formed, continues to exist as a dipole regardless of the distance of the two interacting charges (see Ref. [1] and [2]), the following three properties hold:

A - The total action $Q \odot \overline{Q}$ obtained by a pair of interacting particles with integer charges $Q\overline{Q}$ is a constant primitive value. Any charge fractionation must have a total action not exceeding the original value.

B - The value of the action depends on the value of the interacting charges Q or $\overline{Q}$ and can vary according to the external constrains acting on the charges with the assumption that the total energy of the system must be conserved.

C - The integer charge Q or $\overline{Q}$ of each individual interacting particle can be fractioned but the sum of its parts maintains the initial value.

D - In nature, protons are made up of three particles with fractional charge two of which have the same charge value.

In the case of fractionation in sub-DEMS, the previous properties for a free interaction between two particles of unit charge divided in three pairs of fragments can be rewritten in the form:

(a) Using Equations (4)–(6) the total action of the sub-DEMS produced must not exceed in value the total action of the primary bubble.

$$\sum_i^3 \chi_i^2 \le 1 \tag{9}$$

(b) The total fractional charge must be equal to that original:

$$\sum_i^3 \chi_i = \pm 1 \tag{10}$$

(c) Two of the three charge fragments obtained must have equal value:

$$\chi_2 = \chi_3 \tag{11}$$

The three previous conditions put into the system

$$\begin{cases} \chi_1^2 + \chi_2^2 + \chi_3^2 \le 1 \\ \chi_1 + \chi_2 + \chi_3 = \pm 1 \\ \chi_2 - \chi_3 = 0 \end{cases} \tag{12a}$$

Lead to two independent systems

$$\begin{cases} \overline{\chi}_1 = -1 - 2\overline{\chi}_3 \\ \overline{\chi}_2 = \overline{\chi}_3 \\ (3\overline{\chi}_3 + 2)\,\overline{\chi}_3 \le 0 \end{cases}$$

(12b)

$$\begin{cases} \chi_1 = +1 - 2\chi_3 \\ \chi_2 = \chi_3 \\ (3\chi_3 - 2)\,\chi_3 \le 0 \end{cases}$$

(12c)

The third equation of the system (12b) has solutions in the interval $\overline{S} = \left\{ \overline{\chi}_3 \in \left[-\dfrac{2}{3} \quad 0 \right] \right\} \cap \mathbb{R}^-$

for a negative charge generator and in the interval $S = \left\{ \chi_3 \in \left[0 \quad +\dfrac{2}{3} \right] \right\} \cap \mathbb{R}^+$ for a positive charge

generator. Considering that a small but finite amount of energy is lost to produce the fractionation, the total action after fractionation is therefore somewhat less than that resulting after the fractionation. Therefore, one can write the solution for a negative generator as

$$\overline{S} = \left\{ \overline{\chi}_3 \in \left[\lim_{\varepsilon_Q \to \delta Q} \left(-\frac{2}{3} + \varepsilon_Q \right) \quad \lim_{\varepsilon_Q \to \delta Q} \left(0 - \varepsilon_Q \right) \right] \right\} = \left\{ \overline{\chi}_3 \in \left[-\frac{2}{3}^{(+)} \quad 0^{(-)} \right] \right\}$$

(13a)

analogously for the system (12c) for a positive generator

$$S = \left\{ \chi_3 \in \left[\lim_{\varepsilon_Q \to \delta Q} \left(0 + \varepsilon_Q \right) \quad \lim_{\varepsilon_Q \to \delta Q} \left(+\frac{2}{3} - \varepsilon_Q \right) \right] \right\} = \left\{ \chi_3 \in \left[0^{(+)} \quad +\frac{2}{3}^{(-)} \right] \right\}$$

(13b)

in both cases $\delta Q < \varepsilon_Q$ where δQ is a non-zero but very close to zero the value of which is not currently determined. Considering that among all the infinite particular solutions inside the intervals $\overline{S}$ and S, the values $\overline{\chi}_3$ and χ_3 must be those that minimize the difference between the initial action of the particles with integer charge and the final total action of the pairs with fractional charge, for this to happen, only values close to the extremes of the intervals $\overline{S}$ and S satisfy this condition, therefore, the solutions can be written in the form $\overline{\chi}_3 = \left(-\dfrac{2}{3}^{(+)}, \; 0^{(-)} \right)$ for the negative generator and

$\chi_3 = \left(+\dfrac{2}{3}^{(-)}, \; 0^{(+)} \right)$ for the positive generator. The symbols $(-),(+)$ at top right of the values of

charge with theirs eventual multiplicity expresses the sign of the "Charge Tendency" (CT) defined as multiple of the defect or excess of electric charge δQ, this symbol at the moment is indicative and does not define an exact value of the charge but represents how each charge value exceeds or is lower than that assigned by the solution justifying also in the leptonic solution the fractioning principle. The CT is a tiny quantity of charge due to the spontaneous fractionation of the original electric charge unit of the proton charge. Its value can be used as a free parameter in the context of BT to adjust the value provided in the theory of appropriate physical quantities, such as masses of particles and coupling coefficients.

Using the two pair of generators and the first two equations of the Equations (12b) and (12c), one obtains the complete sets of the fractioned charge divided into anticharge and charge for hadronic (*H*) and leptonic (*L*) type

$$\bar{\chi}_3 = \left(-\frac{2}{3}^{(+)}, \; 0^{(-)} \right) \rightarrow \begin{cases} \bar{H} = \left(+\frac{1}{3}^{(-\,-)} \quad -\frac{2}{3}^{(+)} \quad -\frac{2}{3}^{(+)} \right) \\[3mm] \bar{L} = \left(-1^{(+\,+)} \quad 0^{(-)} \quad 0^{(-)} \right) \end{cases}$$

$$\chi_3 = \left(+\frac{2}{3}^{(-)}, \; 0^{(+)} \right) \rightarrow \begin{cases} H = \left(-\frac{1}{3}^{(+\,+)} \quad +\frac{2}{3}^{(-)} \quad +\frac{2}{3}^{(-)} \right) \\[3mm] L = \left(+1^{(-\,-)} \quad 0^{(+)} \quad 0^{(+)} \right) \end{cases}$$

(13c)

the solutions (13c) obtained for the systems (12b) and (12c) are unique and depend on the conservation of charge and action value which, associated with a characteristic fractionation time, corresponds to the conservation of energy.

To simplify the display of the solutions (13), one collects the charges in two matrices, one hadronic

$$\mathbf{H} = \begin{pmatrix} H \\ \bar{H} \end{pmatrix} = \begin{pmatrix} -\frac{1}{3}^{(+\,+)} & +\frac{2}{3}^{(-)} & +\frac{2}{3}^{(-)} \\[3mm] +\frac{1}{3}^{(-\,-)} & -\frac{2}{3}^{(+)} & -\frac{2}{3}^{(+)} \end{pmatrix} \Leftrightarrow \begin{pmatrix} d & u & u \\ \bar{d} & \bar{u} & \bar{u} \end{pmatrix} \qquad (14)$$

in which there are three fractional values of the charge generator in correspondence with the existence of two flavours of quarks and one leptonic

$$\mathbf{L} = \begin{pmatrix} L \\ \bar{L} \end{pmatrix} = \begin{pmatrix} +1^{(-\,-)} & 0^{(+)} & 0^{(+)} \\ -1^{(+\,+)} & 0^{(-)} & 0^{(-)} \end{pmatrix} \Leftrightarrow \begin{pmatrix} \bar{e} & v & v \\ e & \bar{v} & \bar{v} \end{pmatrix} \qquad (15)$$

Solutions (14) and (15) show that all particles besides the charge value have a CT, i.e., that the charges are not exactly equal to the declared values but that they are slightly lower or higher due to fractionation, this can have a physical measurable effect on the particles.

Considering that the CT changes in signs if the sign of the unitary generator changes, CT allows to all the sub-DEMS has got a part of the total energy of the primordial DEMS allowing them to evolve energetically.

The solutions (14) and (15) have as consequence that the proton must have a value of charge an amount $2\delta Q$ greater than the unit charge of the positron, hence $e^\dagger > e$, by reopening a discussion on the real neutrality of atoms and molecules [12,13].

4. Use of the Solutions L and H to Build the First Generation of the Elementary Particles

To describe the quarks in Equation (14), the CT is not essential because the quarks, unlike neutrinos, have a charge to interact with each other, their CT can only be necessary considering the behaviour during their interaction in groups of particles forming mesons or baryons, which is not currently taken into account. In this work it is sufficient to establish that there is a fractionation mechanism that leads to the existence of hadrons with fractional charges not with the exact same value, therefore with different positive or negative tendencies of the charge value. This mechanism could define the colour charge of quarks allowing direct interaction between quarks of the same type, an example could be $\left(+\frac{2}{3}^{(-)}, +\frac{2}{3}^{(-\,-)}, -\frac{1}{3}^{(+++)} \right)$ that it can be considered for example equivalent to *u*-RED, *u*-GREEN and *d*-BLUE, in such a way that the resulting proton *uud* formed by the three quarks taken together can form an exact unitary charged particle with zero CT in agreement with QCD and with a total charge only a little greater than the electron.

Since the use of the CT notation for the hadronic solution currently appears redundant, we will use it only when and if necessary.

5. Mixed Solutions

Since the fractionations of the charges of the particles that form the original DEMS occurs on the row of the matrix and the two rows are independent because they are independent solutions, the only conditions that must be verified are those previously reported in points A-B-C-D, the mixed matrices

$$\mathbf{M} = \begin{pmatrix} H \\ L \end{pmatrix} = \begin{pmatrix} -\dfrac{1}{3} & +\dfrac{2}{3} & +\dfrac{2}{3} \\ -1^{(+\ +)} & 0^{(-)} & 0^{(-)} \end{pmatrix} \Leftrightarrow \begin{pmatrix} d & u & u \\ e & \bar{v} & \bar{v} \end{pmatrix} \tag{16}$$

and its symmetrical

$$\bar{\mathbf{M}} = \begin{pmatrix} \bar{H} \\ L \end{pmatrix} = \begin{pmatrix} +\dfrac{1}{3} & -\dfrac{2}{3} & -\dfrac{2}{3} \\ +1^{(-\ -)} & 0^{(+)} & 0^{(+)} \end{pmatrix} \Leftrightarrow \begin{pmatrix} \bar{d} & \bar{u} & \bar{u} \\ \bar{e} & v & v \end{pmatrix} \tag{17}$$

they are particularly interesting because they are obtained with a mix of **H** and **L** compatible solutions. Solutions (16) and (17) can exist together because they are two separate solutions of the two generators of charge $(-1, +1)$. The choice of which of the two matrices is the antimatrix is completely arbitrary, in this context the one containing the elementary particles of ordinary matter compatible with the existence of hydrogen atoms has been chosen as the matrix and the one containing the particles compatible with the existence of antihydrogen atoms has been chosen as the antimatrix.

In this case one could have the coexistence in a same electromagnetic bubble of a proton or antiproton and of three leptons violating the creation in pairs of the particles associated to the sub-DEMS. This is possible if the fractionation takes place by particle of integer charge and not by pair, in this case the interaction takes place by cluster, therefore by rows and the mixed bubble does not violate the invariance of the total charge, of the spin of the bubble and preserves the sum of the baryon and lepton numbers

$$B + L = 0 \tag{18}$$

The asymmetric fractionation characterizing the mixed solutions (16) and (17) suggests that with the different charged particles collected in the X-matrix associated to the fractionation process

$$\mathbf{X} = \begin{pmatrix} -1^{(++)} & 0^{(-)} & 0^{(-)} \\ +1^{(--)} & 0^{(+)} & 0^{(+)} \\ -\dfrac{1}{3} & +\dfrac{2}{3} & +\dfrac{2}{3} \\ +\dfrac{1}{3} & -\dfrac{2}{3} & -\dfrac{2}{3} \end{pmatrix} \Leftrightarrow \begin{pmatrix} e & \bar{v} & \bar{v} \\ \bar{e} & v & v \\ d & u & u \\ \bar{d} & \bar{u} & \bar{u} \end{pmatrix} \tag{19}$$

they can interact electromagnetically forming a DEMS invariant in energy and action only considering charge clusters each obtained from a different row, aggregating elements arranged on the same row of the matrix (19), Each cluster corresponds to a non-elementary particle.

Extending these considerations, charge clusters can be produced using the elementary particles in the matrix (19) in such a way that the initial charge values can be reproduced forming new particles like for example $p \equiv uud$, $\bar{p} \equiv \overline{uud}$ or $\pi^+ \equiv u\bar{d}$, $\pi^- \equiv \bar{u}d$, but there is also the possibility to produce new heavy clusters with fractional charges that can be considered later generation quarks such as $\bar{d}^{(II)} = d\bar{d}d$, $\bar{d}^{(III)} = u\bar{u}\bar{d}$ and $d^{(II)} = d\bar{d}d$, $d^{(III)} = u\bar{u}d$ or $\bar{u}^{(II)} = d\bar{d}\bar{u}$, $\bar{u}^{(III)} = u\bar{u}\bar{u}$ and $u^{(II)} = d\bar{d}u$, $u^{(III)} = u\bar{u}u$ and other possible ones that could be related to quarks belonging to the second and third generation. In this sense, generations subsequent to the third would also be possible differing from previous generations only in energy content. This mode is the only one that can be used in this model to maintain the charge and action unchanged during the formation of a DEMS between pairs of charged clusters, that necessarily have different energy and more mass because they are formed by a different number of active sub-DEMS.

Equation (19) puts in evidence a perfect symmetry in particles-antiparticles primary production with an abundance of two neutrinos for each hydrogen atom and two antineutrinos for each anti-hydrogen atom, having four neutrinos for each pair of hydrogen-anti-hydrogen. Considering that at present it is not yet possible to know where and when the antihydrogen disappears, starting with Eq. (19) it will be interesting in the future to try to draw all the possible scenarios capable of describing the situation of our universe.

6. Discussion and Conclusions

The proposed model suggests that the spontaneous fractionation of a heavy lepton pair, as dictated by the principles of Bridge Theory, provides a plausible mechanism for the emergence of quarks and leptons in the early universe. This mechanism not only accounts for the existence of fractional charges but also introduces a framework in which neutrinos may possess a small, yet nonzero, electric charge.

The particles collected in the fractionation solutions displayed in the X-matrix, show that the fractionation cannot occur for particles with an electric charge equal to that of an electron, otherwise following BT, there would be no neutrinos with charge and mass.

Since in BT an elementary particle interacts with other particles only electromagnetically [13], that can occur only if all the particles have electric charge, therefore, all particles must first of all have a charge. The charge of the neutrinos must obviously be very small and currently this value has not yet been strictly estimated [14] but using BT theoretically this can be made.

As a result of the model application, one deduces that the positron has a unit of charge e only slightly lower than that of the proton $e^\dagger$, the difference of which is instrumentally difficult to assess but CT can have important effects on all the interactions.

The introduction of the concept of CT, in addition to allowing a charge, even if very small, to be attributed to the neutrino, suggests a mechanism that justifies the existence of the colour charge of quarks, giving in this case the possibility to two apparently identical particles to interact by binding even if weakly, electromagnetically to each other.

One of the key implications of this model is the potential explanation of the apparent matter-antimatter asymmetry [15] observed in the universe. In fact, it may be interesting to consider that in the model, matter and antimatter would have as a distinctive characteristic the sign of the charge generator, when the sign is positive the fractionation produces particles, when the sign is negative the fractionation produces antiparticles. Therefore, the electron would be the antiparticle of the positron, and not the other way around, this for a universe full of hydrogen means that there are as many protons as electrons, so since the proton is made up of three quarks uud defined all as particles and one electron defined as antiparticle, defining a matter-antimatter asymmetry number based on the elementary particles: $A = \pm k$, a hydrogen atom would be formed by three particles (quarks) with $A_{uud} = 3$ and by an antiparticle (electron) $A_e = -1$ with a total asymmetry $A_{p+e} = +2$. If we consider the complete solution of the six fractionated particles that appear in the mixed matrix in Eq. (16), in which two antineutrinos are produced together with the electron, this solves the problem of matter-antimatter asymmetry in the universe in terms of particles-antiparticles, in fact hydrogen would consist of a non-elementary particle (*p*) and an elementary antiparticle (*e*) which together with the two antineutrinos emitted in the primordial formation process cancel the asymmetry number, solving the problem of the apparent asymmetry in favour of matter in the universe. In this case, the antineutrinos produced can be considered the dark matter associated with the X-process and account for most of the energy. In fact, ignoring the photons that can be produced in different associated processes, the ratio of the mass of a neutral hydrogen atom $m_H \simeq 0.939\ 10^{-3}\,\text{TeV}$ to the expected mass of a KK graviton of 2.68 TeV is close to 0.035%, i.e., the energy missing represents more than 99%.

The fact that the matter-antimatter asymmetry in terms of particles can be considered zero, however, does not solve the problem of the absence of antihydrogen in the early universe. However,

the author believes that the conjecture on the existence of the X-process that produces fractionation, if proven by the identification of a pair of candidate particles, may contribute to find a way to understand the baryon asymmetry of the universe.

Additionally, the concept of Charge Tendency (CT), introduced in this work, suggests that elementary charges are not perfectly quantized but exhibit small variations that could be measurable. Future high-precision experiments aimed at detecting charge discrepancies between protons and electrons or establishing a nonzero charge for neutrinos could provide empirical support for this model.

While this conjecture provides a compelling theoretical foundation, several open questions remain. The detailed energetic conditions required for fractionation, the possible role of higher-dimensional effects beyond five dimensions, and the full dynamical description of the X-process require further investigation. Moreover, future studies may explore whether later generations of quarks and leptons arise from similar fractionation mechanisms at higher energy scales.

In conclusion, this work introduces a novel perspective on the cosmological origin of matter through a structured fractionation mechanism. If confirmed, the implications could extend beyond particle physics, influencing our understanding of the early universe, dark matter candidates, and the fundamental structure of charge quantization. Experimental efforts in high-energy physics and astrophysics will be crucial in testing the reliability of this model and its predictions.

Abbreviations

The following abbreviations are used in this manuscript:

SM   Standard Model
BT   Bridge Theory
MBU   Multi-Bubble Universe
DEMS   Dipole Electromagnetic Source
CT   Charge Tendency

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