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THE LAW OF BARYOGENESIS: NEW CONSTANTS OF ELEMENTARY PARTICLES - MASS DEFECT AND MAGIC NUMBER.

Abstract. *The law of baryogenesis possesses predictive power and yields a series of new results. Some of these results have proven unexpected and require further in-depth study. The law of baryogenesis introduces two new constants of elementary particles - the magic number and mass defect. It is demonstrated that Mersenne numbers are the magic numbers for electrically charged elementary particles, while doubled Mersenne numbers serve as the magic numbers for neutral elementary particles. The mass defect of elementary particles is a novel concept and constant in the realm of elementary particles. Equations for calculating the magic numbers and mass defect of elementary particles are derived from the fractal mechanism of baryogenesis. The law of baryogenesis unifies three dimensionless constants of elementary particles: the ratio of particle mass to electron mass, the ratio of mass defect to electron mass, and the magic number.*

Keywords: *law of baryogenesis, fractals of elementary particles, dimensionless constants of elementary particles, fractal formula, antimatter, leptosynthesis, baryosynthesis, mass defect, Mersenne numbers, doubled Mersenne numbers.*

1. Introduction

The foundation for deducing the law of bariogenesis is rooted in the fractal mechanism of proton formation [1], which involves the interaction of antimatter and matter. This mechanism is based on the interaction of electrons and positrons, leading to the formation of positronium and subsequent synthesis reactions resulting in the creation of protons and neutrons. Electrons and positrons act as both reactants and catalysts in the baryosynthesis reaction.

The discovery of positronium [2] was the first indication of the coexistence of matter and antimatter without annihilation. Positronium can associate with an additional electron or positron during its lifetime, forming positronium ions. The formation of positronium ions represents the second step in the baryosynthesis reaction involving antimatter. Additionally, positronium atoms can combine to form positronium molecules, confirming that the synthesis path, rather than annihilation, is not foreign to both antimatter and matter.

Historically, the existence of positronium ions and molecular positronium was predicted by Wheeler in 1946 [3]. In 1981, Allen Mills obtained a negatively charged positronium ion consisting of two electrons and one positron [4]. In 2007, molecular positronium was experimentally observed [5 - 10].

Beyond positronium, other combined particle-antiparticle systems have been obtained, including pion-antipion systems (pionium) and proton-antiproton systems (protonium) [11 - 13]. Ongoing research is exploring additional systems composed of matter and antimatter, such as muon-

antimuon systems (dimuonium) [14], true tauonium systems [15], and kaon-antikaon systems (kaonium) [16].

2. Fractal Mechanism of Bariogenesis

The fractal mechanism of bariogenesis has led to the derivation of the law of bariogenesis [17]. The detailed description of the fractal mechanism of bariogenesis can be found in [17 - 19]. In Figure 1, the first three stages of baryosynthesis are illustrated. The initial particles in the pathway of baryosynthesis are positronium atoms (P_s). Subsequently, through the addition of an electron and a positron to the positronium atoms, charge-conjugated pairs of positronium ions, Ps- and Ps+, are formed.

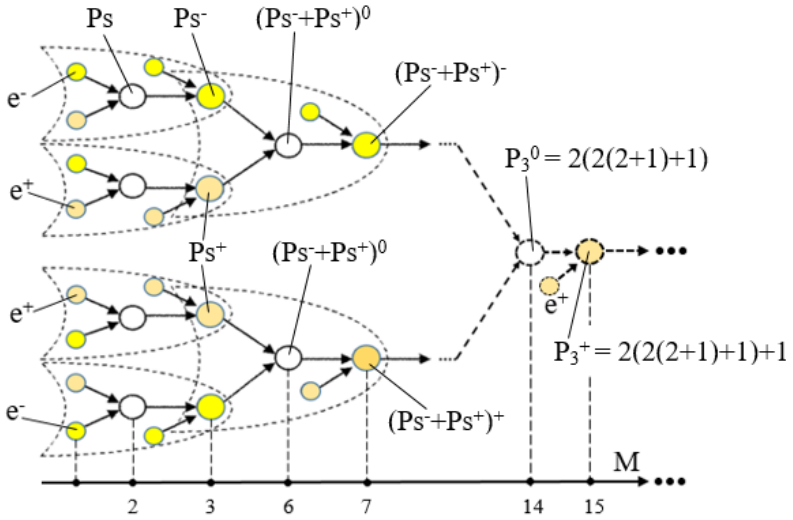

Fig. 1. Fractal Mechanism of Baryosynthesis.

Positronium ions, through Coulomb interaction, give rise to new neutral particles $(Ps- + Ps+)^0$. Electrons and positrons act as both reactants and catalysts in the baryosynthesis process [19]. The catalytic process of baryosynthesis continues by doubling the mass and adding an electron and a positron to the neutral particles. The fractal mechanism of replicating intermediate elementary particles is realized. Throughout the entire pathway of baryosynthesis, the formation of a new particle or antiparticle is accompanied by a mass defect. The magnitude of the mass defect determines the binding energy of elementary particles.

Examples of elementary particle fractals include muon, proton, and deuteron fractals (Fig. 2) [17 - 19].

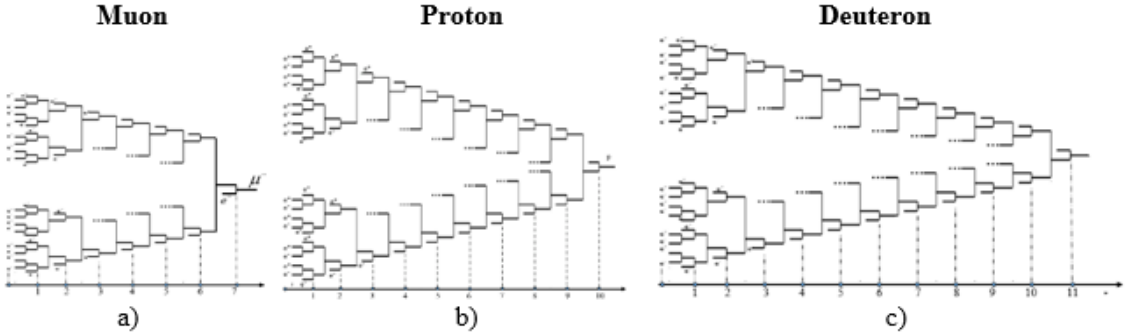

Fig. 2. Muon (a), Proton (b), and Deuteron (c) Fractals.

Fractals depict the sequential stages of elementary particle synthesis. These structures are self-similar, repeating the elementary cell of the fractal according to the law 2^n.

Examples of combined fractals include the neutron and π- meson fractals (Fig. 3) [18 - 19].

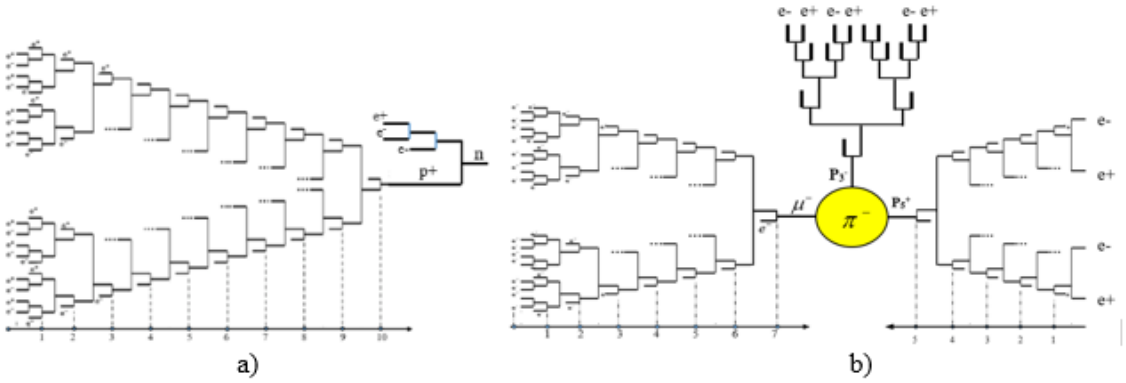

Fig. 3. Neutron (a) and π- Meson (b) Fractals.

Combined fractals are formed by the merging of particles and antiparticles generated through the fractal mechanism.

3. The Role and Place of Antimatter in the Mechanism of Leptogenesis and Bariogenesis

To form protons, neutrons, and all visible matter in the Universe, only two types of charge-symmetric particles are needed [17 - 19]. These particles are electrons (matter) and positrons (antimatter). Matter and antimatter can not only annihilate but also coexist and interact, creating elementary particles. Through the combination and replication of matter together with antimatter, they generate leptons, protons, neutrons, and the entire diversity of substances. Examples of the synthesis of muons, protons, neutrons, π- mesons, kaons, tau leptons, tritons, and helions demonstrate that the fractal mechanism of bariogenesis involving antimatter is a universal mechanism [18 - 19]. The mechanism operates in the stages of leptosynthesis, baryosynthesis, and nucleosynthesis. The interaction and coexistence of matter and antimatter without annihilation are the primary conditions for baryosynthesis. Without antimatter, the formation and existence of matter in the Universe would be impossible.

4. The Law of Bariogenesis

The law of bariogenesis is derived from the fractal mechanism of bariogenesis (Fig. 4):

$$m_j = M_j \bullet m_e - \Delta m_j$$

Fig. 4. The Law of Bariogenesis. M_j - magical number of elementary particle, m_j - mass of elementary particle, m_e - mass of electron, Δm_j - mass defect of elementary particle.

The formulation of the law of bariogenesis is as follows: "*The mass of an elementary particle is equal to the sum of the masses of electrons and positrons participating in baryosynthesis, reduced by the magnitude of their cumulative mass defect*." The law of bariogenesis is derived from the fractal

mechanism of baryosynthesis, where antimatter plays a crucial role in the formation of protons and neutrons.

5. Two new constants of elementary particles.

The law of baryogenesis is derived and formulated using two new constants of elementary particles. These constants are the magic number of an elementary particle and the mass defect of an elementary particle. The magic number indicates how many electrons and positrons participated in the formation of the corresponding particle or antiparticle.

The mass defect of an elementary particle determines the binding energy. The mass defect arises in all products of leptosynthesis and baryosynthesis reactions. Electrons, positrons, and more complex particles and antiparticles are involved in these reactions. As a result, the mass of the formed particle or antiparticle is always less than the sum of the reactants' masses.

In the mass defect of an elementary particle, one should seek an answer not only to the origin of mass but also to the origin of the strong interaction coupling constant. The mass defect constant is the part of the synthesis participants' mass that is "spent" on binding energy. The remaining part of the reactants' mass is the mass of the elementary particle. Both the magic number and the mass defect arise from the fractal mechanism of baryogenesis and are quantitative characteristics of the mechanism of lepton and baryon synthesis.

The law of baryogenesis unveils the mystery behind the origin of the dimensionless constant proton-electron mass ratio (m_p/m_e = 1836.15267343(11)). To confirm this, let us express the law of baryogenesis as follows:

$$m_j / m_e = M_j - \Delta m_j / m_e$$

The law of baryogenesis unifies three dimensionless constants of elementary particles: the ratio of particle mass to electron mass, the ratio of mass defect to electron mass, and the magic number. For the dimensionless constants of the proton, we obtain:

$$m_p / m_e = M_{10} - \Delta m_p / m_e \quad = \quad 1836.15267343(11) = 2047 - 210.84732657(11)$$

The law of baryogenesis predicts the values of other dimensionless fundamental constants of elementary particles with high precision. Examples of these dimensionless fundamental constants, derived from the law of baryogenesis, include the following constants of elementary particles: proton-electron mass ratio (m_p/m_e), neutron-electron mass ratio (m_n/m_e), muon-electron mass ratio (m_μ/m_e), tau-electron mass ratio (m_τ/m_e), helion-electron mass ratio (m_h/m_e), deuteron-electron mass ratio (m_d/m_e), and triton-electron mass ratio (m_t/m_e) [17 - 19]. The values of these constants were previously known only from experiments. The standard model lacks a theory of mass spectrum and does not predict the masses of these elementary particles.

6. Magical Numbers of Elementary Particles

A new constant of elementary particles is incorporated into the formula of the law of bariogenesis - the magical number M_j. Magical numbers M_j indicate how many electrons and positrons were involved in the formation of the corresponding particle or antiparticle. The values of magical numbers are calculated from fractal formulas.

The fractal formula for particles with an electric charge is given by [17 - 19]:

$$M = 2(2(...2(2(2+1)+1)+1)+...+1)+1 \qquad (1)$$

The fractal formula for neutral particles is expressed as:

$$M = 2(2(...2(2(2+1)+1)+1)+...+1) \qquad (2)$$

At the core of the fractal formula lies a mathematical construction of the form (2+1), which reflects the beginning of the baryosynthesis mechanism. Subsequently, the fractal formula is built according to the mechanism of replication. The (2+1) construction is repeated and doubled in accordance with the fractal mechanism of the structural genesis of elementary particles. The sequence of stages in the structural genesis of elementary particles represents a block of fractal formulas. The block of fractal formulas is presented as a fractal triangle (Fig. 5).

$$\mathbf{2 = M_1,}$$
$$\mathbf{2+1 = M_1,}$$
$$\mathbf{2(2+1) = M_2,}$$
$$\mathbf{2(2+1)+1 = M_2,}$$
$$\mathbf{2(2(2+1)+1) = M_3,}$$
$$\mathbf{2(2(2+1)+1)+1 = M_3,}$$
$$\mathbf{2(2(2(2+1)+1)+1) = M_4,}$$
$$\mathbf{2(2(2(2+1)+1)+1)+1 = M_4,}$$
$$\mathbf{2(2(2(2(2+1)+1)+1)+1) = M_5,}$$
$$\mathbf{2(2(2(2(2+1)+1)+1)+1)+1 = M_5,}$$
$$\mathbf{2(2(2(2(2(2+1)+1)+1)+1)+1) = M_6,}$$
$$\mathbf{\dots,}$$
$$\mathbf{2(2(\dots 2(2(2(2+1)+1)+1)+1)+\dots+1)+1 = M_j}$$

Fig. 5. Fractal Triangle depicting stages of structural genesis of elementary particles.

The block of fractal formulas of an elementary particle (fractal triangle) illustrates the synthesis mechanism of an elementary particle. It represents the sequence of stages in the formation of the particle. The fractal triangle indicates that all elementary particles are formed according to a unified fractal algorithm. The fractal triangle defines the magical numbers M_j of particles and antiparticles participating in structural genesis.

Blocks of fractal formulas (fractal triangles) generate the following sequence of magical numbers:

2, 3, 6, 7, 14, 15, 30, 31, 62, 63, 126, 127, 254, 255, 510, 511, 1022, 1023, 2046, 2047, 4094, … (3)

Each odd magical number corresponds to a pair of electrically charged elementary particles. Each even magical number corresponds to a neutral elementary particle. Some elementary particles are already known and experimentally obtained. There aren't many of them. From the sequence (3) in the range 2 - 4095, these are particles associated with the numbers: 2 (positronium), 3 (positronium ions), 255 (muon), 2047 (proton), 4094 (protonium), 4095 (deuteron). The law of bariogenesis indicates that more particles and antiparticles remain undiscovered in this range. They are yet to be obtained in experiments.

The block of fractal formulas of an elementary particle concludes with a specific magical number. For example, for the muon, the sequence ends with the magical number 255. For the proton, the sequence ends with the magical number 2047. For the deuteron, the sequence ends with the magical number 4095.

The sequence of magical numbers of elementary particles is a combination of two sequences. One of the sequences is Mersenne numbers [20]:

3, 7, 15, 31, 63, 127, 255, 511, 1023, 2047, 4095, … (4)

The second sequence of magical numbers is doubled Mersenne numbers:

2, 6, 14, 30, 62, 126, 254, 510, 1022, 2046, … (5)

Magical numbers of electrically charged elementary particles are Mersenne numbers. Magical numbers of neutral elementary particles are doubled Mersenne numbers.

The proton and antiproton correspond to the Mersenne number $M_{10} = 2047$. A unique feature of the proton and antiproton is that they are the first and only stable elementary particles after the electron and positron. It is worth noting that the Mersenne number 2047 also has a special property. It is the first composite Mersenne number with a prime number 11 in the exponent: $2047 = 2^{11}-1$.

Magical numbers can be represented both as topological formulas and analytical formulas. The topological formula for particles and antiparticles with an electric charge is as follows:

$$M_j = \underbrace{2(2(\ldots 2(2(2}_{j} + \underbrace{1) + 1) + 1) + \ldots + 1) + 1}_{j} = 2^{j+1} - 1 \quad (6)$$

Topological formula for particles and antiparticles with zero charge:

$$M_j = \underbrace{2(2(\ldots 2(2(2}_{j} + \underbrace{1) + 1) + 1) + \ldots + 1)}_{(j-1)} = 2^{j+1} - 2 \quad (7)$$

Analytical formula for particles and antiparticles with an electric charge:

$$M_j = 2^{j+1} - 1 \quad (8)$$

Analytical formula for particles and antiparticles with zero charge:

$$M_j = 2^{j+1} - 2 \quad (9)$$

7. Binding Energy and Mass Defect of Elementary Particles.

The concept of mass defect is commonly used in atomic and nuclear physics. The mass defect of elementary particles is a novel concept that emerged as a consequence of the baryosynthesis mechanism involving particles and antiparticles. This arises due to the establishment of connections

between particles and antiparticles in synthesis reactions without annihilation. The law of bariogenesis reveals the mechanism of the emergence of binding energy (mass defect) for elementary particles.

mass defect is a new constant of elementary particles. Its value is a quantitative measure of the binding energy of elementary particles. The mass defect arises from the interaction between matter and antimatter during the formation of an elementary particle. All elementary particles, except the electron and positron, possess a mass defect acquired during lepto- and baryosynthesis. As a result, the mass of an elementary particle is less than the sum of the masses of the particles and antiparticles involved in the synthesis.

The mass defect Δm_j is included in the formula of the law of bariogenesis. The formula for calculating the mass defect is derived from the fractal mechanism of structural genesis of elementary particles. It takes the form:

$$\Delta m_j = m_e \bullet \sum_{i=1}^{j+1} (2^i - 1) \bullet (1 - k_s^{j+2-i}) \quad (10)$$

where: m_e - electron mass, Δm_j - mass defect of elementary particle, k_s - constant determining the mass defect.

The mass defect of an elementary particle consists of the mass defects of intermediate particles and antiparticles on the path of synthesizing a specific elementary particle. The formula for calculating the mass defect constant reflects the topological features of the elementary particle fractal. Two quantities, j and k_s, define the mass of an elementary particle. The value of j is the number of stages in the structural genesis of the elementary particle. The dimensionless constant k_s contains the fine-structure constant α (1/137).

In quantum electrodynamics, for large distances (> 10^{-15} m), the constant 1/137 is used. For small distances, constants 1/133 and 1/129 are used [21 - 27]. The choice of the constant depends on the scale of distances at which the interaction occurs and the energy of the process. Three values of the electromagnetic interaction constant are present in theories: α=1/137, α_2=1/133, and α_3=1/129 [21 - 27]. In [25] and [26], values of α_2 = 1/133.29 and α_2 = 1/133.472±0.007 are proposed for the constant α_2 = 1/133. More precise values for constants 1/133 and 1/129 are derived from the assumption of their connection with the number π [18, 19]:

$$\frac{1}{\sqrt[20]{\pi \bullet 10^{-43}}} = 133.395907639 \quad (11)$$

$$\frac{\alpha}{\sqrt[10]{\pi \bullet 10^{-43}}} = 129.85250805... \quad (12)$$

There exists the following relationship between the constants 1/137, 1/133, and 1/129:

$$133.395907639... = \sqrt{129.85250805... \bullet 137.03599908...} \quad (13)$$

The number π can be considered as the geometric equivalent of the constant α_2 = 1/133.395907639…. Correspondingly, the geometric equivalent of the fine-structure constant α = 1/137.03599908 is the number π_2 = 1.8336084.

The quantitative measure when transitioning to higher energy scales is the ratio of constants:

$$\frac{\alpha}{\alpha_2} = \sqrt[20]{\frac{\pi_2}{\pi}} = 0.973436969... = k_{s1} \qquad (14)$$

$$\frac{\alpha}{\alpha_3} = \sqrt[10]{\frac{\pi_2}{\pi}} = 0.947579533... = k_{s2} \qquad (15)$$

Equivalent formulas for calculating constants k_{s1} and k_{s2} take the form:

$$k_{s1} = \frac{133.395907639...}{137.03599908...} = \sqrt[10]{D_0} \bullet \alpha^2 = \frac{\alpha}{\sqrt[20]{\pi \bullet 10^{-43}}} = \sqrt[20]{\frac{\pi_2}{\pi}} = 0.973436969 \qquad (16)$$

$$k_{s2} = \frac{129.85250805...}{137.03599908...} = (\sqrt[10]{D_0} \bullet \alpha^2)^2 = \frac{\alpha^2}{\sqrt[10]{\pi \bullet 10^{-43}}} = \sqrt[10]{\frac{\pi_2}{\pi}} = 0.947579533 \qquad (17)$$

where: α - fine-structure constant, D_0 - Dirac's large number ($D_0 = 4.16561...\times10^{42}$).

The ratio of electric force to gravitational force in the positronium atom Fe/Fg = $4.16561\ldots\times10^{42}$ is also expressed through constants α, α_2, π, and π_2 [28]:

$$\frac{10^{43}}{\sqrt{\pi \bullet \pi_2}} = \frac{1}{\alpha^{10} \bullet \alpha_2^{10}} = 4.16561... \bullet 10^{42} = D_0 \qquad (18)$$

Thus, each magic number M_j is associated with two values of mass defect Δm_{j1} and Δm_{j2}. The first value of mass defect Δm_{j1} is determined by the parameter $k_{s1} = 0.9734369693$. The second value of mass defect Δm_{j2} is determined by the parameter $k_{s2} = 0.947579533$:

$$\Delta m_{j1} = m_e \bullet \sum_{i=1}^{j+1} (2^i - 1) \bullet (1 - k_{s1}^{j+2-i})$$

$$\Delta m_{j2} = m_e \bullet \sum_{i=1}^{j+1} (2^i - 1) \bullet (1 - k_{s2}^{j+2-i}) \qquad (19)$$

Constant k_{s1} allows obtaining the mass defect for "heavy" particles. Constant k_{s2} allows obtaining the mass defect for "light" particles. The origins of the formation of "light" and "heavy" particles should be sought in two modifications of positronium (parapositronium, orthopositronium).

The correctness of determining the values of constants 133.395907639… and 129.85250805… is confirmed by their application in the law of baryogenesis together with the constant 137.03599908…, which made it possible to obtain the value of Dirac's large number $D_0 = 4.16561...\times10^{42}$, as well as the fundamental constants of elementary particles: proton-electron mass ratio (m_p/m_e), neutron-electron mass ratio (m_n/m_e), muon-electron mass ratio (m_μ/m_e), tau-electron mass ratio (m_τ/m_e), helion-electron mass ratio (m_h/m_e), deuteron-electron mass ratio (m_d/m_e), triton-electron mass ratio (m_t/m_e) [17 - 19]. These constants could not be obtained within the standard model. Their values are known only from experiments.

8. Conclusion.

The law of baryogenesis has proven to be highly productive, yielding a series of new results. Venturing beyond known models and employing a fractal model has provided a novel explanation for previously established facts. The utilization of the fractal model has led to a series of new predictions. The law of baryogenesis unveils the mystery behind the origin of dimensionless constants of elementary particles. It predicts the existence of new, as-yet-undiscovered elementary particles. From the law of baryogenesis, it follows that the symmetry between matter and antimatter in the Universe remains unbroken. Half of all matter is composed of antimatter. Antimatter is present around us and within ourselves. The problem of baryon asymmetry proves to be much more complex. It needs to be addressed independently of the symmetry or asymmetry between matter and antimatter. Some results have been unexpected and require further in-depth study.

9. Conclusions.

1. The law of baryogenesis is represented by the following formula:

$$m_j = M_j \bullet m_e - \Delta m_j$$

where: m_e - electron mass, M_j - magic number, Δm_j - mass defect.

2. Magic numbers of elementary particles are Mersenne numbers and doubled Mersenne numbers:

2, 3, 6, 7, 14, 15, 30, 31, 62, 63, 126, 127, 254, 255, 510, 511, 1022, 1023, 2046, 2047, …

3. The formula for calculating the mass defect is:

$$\Delta m_j = m_e \bullet \sum_{i=1}^{j+1} (2^i - 1) \bullet (1 - k_s^{j+2-i})$$

where: m_e - electron mass, Δm_j - mass defect of elementary particle, k_s - constant determining the mass defect.

4. The law of bariosynthesis shows that matter and antimatter can not only annihilate but also coexist and interact with each other, creating elementary particles.

5. From the law of baryogenesis, the existence of a large number of yet undiscovered elementary particles follows.

6. From the law of baryogenesis, it follows that the symmetry between matter and antimatter in the universe is not violated.

7. The problem of baryon asymmetry needs to be addressed independently of the symmetry or asymmetry of matter and antimatter.

8. The law of baryogenesis unveils the mystery behind the origin of dimensionless fundamental constants of elementary particles. It unifies three dimensionless constants of elementary particles: the ratio of particle mass to electron mass, the ratio of mass defect to electron mass, and the magic number.

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