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The Cyclic Universes Model Based on the Split Division Algebras

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Abstract

The proposed cyclic universes model based on the split division algebras accounts for the inflation, the Big Bang, gravity, dark energy, dark matter, the standard model, and the masses of all elementary particles. The split algebras (complex quaternion and complex octonion) as the Furey model generate the fixed spacetime dimension number for the observable universe with the fixed 4-dimensional spacetime (4D) standard model particles and the oscillating spacetime dimension number for the oscillating universes (hidden or dark energy) with the oscillation between 11D and 11D through 10D and between 10D and 10D through 4D. 11D has the lowest rest mass, the highest speed of light, and the highest vacuum energy, while 4D has the highest rest mass, the lowest (observed) speed of light, and zero vacuum energy. In the cyclic universes model, the universes start with the positive-energy and the negative-energy 11D membrane-antimembrane dual universes from the zero-energy inter-universal void, and are followed by the transformation of the 11D membrane-antimembrane dual universes into the 10D string-antistring dual universes and the external dual gravities as in the Randall-Sundrum model, resulting in the four equal and separate universes consisting of the positive-energy 10D universe, the positive-energy external gravity, the negative-energy 10D universe, and the negative-energy external gravity. Under the fixed spacetime dimension number, the positive-energy 10D universe is transformed into 4D standard model particles through the inflation and the Big Bang. Dark matter is the right-handed neutrino, exactly five times of baryonic matter in total mass in the universe. Under the oscillating spacetime dimension number, the other three universes oscillate between 10D and 10D through 4D, resulting in the hidden universes when D > 4 and dark energy (the maximum dark energy = 3/4 = 75%) when D = 4. Eventually, all four universes return to the 10D universes.

Keywords

Cyclic Universes Model, Division Algebras, Furey, Complex Quaternion,

Complex Octonion, Dark Energy, Dark Matter, Standard Model, Gravity

1. Introduction

Cosmology explains the origin, evolution and ultimate fate of the entire universe [1]. Ultimately, cosmology must be able to account for the well-established phenomena, such as the inflation, the Big Bang, gravity, dark energy, dark matter, baryonic matter, the standard model particles (leptons, quarks, gauge bosons, and the Higgs boson), and the masses of all elementary particles. The standard model [2] classifies all known elementary particles, and describes the electromagnetic, weak, and strong interactions, and not including the gravitational force. On the deeper level of understanding, cosmology must explain the relation between spacetime and internal symmetry and the relation between the four dimensional spacetime and the higher dimensional spacetime.

The conventional cosmology based on supersymmetry (superstring theory and M-theory) [3] [4] has not clearly accounted for the well-established phenomena. In the conventional cosmology, 11 dimensional spacetime (11D) and 10 dimensional spacetime (10D) produce many possible models for internal symmetry, unlike the simple internal symmetry in the standard model. In the conventional cosmology, 4D is derived from the compactification of 10D with many possible ways for the compactification. This paper proposes the cyclic universes model based on the split division algebras to account for all well-established phenomena, the simple relation between 4D and the internal symmetry in the standard model for the observable universe, and the oscillating dimension number among different spacetime dimensions for the reversible cyclic universes model. The split division algebras are the Furey model [5] [6] [7] where the division algebras are split into complex quaternion and complex octonion. This paper proposes that the split division algebras produce the fixed spacetime dimension number and the oscillating spacetime dimension number. Under the fixed spacetime dimension number, the combination of 4D derived from complex quaternion and the standard model particles derived from complex octonion generates the fixed 4D standard model particle to account for the observable universe. Under the oscillating spacetime dimension number [8], the combination of 4D particle derived from complex quaternion and 10D string and 11D membrane derived from complex octonion through Lie superalgebra [9] [10] [11] generates the oscillating spacetime dimension number between 11D membrane and 11D membrane through 10D string and between 10D particle and 10D particle through 4D particle to account for the oscillating universes as hidden or dark energy [12] [13]. 11D has the lowest rest mass, the highest speed of light, and the highest vacuum energy, while 4D has the highest rest mass, the lowest (observed) speed of light, and zero vacuum energy.

In the cyclic universes model [12] [13], the origin of the cyclic universes is the

zero-energy inter-universal void. The universes start with the positive-energy and the negative-energy 11D membrane-antimembrane dual universes from the zero-energy inter-universal void, and are followed by the transformation of the 11D membrane-antimembrane dual universes into the 10D string-antistring dual universes and the external dual gravities as in the Randall-Sundrum model [14] [15], resulting in the four equal and separate universes consisting of the positive-energy 10D universe, the negative-energy 10D universe, the positive-energy external gravity, and the negative-energy external gravity. Under the fixed spacetime dimension number, the positive-energy 10D universe is transformed into 4D standard model particles through the inflation and the Big Bang. Dark matter is the right-handed neutrino, exactly five times of baryonic matter in mass in the universe. Under the oscillating spacetime dimension number, the other three universes oscillate between 10D and 10D through 4D, resulting in the hidden universes when D > 4 and dark energy (the maximum dark energy = 3/4 = 75%) when D = 4. Eventually, all four universes return to the 10D universes.

The proposed cyclic universes model based on the split division algebras accounts for the inflation, the Big Bang, gravity, dark energy, dark matter, the standard model, and the masses of all elementary particles. Section 2 describes the split division algebras. Section 3 describes the space structure in terms attachment space and detachment space. Section 4 describes the seven-step cyclic universes model.

2. The Split Division Algebras

Division algebras [16] are four normed division algebras including the reals (**R**), complex numbers (**C**), quaternions (**H**), and octonions (**O**) which are the only kinds of numbers that can be added, subtracted, multiplied and divided. Physically, real numbers appear in all places, complex numbers provide the mathematics of quantum mechanics, and quaternions triggers special theory of relativity in four dimensional spacetime.

In the Furey model [5] [6] [7], Cohl Furey splits the four normed division algebras $\mathbf{R}\otimes\mathbf{C}\otimes\mathbf{H}\otimes\mathbf{O}$ into complex quaternion $\mathbf{C}\otimes\mathbf{H}$ and complex octonion $\mathbf{C}\otimes\mathbf{O}$. $\mathbf{C}\otimes\mathbf{H}$ is written $a+b\mathbf{i}+c\mathbf{j}+d\mathbf{k}$ where $a, b, c, d \in \mathbf{C}$. $\mathbf{i}, \mathbf{j}, \mathbf{k}$ follow the non-commutative quaternionic multiplication rules. For $\mathbf{C}\otimes\mathbf{O}$,

$$\begin{aligned} A &= A_0e_0 + A_1e_1 + A_2e_2 + A_3e_3 + A_4e_4 + A_5e_5 + A_6e_6 + A_7e_7 \\ &= A_0e_0 + \sum_{n=1}^{7} A_ne_n \qquad (n = 1, 2, \cdots, 7) \end{aligned} \tag{1}$$

where the $A_n \in \mathbf{C}$, e_n are octonionic imaginary units, and the octet (e_0, e_1, e_2, e_3, e_4, e_5, e_6, e_7) is known as the eight dimensional octonion basis.

The split division algebras produce the fixed spacetime dimension number to account for the observable universe and the oscillating spacetime dimension number to account for the reversible cyclic expansion-contraction universes.

2.1. The Fixed Spacetime Dimension Number

Under the fixed spacetime dimension number [5] [6] [7], complex quaternion

generates the complex Clifford algebra $C\ell(2)$ to produce Lorentz transformations (scalars, spinors, 4-vectors, and field strength tensors) in four dimensional spacetime. Complex octonion generates the complex Clifford algebra $C\ell(6)$ with 64 dimensions. This 64 complex dimensional Clifford algebra produces exactly the three generations of the particles and their interactions in the standard model. Under the fixed spacetime dimension number, complex quaternion generates 4D for Lorentz transformations, while complex octonion generates the standard model particles, resulting in the fixed 4D standard model particles.

2.2. The Oscillating Spacetime Dimension Number

Under the oscillating spacetime dimension number, complex octonion from the split division algebras is transformed into 10D string and 11D membrane through Lie 2-superalgebra and Lie 3-superalgebra, respectively [9] [10] [11], so the split division algebras contain 4D particle from complex quaternion and 10D string, and 11D membrane from complex octonion. Under oscillating spacetime dimension number, the split division algebras generate the oscillating spacetime dimension number between 11D membrane and 11D membrane through 10D string and between 10D particle and 10D particle through 4D particle as described in the previous papers [13] [14]. Because membrane and string require 11D and 10D, respectively, any spacetime dimension below 10D has to be the spacetime dimension for particle which allows any spacetime dimension numbers.

The Membrane-String Oscillation between 11D4d and 11D4d through 10D4d

In the membrane-string oscillation, the 11D brane is transformed into the 10D string with an extra dimension. This 11D warped brane world in the 10D string with compact extra dimension is analogous to the 5D warped brane world in our 4D universe with compact extra dimension in the Randall–Sundrum model [13] [14]. The RS1 of the Randall-Sundrum model produces the two different branes consisting of the Tevbrane and the Planckbrane. The Planckbrane has very strong gravity, while the Tevbrane has all other forces and extremely weak gravity. There are boundaries between the Tevbrane and the Planckbrane. The Tevbrane corresponds to our universe with extremely weak gravity comparing with other forces. Almost all gravity is external gravity outside of our universe. The Randall-Sundrum model explains the hierarchy problem between gravity and other forces.

In the same way as the RS1 in the Randall-Sundrum model, two 11D membranes produce the 10D string corresponding to the Tevbrane and the external gravity corresponding to the Planckbrane. The 11D membrane, the 10D string, and the external gravity have about the same energy. The 10D string has the extremely weak internal gravity as in the Tevbrane with an extremely weak gravity in the Randall-Sumdrum model.

$$\begin{aligned}&\text{The RS1 in the Randall-Sundrum model}\\&\text{5D brane world} \xrightarrow{\text{compact extra space dimension}} \text{Tevbrane} + \text{Planckbrane}\\&\text{two 11D membranes} \xrightarrow{\text{from 11D membrane to 10D string}} \text{10D string} + \text{external gravity}\end{aligned} \tag{2}$$

The membrane-string oscillation is reversible, so the 10D string and the external gravity can also reverse back to the 11D membrane.

The Particle Oscillation between 10D and 10D through 4D

The particle oscillation between 10D and 10D through 4D involves mass dimension (denoted as d) to represent the mass. In the initial condition for the particle oscillation, D + d = 14 where D and d are between 4 and 10. For an example, a dimension has a dual spacetime-mass dimension numbers of 10D4d or 4D10d. The transformations for oscillating dimension number between 10D and 4D consist of the varying speed of light dimensional (VSLD) transformation for spacetime dimension D and the varying supersymmetry dimensional (VSD) transformation for mass dimension d. In the VSLD transformation for D, the speed of light increases with increasing D as follows.

$$\begin{aligned} c_{\mathrm{D}} &= c/\alpha^{\mathrm{D}-4}, \\ c_{\mathrm{D}} &= c_{\mathrm{D}-n}/\alpha^{2n}, \end{aligned} \tag{3}$$

where c_D is the speed of light in spacetime dimension number, D, from 4 to 10, c is the observed speed of light in the 4D spacetime, α is the fine structure constant for electromagnetism, and n is an integer. Consequently, rest mass M_0 in special relativity decreases with increasing D as follows.

$$\begin{aligned} E &= M_0 c_D^2 = M_0 \cdot \left(c^2/\alpha^{2(\mathrm{D}-4)}\right) \\ M_{0,\mathrm{D}} &= M_{0,\mathrm{D}-n}\alpha^{2n}, \end{aligned} \tag{4}$$

For an example, according to the calculation from Equation (4), the rest mass of 4D10d is $1/\alpha^{12} \approx 137^{12}$ times of the mass of 10D4d. In terms of rest mass, 10D 4d has the lowest rest mass, and 4D10d has the highest rest mass. (11D4d membrane and 10D4d string have the same rest mass.)

The decrease in rest mass means the increase in vacuum energy, so for zero vacuum energy at 4D, the vacuum energy is as follows.

$$E_{vacuum,D} = M_{0,4}C^2 - M_{0,\mathrm{D}}C^2 \tag{5}$$

Therefore, 10D4d has the highest speed of light, the lowest rest mass, and the highest vacuum energy, while 4D10d has the lowest (observed) speed of light, the highest rest mass, and zero vacuum energy.

Since the speed of light increases with increasing spacetime dimension number, and the speed of light for >4D particle is greater than the speed of light for 4D particle, the observation of >4D superluminal particles by 4D particles violates casualty. Thus, >4D particles are hidden particles with respect to 4D particles. Particles with different spacetime dimensions are transparent and oblivious to one another, and separate from one another if possible.

In the normal supersymmetry transformation, the repeated application of the fermion-boson supersymmetry transformation carries over a boson (or fermion) from one point to the same boson (or fermion) at another point at the same mass, resulting in translation without changing mass. Under the varying supersymmetry dimensional (VSD) transformation, the repeated application of the

fermion-boson supersymmetry transformation carries over a boson from one point to the boson at another point at different mass dimension number at different mass, resulting in translation and fractionalization or condensation. The repeated VSD transformation carries over a boson B_d into a fermion F_d and a fermion F_d to a boson B_{d-1}, which can be expressed as follows.

$$M_{d,F} = M_{d,B}\alpha_{d,B}, \tag{6}$$

$$M_{d-1,B} = M_{d,F}\alpha_{d,F}, \tag{7}$$

where $M_{d,B}$ and $M_{d,F}$ are the masses for a boson and a fermion, respectively, d is the mass dimension number, and $\alpha_{d,B}$ or $\alpha_{d,F}$ is the fine structure constant that is the ratio between the masses of a boson and its fermionic partner. where $M_{d,B}$ and $M_{d,F}$ are the masses for a boson and a fermion, respectively, d is the mass dimension number, and $\alpha_{d,B}$ or $\alpha_{d,F}$ is the fine structure constant that is the ratio between the masses of a boson and its fermionic partner. Assuming α's are the same, it can be expressed as

$$M_{d,B} = M_{d+1,B}\alpha_{d+1}^2. \tag{8}$$

The VSD transformation involves the translation and fractionalization from d to d − 1 or condensation from d to d + 1 at the same D. The translation and fractionalization-condensation account for the cosmic expansion-contraction for the oscillating universes.

The oscillating dimension number transformation between 10D4d and 10D4d through 4D4d involves both the VSLD transformation and the VSD transformation as the stepwise two-step transformation as follows.

$$\begin{aligned} &\text{stepwise two-step varying transformation} \\ &(1)\quad \mathrm{D,d} \xleftrightarrow{\text{VSLD}} (\mathrm{D}\mp 1),(\mathrm{d}\pm 1) \\ &(2)\quad \mathrm{D,d} \xleftrightarrow{\text{VSD}} \mathrm{D},(\mathrm{d}\pm 1) \end{aligned} \tag{9}$$

The repetitive stepwise two-step dimension number oscillation between 10D4d and 10D4d through 4D4d as follows.

$$\begin{aligned} 10\mathrm{D4d} &\to 9\mathrm{D5d} \to 9\mathrm{D4d} \to 8\mathrm{D5d} \to 8\mathrm{D4d} \to 7\mathrm{D5d} \to 7\mathrm{D4d} \\ &\to 6\mathrm{D5d} \to 6\mathrm{D4d} \to 5\mathrm{D5d} \to 5\mathrm{D4d} \to 4\mathrm{D5d} \to 4\mathrm{D4d} \\ &\to 5\mathrm{D4d} \to 5\mathrm{D5d} \to 6\mathrm{D4d} \to 6\mathrm{D5d} \to 7\mathrm{D4d} \to 7\mathrm{D5d} \\ &\to 8\mathrm{D4d} \to 8\mathrm{D5d} \to 9\mathrm{D4d} \to 9\mathrm{D5d} \to 10\mathrm{D4d} \end{aligned} \tag{10}$$

As described previously [12] [13], the particle oscillation between 10D4d and 10D4d through 4D4d results in the reversible cyclic expansion-contraction of the universe.

In summary, under the fixed spacetime dimension number, the combination of 4D derived from complex quaternion and the standard model particles derived from complex octonion generates the fixed 4D standard model particle to account for the observable universe. Under the oscillating spacetime dimension number, the combination of 4D particle derived from complex quaternion and 10D string and 11D membrane derived from complex octonion through Lie superalgebra generates the oscillating spacetime dimension number between 11D

membrane and 11D membrane through 10D string and between 10D particle and 10D particle through 4D particle to account for the reversible cyclic expansion-contraction universes.

3. The Space Structure

As described in the previous papers [12] [13], in the space structure, attachment space attaches matter to a fixed space permanently or reversibly, while detachment space detaches matter from a fixed space at the speed of light. Attachment space and detachment deal with rest (rest mass) and movement (kinetic energy). They involve the Higgs field and the reverse Higgs field and the three spaces.

3.1. The Higgs Field and the Reverse Higgs Field

Attachment space is the permanent source of the transitional Higgs field which transforms a moving massless particle into a resting massive particle. Attachment space is active to react with matter. The reaction of permanent attachment space with a moving massless particle produces the transitional Higgs field-particle composite, resulting in spontaneous symmetry breaking. Upon spontaneous symmetry restoring, the transitional Higgs field-particle composite is converted into massive particle with the longitudinal component on zero-energy attachment space without the Higgs field as follows.

$$\begin{aligned}&\text{massless particle} + \text{attachment space} \xrightarrow{\text{spontaneous symmetry breaking}} \\ &\left[\text{the transitional Higgs field-particle composite}\right] \xrightarrow{\text{spontaneous symmetry restoring}} \\ &\text{massive particle with the longitudinal component on attachment} \\ &\text{space without the Higgs boson}\end{aligned} \tag{11}$$

The transitional Higgs field model avoids the cosmological problem in the permanent nonzero-energy Higgs field which has the huge gravitational effect [17].

Detachment space is the permanent source of the transitional reverse Higgs field which transforms a resting massive particle into a moving massless particle. Detachment space is active to react with matter. The reaction of permanent detachment space with a resting massive particle produces the transitional reverse Higgs field-particle composite, resulting in spontaneous symmetry breaking. Upon spontaneous symmetry restoring, the transitional reverse Higgs field-particle composite is converted into massless particle without the longitudinal component on detachment space without the reverse Higgs field as follows.

$$\begin{aligned}&\text{massive particle} + \text{detachment space} \xrightarrow{\text{spontaneous symmetry breaking}} \\ &\left[\text{the transitional reverse Higgs field-particle composite}\right] \\ &\xrightarrow{\text{spontaneous symmetry restoring}} \text{massless particle without the longitudinal} \\ &\text{component on detachment space without the reverse Higgs boson}\end{aligned} \tag{12}$$

Without spontaneous symmetry restoring, the Higgs boson emerges as follows.

$$\begin{aligned}&\text{massless particle} + \text{attachment space} \xrightarrow{\text{spontaneous symmetry breaking}} \\ &\left[\text{the transitional Higgs field-particle composite}\right] \\ &\xrightarrow{\text{no spontaneous symmetry restoring}} \text{massless particle with the Higgs boson}\end{aligned} \tag{13}$$

3.2. The Three Spaces

The combination of n units of attachment space as 1 and n units of detachment space as 0 brings about three different spaces: binary partition space, miscible space, or binary lattice space as below.

$$\begin{aligned}&(1)_n \quad + \quad (0)_n \quad \xrightarrow{\text{combination}} \\ &\text{attachment space} \quad \text{detachment space} \\ &(1)_n(0)_n, \quad (1+0)_n, \quad \text{or} \quad (1\,0)_n \\ &\text{binary partition space,} \quad \text{miscible space,} \quad \text{binary lattice space}\end{aligned} \tag{14}$$

Binary partition space, $(1)_n(0)_n$, consists of two separated continuous phases of multiple quantized units of attachment space and detachment space, and it is the space structure for wave-particle duality in quantum mechanics. In miscible space, $(1 + 0)_n$, attachment space is miscible to detachment space, and there is no separation of attachment space and detachment space, and it is the space structure for miscible mass-energy in relativity. Binary lattice space, $(10)_n$, consists of repetitive units of alternative attachment space and detachment space, and it is the space structure for virtual particles in quantum field theory.

An object in binary partition space $(1)_n(0)_n$ has both movement and rest at the same time, resulting in wave-particle duality for movement-rest duality in quantum mechanics. An object in binary partition space cannot be completely at movement (zero momentum) or completely at rest (zero distance), resulting in the uncertainty principle as follows.

$$\sigma_x \sigma_p \geq \frac{\hbar}{2} \tag{15}$$

where x is position and p is momentum. The interference to binary partition space collapses binary partition space, resulting in miscible space as follows.

$$\begin{aligned}&(0)_n(0)_n \quad \xrightarrow{\text{collapse}} \quad (0+1)_n \\ &\text{binary partition space} \qquad \text{miscible space}\end{aligned} \tag{16}$$

In miscible space, attachment space is miscible to detachment space, resulting in miscible mass and energy where attachment space for mass provides zero speed for rest mass m_0, while detachment space for energy provides the speed of light for kinetic energy. The total energy is the combination of both as follows.

$$E = K + m_0c^2 = \gamma m_0 c^2 \tag{17}$$

where $\gamma = 1/\left(1 - v^2/c^2\right)^{1/2}$ is the Lorentz factor for time dilation, m_0 is rest mass, E is the total energy, and K is the kinetic energy. Binary lattice space, $(10)_n$ is the space structure for virtual particles in quantum field theory which will be described in the next section.

4. The Cyclic Universes Model

The seven steps in the cyclic universes model are 1) the formation of positive-energy and negative-energy dual 11D4d membrane-antimembrane universes from the zero-energy inter-universal void, 2) the transformation of the 11D4d membrane-antimembrane dual universes to the 10D4d string-antistring dual universes and dual external dual gravities, 3) the transformation from the string-antistring dual universes to the particle-antiparticle dual universes, 4) the transformation of the positive-energy 10D4d universe into the positive-energy 4D universe, and the transformation of the other three universes into the hidden oscillating dimension number universes from 10D to 5D, 5) the transformation of all four universes into the 4D universes, 6) the positive-energy 4D universe and the three hidden oscillating dimension number from 5D to 10D, and (7) the return to the 10D4d particle-antiparticle universes (the step 3) as in Figure 1 and Figure 2.

1) The formation of the positive-negative-energy 11D4d membrane-antimembrane dual universes

In the cyclic universes model, the universes start with the positive-energy

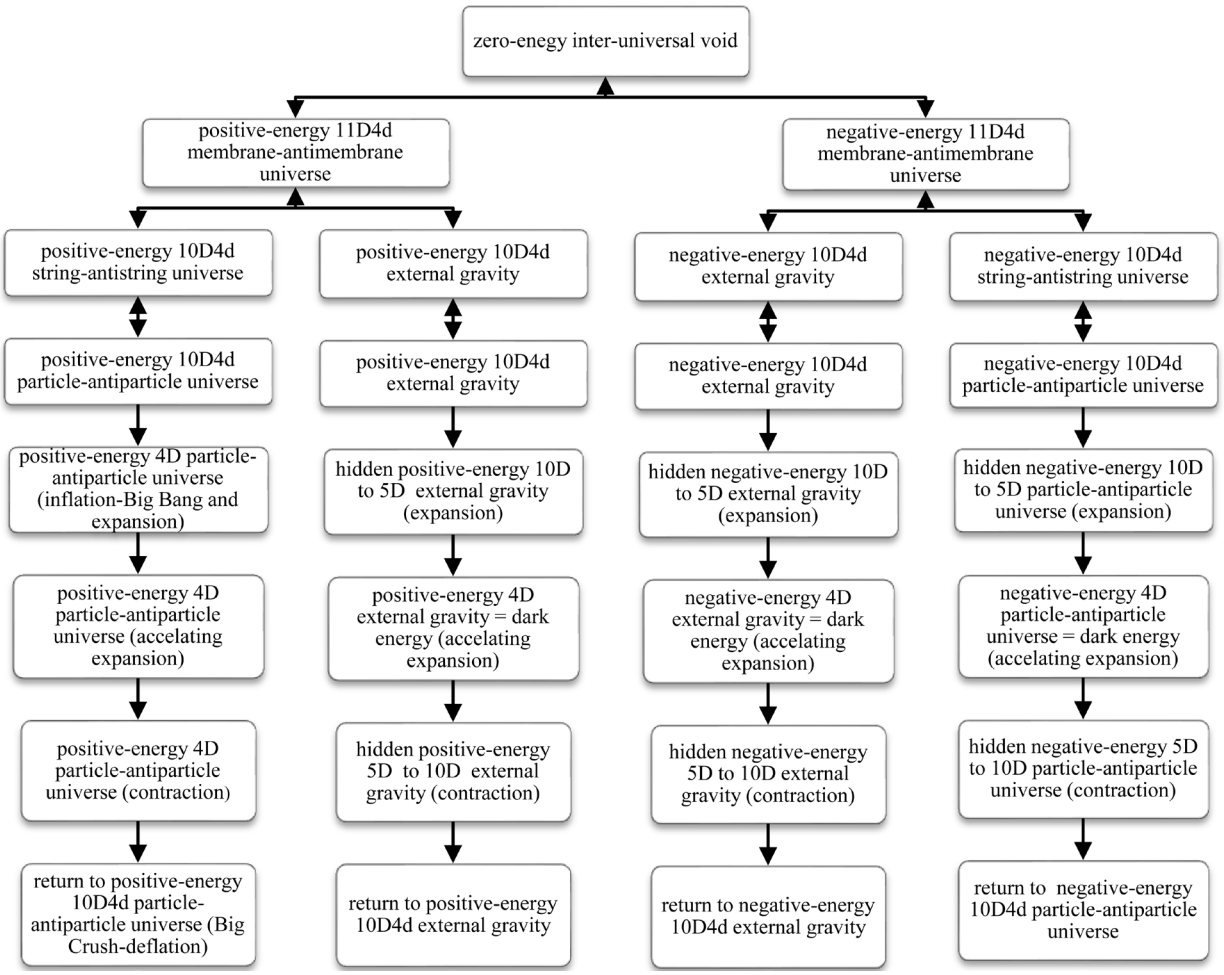

Figure 1. The cyclic universes model.

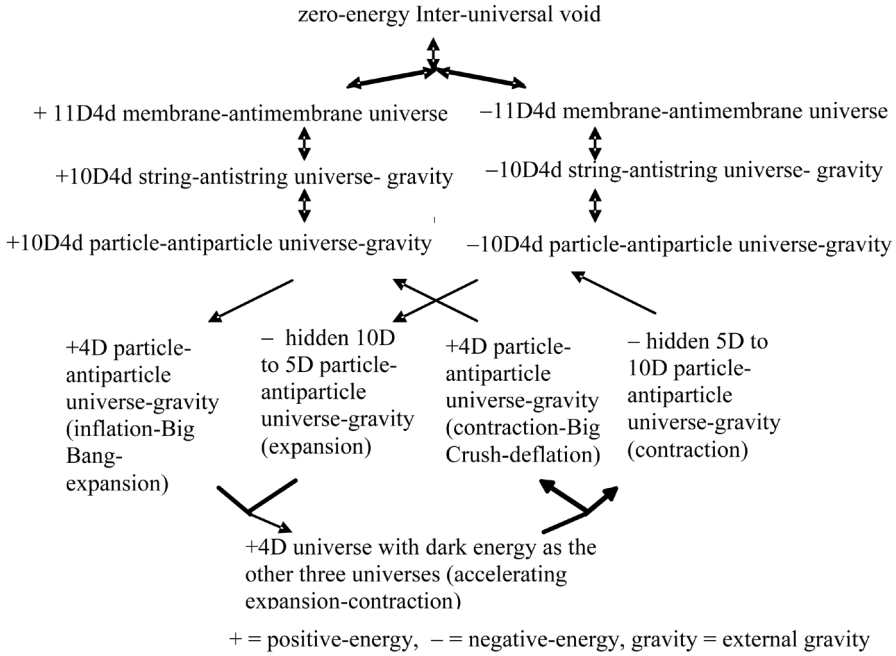

Figure 2. The cyclic universes model.

11D4d membrane-antimembrane universe and the negative-energy 11D4d membrane-antimembrane universe derived from the zero-energy inter-universal void. The energy sum of the dual universes is zero. The zero-energy inter-universal void and the dual universe are reversible, so the dual universe can reverse back to the zero-energy inter-universal void. The inter-universal void contains only detachment space to prevent irreversible inter-universal collision, while the dual universes contain only attachment space without kinetic energy. In terms of the split division algebras, these 11D dual universes are the universes with the oscillating spacetime dimension number, and start the process of oscillation between 11D and 11D through 10D and between 10D and 10D through 4D.

2) The transformation of the 11D4d membrane-antimembrane dual universes to the 10D4d string-antistring dual universes and dual external gravities

As described in Section 2.2 and the previous papers [12] [13], the transformation of the 11D membrane produces the 10D string and the external gravity. The results are the positive-energy 10D4d string-antistring universe, the positive-energy external gravity, the negative-energy 10D4d string-antistring universe, and the negative-energy external gravity. These four universes are separate, and have equal energy. The 10D4d string-external gravity and the 11D4d membrane are reversible.

3) The transformation from the string-antistring dual universes to the particle-antiparticle dual universes

Since string exists only in 10D, so any further transformation of D to lower than 10 cannot be string. As a result, to transform lower than 10, string-antistring is converted into particle-antiparticle. The results are the positive-energy 10D4d particle-antiparticle universe, the positive-energy 10D4d external gravity, the

negative-energy 10D4d particle-antiparticle universe, and the negative-energy 10D4d external gravity. Particle-antiparticle and string-antistring are reversible.

4) The transformation of the positive-energy 10D4d particle-antiparticle universe into the positive-energy 4D universe, and the transformation of other three universes into the hidden oscillating dimension number universes from 10D to 5D

The positive-energy 10D particle-antiparticle universe is transformed into the positive-energy 4D universe under the fixed spacetime dimension number in the split division algebras to produce the 4D standard model particles as described in Section 2.1. Under the oscillating spacetime dimension number, the negative-energy 10D particle-antiparticle, the positive-energy external gravity, and the negative-energy external gravity are transformed into the hidden oscillating dimension number universes from 10D to 5D.

4a) The formation of the positive-energy 4D particle-antiparticle universe

The formation of the positive-energy 4D particle-antiparticle universe includes the inflation and followed by the Big Bang. The inflation involves the VSLD transformation from 10D4d to 4D10d, because from Equation (4), the rest mass M_0 of 4D10d is $M_{0,10} = M_{0,4} / \alpha^{2(10-4)} \approx 137^{12}$ times of the rest mass of 10D4d, resulting in the inflation for the rapid expansion.

The Big Bang involves the entrance of detachment space from the inter-universal void to the positive-energy universe. Detachment space introduces massless particles and kinetic energy for the cosmic expansion, and forms the three spaces with attachment space. The Big Bang consists of the two steps. In the first step, all particles are converted into massless particles by detachment space for the reverse Higgs field as in Equation (12). The second step involves the partial conversion of massless particles into massive particles by attachment space for the Higgs field to produce massless particles, massive particles, and the Higgs boson as in Equations (11) and (13) for the standard model. The emergence of detachment space starts kinetic energy which causes the cosmic expansion.

$$\begin{aligned} &\text{the inflation and the Big Bang}\left(\text{detachment space+partial attachment space}\right) \\ &10\text{D4d} \xrightarrow{\text{the inflation}} 4\text{D10d} \xrightarrow{\text{detachment space(reverse Higgs field)}} \text{massless particles} \\ &\xrightarrow{\text{partial attachment space(Higgs field)}} \text{massive particles, massless particles, Higgs boson} \end{aligned} \quad (18)$$

As described in Section 3.2, the space structure with both attachment space and detachment produces binary partition space (1)n(0)n for wave-particle duality in quantum mechanics, miscible space (1 + 0)n for miscible mass-energy in relativity, and binary lattice space (10)n for virtual particles in quantum field theory. Binary lattice space is derived from the slicing of mass dimensions by detachment space. 4D10d particles emerge after the inflation. 10d mass dimension is sliced by detachment space into 9d, 8d, 7d, 6d, 5d, and 4d plus the binary lattice space (10)n for virtual particles in quantum field theory. For an example, the slicing of 10d particle into 4d particle is as follows.

$$1_{10} \xrightarrow{\text{slicing}} 1_4 \quad \sum_{d=5}^{10} (0_4\, 1_4)_{n,d} \tag{19}$$

10d particle — 4d core particle — binary lattice space

where 1 is attachment space, 0 is detachment space, 1_{10} is 10d particle, 1_4 is 4d particle, d is the mass dimension number of the dimension to be sliced, n as the number of slices for each dimension, and $(0_4 1_4)_n$ is binary lattice space with repetitive units of alternative 4d attachment space and 4d detachment space. For 4d particle starting from 10d particle, the mass dimension number of the dimension to be sliced is from d = 5 to d = 10. Each mass dimension is sliced into infinite quantized units (n = ∞) of binary lattice space, $(0_4 1_4)_\infty$. For 4d particle, the 4d core particle is surrounded by 6 types (from d = 5 to d = 10) of infinite quantized units of binary lattice space. Such infinite quantized units of binary lattice space represent the infinite units (n = ∞) of separate virtual orbitals for virtual particles in a gauge force field, while the dimension to be sliced is "mass dimensional orbital" (DO), representing a type of gauge force field. In addition to the six DO's for gauge force fields from d = 5 to d = 10, the weak internal gravity appears as the seventh DO at d = 11. As a result, there are seven mass dimensional orbitals as in **Figure 3**.

The seven dimensional orbitals are the base for the periodic table of elementary particles [18] [19] to produce the standard model particles and the internal gravity. For examples, electromagnetism, electron, and the internal gravity are at d = 5, 6, and 11, respectively. The periodic table of elementary particles calculates accurately the particle masses of all leptons, quarks, gauge bosons, the Higgs boson, and the cosmic rays by using only five known constants: the number (seven) of the extra spatial dimensions in the eleven-dimensional membrane, the mass of electron, the masses of Z and W bosons, and the fine structure constant [19]. The calculated masses are in excellent agreements with the observed masses. For examples, the calculated masses of muon, top quark, pion, neutron, and the Higgs boson are 105.55 MeV, 175.4 GeV, 139.54 MeV, 939.43 MeV, and 126 GeV, respectively, in excellent agreements with the observed 105.65 MeV, 172.4 GeV, 139.57 MeV, 939.27 MeV, and 126 GeV, respectively.

10d particle was sliced into six different particles: 9d, 8d, 7d, 6d, 5d, and 4d equally by mass. Baryonic matter is 4d, while dark matter consists of the other five types of particles (9d, 8d, 7d, 6d, and 5d). The mass ratio of dark matter to baryonic matter is 5 to 1. At 72.8% dark energy, the calculated values [20] for baryonic matter and dark matter (with the 1:5 ratio) are 4.53% (= (100 - 72.8)/6) and 22.7% (=4.53 × 5), respectively, in excellent agreement with observed 4.56% and 22.7%, respectively [21]. In terms of the standard model, dark matter is considered as the right-handed neutrino [22] [23] in contrast to the left-handed

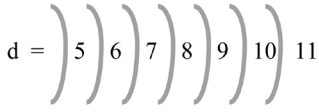

Figure 3. The seven mass dimensions as mass dimensional orbitals.

nearly massless neutrino in baryonic matter. Dark matter as the right-handed neutrino does not undergo any interactions in the standard model [2], and they have only gravity.

The emergence of detachment space brings about the dimensional orbitals which become the base for the standard model particles that have the internal symmetry, so detachment space brings about the internal symmetry. Therefore, in terms of the split division algebras, the emergence of detachment space in the positive-energy 10D4d particle-antiparticle universe with the oscillating space-time dimension number generates the positive-energy 4D particle-antiparticle universe with the fixed spacetime dimension number and the internal symmetry.

4b) The formation of the hidden oscillating dimension number universes from 10D to 5D

The negative-energy 10D particle-antiparticle, the positive-energy external gravity, and the negative-energy external gravity are transformed into the hidden oscillating dimension number universes from 10D to 5D.

$$\begin{aligned} 10D4d \to 9D5d \to 9D4d \to 8D5d \to 8D4d \to 7D5d \\ \to 7D4d \to 6D5d \to 6D4d \to 5D5d \to 5D4d \end{aligned} \tag{20}$$

From Equation (9), under the VSLD transformation and the VSD transformation, the three universes expand through the increasing rest mass and the translation-fractionalization from 10D4d to 5D4d. To the positive-energy 4D universe, the three universes from 10D to 5D are hidden, because as mentioned in Section 2.2, particles with different space-time dimensions and different speeds of light are transparent and oblivious to one another to avoid the violation of causality due to differences in the speed of light. During this time, the positive-energy 4D universe expands normally.

5) The transformation of all four universes into the 4D universes

When all four universes become 4D, the three other universes become dark energy as a part of the positive-energy 4D universe.

$$4D5d \to 4D4d \tag{21}$$

The result is the accelerating expansion. Since the other three universes have no detachment space to produce kinetic energy, dark energy is inert as the inert cosmological constant. According to the theoretical calculation based the algebras cosmology, dark energy started in 4.47 billion years ago [20] in agreement with the observed 4.71 ± 0.98 billion years ago [24]. The maximum dark energy is 75% for the three out of the four universes.

6) The positive-energy 4D universe and the three hidden oscillating dimension number universes from 5D to 10D

The three oscillating universes from 5D to 10D again become the hidden universes.

$$\begin{aligned} 5D4d \to 5D5d \to 6D4d \to 6D5d \to 7D4d \to 7D5d \\ \to 8D4d \to 8D5d \to 9D4d \to 9D5d \to 10D4d \end{aligned} \tag{22}$$

They contract by the decreasing rest mass and the translation-condensation. The positive-energy 4D universe contracts through gravity. Through symmetry,

all four universes contract synchronically and equally.

7) The return to the 10D4d particle-antiparticle universes (step 3)

Eventually, the oscillating universes return to the original 10D. The positive-energy 4D universe reaches the Big Crush to lose all detachment space to become 4D10d, and followed by the deflation to transform into 10D4d. The four universes return to the step 3.

$$\begin{aligned}&\text{In the positive-energy 4D universe}\\&4\text{D} + \text{various d's particles} \xrightarrow{\text{the Big Crush}} 4\text{D10d particles}\\&\xrightarrow{\text{the deflation}} 10\text{D4d particles}\\&\text{In the other three universes}\\&9\text{D5d particles} \xrightarrow{\text{VSLD}} 10\text{D4d particles}\end{aligned} \tag{23}$$

From the step 3, the universes can undergo another cycle of the particle-antiparticle universes, or can reverse to the step 2 for the string-antistring dual universes, to the step 1 for the membrane-antimembrane dual universes, and ultimately, to the zero-energy inter-universal void.

5. Summary and Conclusions

The cyclic universes model is based on the split division algebras as the Furey model consisting of complex quaternion and complex octonion to produce the fixed spacetime dimension number and the oscillating spacetime dimension number. Under the fixed spacetime dimension number, the combination of 4-dimensional spacetime (4D) derived from complex quaternion and the standard model particles derived from complex octonion generates the fixed 4D standard model particle to account for the observable universe. Under the oscillating spacetime dimension number, the combination of 4D particle derived from complex quaternion and 10D string and 11D membrane derived from complex octonion through Lie superalgebra generates the oscillating spacetime dimension number between 11D membrane and 11D membrane through 10D string and between 10D particle and 10D particle through 4D particle to account for the reversible cyclic expansion-contraction universes.

The particle oscillation between 10D and 10D through 4D involves mass dimension (denoted as d) to represent the mass. In the initial condition for the particle oscillation, D + d = 14 where D and d are between 4 and 10. For an example, a dimension has a dual spacetime-mass dimension numbers of 10D4d or 4D10d. Different dimensions have different speeds of light, rest masses, and vacuum energies. The transformations for oscillating dimension number between 10D and 4D consist of the varying speed of light dimensional (VSLD) transformation for spacetime dimension D and the varying supersymmetry dimensional (VSD) transformation for mass dimension d. 10D4d has the highest speed of light, the lowest rest mass, and the highest vacuum energy, while 4D10d has the lowest (observed) speed of light, the highest rest mass, and zero vacuum energy. Different universes with different Ds and the speeds of light are transparent (hidden) to one another. The oscillation between 10D and 10D through 4D pro-

vides the expansion and the contraction for the oscillating universes.

The space structure consists of attachment space to attach object at fixed space and detachment space to detach object from fixed space to account for rest mass and kinetic energy, respectively. Attachment space is the permanent source for the transitional Higgs field, while detachment space is the permanent source for the transitional reverse Higgs field. The three spaces from the combination of attachment space and detachment space are binary partition space for wave-particle in quantum mechanics, binary miscible space for miscible mass-energy in special relativity, and binary lattice space for virtual particles in quantum field theory.

In the cyclic universes, the universes start with the positive-energy and the negative-energy 11D4d membrane-antimembrane dual universes from the zero-energy inter-universal void, and are followed by the transformation of the 11D4d membrane-antimembrane dual universes into the 10D4d string-antistring dual universe and the external dual gravities as in the Randall-Sundrum model, resulting in the four equal and separate universes consisting of the positive-energy 10D4d string-antistring universe, the negative-energy 10D4d string-antistring universe, the positive-energy external gravity, and the negative-energy external gravity. The four universes have only attachment space, while the inter-universal void has only detachment space to prevent irreversible inter-universal collision. The string and string-antistring universes are converted into particle-antiparticle universes to be able to oscillate below 10D.

Under the fixed spacetime dimension number, the positive-energy 10D4d particle-antiparticle universe is transformed into 4D standard model particles. The immediate transformation from the low mass 10D4d to high mass 4D10d causes the inflation. The emergence of detachment space for kinetic energy in the positive-energy universe causes the Big Bang, the formation of the three spaces, the internal symmetry, and the periodic table of elementary particles for the standard model particles and gravity. The periodic table of elementary particles calculates accurately the particle masses of all leptons, quarks, gauge bosons, the Higgs boson, and the cosmic rays. Dark matter is the right-handed neutrino, exactly five times of baryonic matter in mass in the universe. Under the oscillating spacetime dimension number and without detachment space, the other three universes oscillate between 10D and 10D through 4D, resulting in the hidden universes when $D > 4$ and dark energy (the maximum dark energy = 3/4 = 75%) when $D = 4$. The four universes eventually return to the 10D4d universes through the Big Crush, the deflation, and the oscillating dimension number.

In conclusion, spacetime and internal symmetry are derived from division algebras, so division algebras are more fundamental than spacetime and internal symmetry. The emergence of detachment space in the positive-energy 10D4d particle-antiparticle universe brings about the internal symmetry and the fixed spacetime dimension number. Without detachment space, the three oscillating

universes have only spacetime without internal symmetry. Our observable universe has a fixed spacetime dimension number except dark energy from the oscillating universes when D = 4. The cyclic universes model based on the split division algebras accounts for the inflation, the Big Bang, gravity, dark energy, dark matter, the standard model, and the masses of all elementary particles.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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