# The Observed Higgs Boson as the Avatar Higgs Boson

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The observed Higgs boson at the LHC (Large Hadron Collider) is the Avatar Higgs boson as the dual SM (Standard Model) Higgs boson-forbidden lepton condensate. The SM Higgs boson is filled with the forbidden lepton condensate to become the Avatar Higgs boson. The forbidden lepton is outside of the SM three lepton families, so the single forbidden lepton cannot exist alone, and the forbidden lepton can exist only in the forbidden lepton condensate as the composite of forbidden lepton-antilepton. Unable to decay into the SM leptons and quarks, the forbidden lepton condensate decays into diphoton to account for the observed excess diphoton deviated from the Standard Model. Other decay modes of the Avatar Higgs boson follow the decay modes of the SM Higgs boson as observed. The calculated mass of the forbidden lepton condensate is 128.8 GeV in good agreements with the observed 125 or 126 GeV. The Higgs boson is the Goldstone boson in the Standard Model for the electroweak interaction. The transformation (spontaneous symmetry breaking) between massive particle and massless particle is through the massless scalar Goldstone boson. The addition of the Goldstone boson to a massless particle results in a massive particle. Near the beginning of our universe, the addition of the Goldstone boson converted some massless particles to massive particles to differentiate different forces and particles. During this process for the symmetry breaking in the electroweak force, the remnant of the Higgs boson acquired the mass of the forbidden lepton condensate to become the Avatar Higgs boson. In this paper, the space-object structures, cosmology, and the periodic table of elementary particles are described.

## 1. THE AVATAR HIGGS BOSON

At the LHC (Large Hadron Collider), the ATLAS and CMS experiments of CERN experiments observe a new particle in the mass region around 125-126 GeV with a high degree of certainty, and the decay modes and the spin of the new particle point to the Standard Model Higgs boson [1].

A deviation from the Standard Model is the excess decay rate to diphoton that was observed by both ATLAS and CMS as well as the Fermilab Tevatron [2]. The decay rate of diphoton is nearly twice (1.8 +/- .5 times the SM value) as large as expected by the Standard Model. The significance of the discrepancy with the Standard Model is about 2.5 sigma. Further experimental and analytical work on diphoton is needed.

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If the excess diphoton persists, it can be explained by the Avatar Higgs boson as the dual SM (Standard Model) Higgs boson-forbidden lepton condensate. The Avatar Higgs boson is the SM Higgs boson filled with the forbidden lepton condensate, similar to the top quark condensate [3] that is an alternative to the Higgs boson. The top quark condensate is a composite field composed of the top quark and its antiquark. The top quark condenses with its measured mass (173 GeV) comparable to the mass of the W and Z Bosons, so Vladimir Miransky, Masaharu Tanabashi, and Koichi Yamawaki proposed that the top quark condensate is responsible for the mass of the W and Z bosons. (As described later, the forbidden leptons derived by the W boson and Z boson are partly responsible to the high mass of top quark.) The top quark condensate is analogous to Cooper pairs in a BCS superconductor and nucleons in the Nambu-Jona-Lasinio model. Anna Hasenfratz and Peter Hasenfratz et al. claimed that the top quark condensate is approximately equivalent to a Higgs scalar field. S. F. King proposed a tau lepton condensate to feed the tau mass to muon and electron [4].

As described later in this paper, the forbidden leptons ($\mu'$, $\bar{\mu}'$, $\mu'^{+}$, and $\mu'^{-}$) are derived from the periodic table of elementary particles. Like the top quark condensate, the forbidden lepton condensate is a composite field composed of the forbidden leptons and its antileptons as $\mu'$, $\bar{\mu}'$, $\mu'^{+}$, and $\mu'^{-}$. Like that the observed top quark is a bare quark with the observed mass of about 173 GeV instead of about 346 GeV for $t\,\bar{t}$, the observed forbidden lepton is a bare average forbidden lepton instead of $\mu'\,\bar{\mu}'$ and $\mu'^{+}\,\mu'^{-}$. However, unlike the top quark condensate, the forbidden lepton condensate is outside of the standard three lepton-quark families in the Standard Model. Being forbidden, a single forbidden lepton cannot exist alone, so the forbidden leptons must exist in the lepton condensate as the composite of the leptons-antileptons as $\mu'$, $\bar{\mu}'$, $\mu'^{+}$, and $\mu'^{-}$. Being outside of the standard model family, the forbidden lepton condensate decays into diphoton instead of leptons and quarks inside the standard model family.

The Avatar Higgs boson is filled with the forbidden lepton condensate. The Avatar Higgs boson consists of both the Higgs boson of the Standard Model and the adopted forbidden lepton condensate. When the Avatar Higgs boson decays, it decays as the Higgs boson of the Standard Model except the part of the adopted forbidden lepton condensate that decays into diphoton, resulting in the deviation in the rate of diphoton from the standard model. Other decay modes of the Avatar Higgs boson follow the Standard Model (SM) as follows for the six decay modes of the Avatar Higgs bosons.

**The Decay Modes of the Avatar Higgs Boson**

H (forbidden lepton condensate) $\longrightarrow$ $\gamma\,\gamma$

H (SM) $\longrightarrow$ $\gamma\,\gamma$

H (SM) $\longrightarrow$ Z Z

H (SM) $\longrightarrow$ W W

H (SM) $\longrightarrow$ $b\,\bar{b}$

H (SM) $\longrightarrow$ $\tau\,\bar{\tau}$

As described later in the paper, the forbidden leptons are derived from the periodic table of elementary particles that includes all elementary particles. The calculated masses of the forbidden lepton are 120.7 GeV (for the mass of $\mu'^{\pm}$) and 136.9 GeV (for the mass of μ') in Eq. (41) with the average as 128.8 GeV for the forbidden lepton condensate in good agreements with the results from the LHC (125 GeV or 126 GeV). The Avatar Higgs boson acquires the mass of the forbidden lepton condensate.

The Higgs boson is the Goldstone boson in the Standard Model for the electroweak interaction. As described later, the transformation (spontaneous symmetry breaking) between massive particle and massless particle is through the massless scalar Goldstone boson. The addition of the Goldstone boson to massless particle results in massive particle, while the removal of removal of the Goldstone boson leads to massless particle.

$$massive\ particle \xleftarrow{+Goldstone\ Boson} massless\ particle$$

$$massive\ particle \xrightarrow{-Goldstone\ Boson} massless\ particle$$

The Goldstone boson provides the longitudinal degree of freedom for massive particle. The Goldstone boson itself is a virtual particle by taking energy from and returning energy to the vacuum. The Goldstone boson in the Standard Model for electroweak interaction is the Higgs boson. With zero mass-energy, the Higgs boson avoids the severe problem of the huge energy (cosmological constant) from the gravity-Higgs boson interaction.

Before our universe, all particles were massive, the masses of all particles were equal, and our pre-universe was cold. At the beginning of our universe, the removal of the Goldstone boson converted massive particles into massless particles, resulting in the very hot universe to initiate the Big Bang. Afterward, the addition of the Goldstone boson converted some massless particles back to massive particles to differentiate dark matter and baryonic matter and to differentiate baryonic particles with various different masses.

The observed Avatar Higgs boson is a remnant of the Higgs boson. The Avatar Higgs boson is derived from the asymmetry (symmetry breaking) in the electroweak force consisting of the electromagnetic force with the massless gauge boson (photon) and the weak force with the massive gauge bosons (W+, W−, and Z). Near the beginning of our universe, the coupling of the Higgs field and the electroweak force involved the four Higgs bosons and the four gauge bosons (W+, W−, Z, and photon) in the electroweak force. The three Higgs bosons coupled with the three massless weak bosons (W+, W−, and Z), and were only observable as spin components (longitudinal polarization) of these weak bosons, which became massive; while the one remaining un-coupled Higgs boson became the unused remnant of Higgs boson after the transformation of the electroweak force. The remnant of the Higgs boson could not acquire any mass that already represented an independent elementary particle. The only available mass came from the forbidden lepton in the form of the forbidden lepton condensate. The remnant of the Higgs boson acquired the mass of the forbidden lepton condensate to become the Avatar Higgs boson. The electroweak, strong, and gravitational forces are separated forces, so there is no remnant of the Higgs boson from them.

# 2. THE SPACE-OBJECT STRUCTURES

The unified theory of physics unifies various phenomena in our observable universe and other universes. The unified theory of physics is derived from the space-object structures [5] [6]. All universes are governed by the space-object structures. Different universes are the different expressions of the space-object structures.

## 2.1. The Space Structure

The space structure [7] [8] consists of attachment space (denoted as 1) and detachment space (denoted as 0). Attachment space attaches to object permanently with zero speed. Detachment space detaches from the object at the speed of light. Attachment space relates to rest mass, while detachment space relates to kinetic energy. Different stages of our universe have different space structures.

The transformation (spontaneous symmetry breaking) between mass (massive particle) in attachment space and kinetic energy (massless particle) in detachment space is through the massless scalar Goldstone boson. For example, massive particles with n units of attachment space, denoted as $(1)_n$, are converted into massless particles with n units of detachment space, denoted as $(0)_n$ through the Goldstone bosons. The addition of the Goldstone bosons to massless particles in detachment space results in massive particles in attachment space, while the removal of removal of the Goldstone bosons in attachment space leads to massless particles in detachment space.

$$\begin{array}{l} \textit{massive particles in } (1)_n \xleftarrow{+\textit{Goldstone Bosons}} \textit{massless particles in } (0)_n \\ \textit{massive particles in } (1)_n \xrightarrow{-\textit{Goldstone Bosons}} \textit{massless particles in } (0)_n \end{array} \qquad (1)$$

The Goldstone boson provides the longitudinal degree of freedom for massive particle in attachment space. The Goldstone boson itself is a virtual particle by taking energy from and returning energy to the vacuum. The Goldstone boson in the Standard Model for electroweak interaction is the Higgs boson. With zero mass-energy, the Higgs boson avoids the severe problem of the huge energy (cosmological constant) from the gravity-Higgs boson interaction. The observed Higgs boson at the LHC is a remnant of the Higgs boson with the acquired mass from the forbidden lepton condensate as described earlier.

Our universe has both attachment space and detachment space. Before our universe, all particles were massive, the masses of all particles were equal, and our pre-universe was cold. At the beginning of our universe, the removal of the Goldstone boson converted massive particles into massless particles, resulting in the very hot universe to initiate the Big Bang. Afterward, the addition of the Goldstone boson converted some massless particles back to massive particles.

The combination of attachment space (1) and detachment space (0) brings about three different space structures: miscible space, binary partition space, and binary lattice space for four-dimensional space-time as below.

$$(1)_n \ attachment\ space \ + \ (0)_n \ detachment\ space \xrightarrow{combination}$$
$$(1\ 0)_n \ binary\ lattice\ space,\ (1+0)_n \ miscible\ space,\ or\ (1)_n(0)_n \ binary\ partition\ space \quad (2)$$

Binary lattice space, $(1\ 0)_n$ , consists of repetitive units of alternative attachment space and detachment space. Thus, binary lattice space consists of multiple quantized units of attachment space separated from one another by detachment space. In miscible space, attachment space is miscible to detachment space, and there is no separation of attachment space and detachment space. Binary partition space, $(1)_n(0)_n$, consists of separated continuous phases of attachment space and detachment space.

Binary lattice space consists of multiple quantized units of attachment space separated from one another by detachment space. An object exists in multiple quantum states separated from one another by detachment space. Binary lattice space is the space for wavefunction. In wavefunction,

$$|\Psi\rangle = \sum_{i=1}^{n} c_i |\phi_i\rangle \quad , \quad (3)$$

Each individual basis element, $|\phi_i\rangle$, attaches to attachment space, and separates from the adjacent basis element by detachment space. Detachment space detaches from object. Binary lattice space with n units of four-dimensional, $(0\ 1)_n$, contains n units of basis elements.

Neither attachment space nor detachment space is zero in binary lattice space. The measurement in the uncertainty principle in quantum mechanics is essentially the measurement of attachment space and momentum in binary lattice space: large momentum has small non-zero attachment space, while large attachment space has low non-zero momentum. In binary lattice space, an entity is both in constant motions as wave for detachment space and in stationary state as a particle for attachment space, resulting in the wave-particle duality.

Detachment space contains no object that carries information. Without information, detachment space is outside of the realm of causality. Without causality, distance (space) and time do not matter to detachment space, resulting in non-localizable and non-countable space-time. The requirement for the system (binary lattice space) containing non-localizable and non-countable detachment space is the absence of net information by any change in the space-time of detachment space. All changes have to be coordinated to result in zero net information. This coordinated non-localized binary lattice space corresponds to nilpotent space. All changes in energy, momentum, mass, time, space have to result in zero as defined by the generalized nilpotent Dirac equation by B. M. Diaz and P. Rowlands [9].

$$(\mp \mathbf{k}\partial/\partial t \pm \mathbf{i}\nabla + \mathbf{j}m)(\pm i\mathbf{k}E \pm \mathbf{i}\mathbf{p} + \mathbf{j}m)\exp i(-Et + \mathbf{p.r}) = 0 \quad , \quad (4)$$

where E, **p**, m, t and **r** are respectively energy, momentum, mass, time, space and the symbols ± 1, ± *i*, ± ***i***, ± ***j***, ± ***k***, ± **i**, ± **j**, ± **k**, are used to represent the respective units required by the scalar, pseudoscalar, quaternion and multivariate vector groups. The changes involve the sequential iterative path from nothing (nilpotent) through conjugation, complexification, and dimensionalization. The non-local property of binary lattice space for wavefunction provides the violation of Bell inequalities [10] in quantum mechanics in terms of faster-than-light influence and indefinite property before measurement. The non-locality in Bell inequalities does not result in net new information.

In binary lattice space, for every detachment space, there is its corresponding adjacent attachment space. Thus, no part of the object can be irreversibly separated from binary lattice space, and no part of a different object can be incorporated in binary lattice space. Binary lattice space represents coherence as wavefunction. Binary lattice space is for coherent system. Any destruction of the coherence by the addition of a different object to the object causes the collapse of binary lattice space into miscible space. The collapse is a phase transition from binary lattice space to miscible space.

$$\underset{\textit{binary lattice space}}{\left((0)(1)\right)_n} \xrightarrow{\textit{collapse}} \underset{\textit{miscible space}}{(0+1)_n} \qquad (5)$$

Another way to convert binary lattice space into miscible space is gravity. Penrose [11] pointed out that the gravity of a small object is not strong enough to pull different states into one location. On the other hand, the gravity of large object pulls different quantum states into one location to become miscible space. Therefore, a small object without outside interference is always in binary lattice space, while a large object is never in binary lattice space.

The information in miscible space is contributed by the combination of both attachment space and detachment space, so information can no longer be non-localize. Any value in miscible space is definite. All observations in terms of measurements bring about the collapse of wavefunction, resulting in miscible space that leads to eigenvalue as definite quantized value. Such collapse corresponds to the appearance of eigenvalue, E, by a measurement operator, H, on a wavefunction,Ψ.

$$H\Psi = E\,\Psi \quad , \qquad (6)$$

In miscible space, attachment space is miscible to detachment space, and there is no separation of attachment space and detachment space. In miscible space, attachment space contributes zero speed, while detachment space contributes the speed of light. A massless particle, such as photon, is on detachment space continuously, and detaches from its own space continuously. For a moving massive particle consisting of a rest massive part and a massless part, the massive part with rest mass, $m_0$, is in attachment space, and the massless part with kinetic energy, *K*, is in detachment space. The combination of the massive part in attachment space and massless part in detachment leads to the propagation speed in between zero and the speed of light.

To maintain the speed of light constant for a moving particle, the time (t) in moving particle has to be dilated, and the length (L) has to be contracted relative to the rest frame.

$$t = = t_0 \Big/ \sqrt{1-\upsilon^2/c^2} \;=\; t_0\,\gamma,$$
$$L = L_0 \,/\, \gamma, \tag{7}$$
$$E = K + m_0 c^2 = \gamma\, m_0\, c^2$$

where $\gamma = 1/\sqrt{1-\upsilon^2/c^2}$ is the Lorentz factor for time dilation and length contraction, $E$ is the total energy and $K$ is the kinetic energy.

Binary partition space, $(1)_n(0)_n$, consists of separated continuous phases of attachment space and detachment space. It is for extreme force fields under extreme conditions such as near the absolute zero temperature or extremely high pressure. It will be discussed later to explain extreme phenomena such as superconductivity and black hole.

## 2.2. The Object Structure

The object structure consists of 11D membrane ($3_{11}$), 10D string ($2_{10}$), variable D particle ($1_{4\text{ to }10}$), and empty object ($0_{4\text{ to }11}$). Different universes and different stages of a universe can have different expressions of the object structure. For an example, the four stages in the evolution of our universe are the 11D membrane universe (the strong universe), the dual 10D string universe (the gravitational pre-universe), the dual 10D particle universe (the charged pre-universe), and the dual 4D/variable D particle universe (the current universe).

The transformation among the objects is through the dimensional oscillation [6] that involves the oscillation between high dimensional space-time and low dimensional space-time. The vacuum energy of the multiverse background is about the Planck energy. Vacuum energy decreases with decreasing dimension number. The vacuum energy of 4D space-time is zero. With such vacuum energy differences, the local dimensional oscillation between high and low space-time dimensions results in local eternal expansion-contraction [12]. Eternal expansion-contraction is like harmonic oscillator, oscillating between the Planck vacuum energy and the lower vacuum energy.

For the dimensional oscillation, contraction occurs at the end of expansion. Each local region in the universe follows a particular path of the dimensional oscillation. Each path is marked by particular set of force fields. The path for our universe is marked by the strong force, gravity-antigravity, charged electromagnetism, and asymmetrical weak force, corresponding to the four stages of the cosmic evolution.

The vacuum energy differences among space-time dimensions are based on the varying speed of light. Varying speed of light has been proposed to explain the horizon problem of cosmology [13][14]. The proposal is that light traveled much faster in the distant past to allow distant regions of the expanding universe to interact since the beginning of the universe. Therefore, it was proposed as an alternative to cosmic inflation. J. D. Barrow [15] proposes that the time dependent speed of light varies as some power of the expansion scale factor $a$ in such way that

$$c(t) = c_0\, a^n \tag{8}$$

where $c_0 > 0$ and $n$ are constants. The increase of speed of light is continuous.

In this paper, varying dimension number (VDN) relates to quantized varying speed of light (QVSL), where the speed of light is invariant in a constant space-time dimension number, and the speed of light varies with varying space-time dimension number from 4 to 11.

$$c_{\mathrm{D}} = c/\alpha^{\mathrm{D}-4}, \tag{9}$$

where $c$ is the observed speed of light in the 4D space-time, $c_{\mathrm{D}}$ is the quantized varying speed of light in space-time dimension number, D, from 4 to 11, and $\alpha$ is the fine structure constant for electromagnetism. Each dimensional space-time has a specific speed of light. (Since from the beginning of our observable universe, the space-time dimension has always been four, there is no observable varying speed of light in our observable universe.) The speed of light increases with the increasing space-time dimension number D.

In special relativity, $E = M_0 c^2$ modified by Eq. (9) is expressed as

$$E = M_0 \cdot (c^2/\alpha^{2(\mathrm{D}-4)}) \tag{10a}$$

$$= (M_0/\alpha^{2(\mathrm{d}-4)}) \cdot c^2. \tag{10b}$$

Eq. (10a) means that a particle in the D dimensional space-time can have the superluminal speed $c/\alpha^{\mathrm{D}-4}$, which is higher than the observed speed of light $c$, and has the rest mass $M_0$. Eq. (10b) means that the same particle in the 4D space-time with the observed speed of light acquires $M_0/\alpha^{2(\mathrm{d}-4)}$ as the rest mass, where d = D. D in Eq. (10a) is the space-time dimension number defining the varying speed of light. In Eq. (10b), d from 4 to 11 is "mass dimension number" defining varying mass. For example, for D = 11, Eq. (10a) shows a superluminal particle in eleven-dimensional space-time, while Eq. (10b) shows that the speed of light of the same particle is the observed speed of light with the 4D space-time, and the mass dimension is eleven. In other words, 11D space-time can transform into 4D space-time with 11d mass dimension. 11D4d in Eq. (10a) becomes 4D11d in Eq. (10b) through QVSL. QVSL in terms of varying space-time dimension number, D, brings about varying mass in terms of varying mass dimension number, d.

The QVSL transformation transforms both space-time dimension number and mass dimension number. In the QVSL transformation, the decrease in the speed of light leads to the decrease in space-time dimension number and the increase of mass in terms of increasing mass dimension number from 4 to 11,

$$c_{\mathrm{D}} = c_{\mathrm{D}-n}/\alpha^{2n}, \tag{11a}$$

$$M_{0,\mathrm{D},\mathrm{d}} = M_{0,\mathrm{D}-n,\ \mathrm{d}+n}\,\alpha^{2n}, \tag{11b}$$

$$\mathrm{D},\ \mathrm{d} \xrightarrow{QVSL} (\mathrm{D} \mp n),\ (\mathrm{d} \pm n) \tag{11c}$$

where D is the space-time dimension number from 4 to 11 and d is the mass dimension number from 4 to 11. For example, in the QVSL transformation, a particle with 11D4d is transformed to a particle with 4D11d. In terms of rest mass, 11D space-time has 4d with the lowest rest mass, and 4D space-time has 11d with the highest rest mass.

Rest mass decreases with increasing space-time dimension number. The decrease in rest mass means the increase in vacuum energy, so vacuum energy increases with increasing space-time dimension number. The vacuum energy of 4D particle is zero, while 11D membrane has the Planck vacuum energy.

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

### 2.3. Summary

The unified theory of physics is derived from the space-object structures. Different universes in different developmental stages are the different expressions of the space-object structures. Relating to rest mass, attachment space attaches to object permanently with zero speed. Relating to kinetic energy, detachment space detaches from the object at the speed of light. In our observable universe, the space structure consists of three different combinations of attachment space and detachment space, describing three different phenomena: quantum mechanics, special relativity, and the extreme force fields. The object structure consists of 11D membrane ($3_{11}$), 10D string ($2_{10}$), variable D particle ($1_{\leq 10}$), and empty object (0). The space structure includes attachment space (1) and detachment space (0). The transformation among the objects is through the dimensional oscillation that involves the oscillation between high dimensional space-time with high vacuum energy and low dimensional space-time with low vacuum energy. Our observable universe with 4D space-time has zero vacuum energy.

## 3. COSMOLOGY

Before the current universe, the pre-universe is in the three different stages in chronological order: the strong pre-universe, the gravitational pre-universe, and the charged pre-universe. The strong pre-universe has only one force: the strong force. The gravitational pre-universe has two forces: the strong and the gravitational forces. The charged pre-universe has three forces: the strong, the gravitational, and the electromagnetic forces. All three forces in the pre-universes are in their primitive forms unlike the finished forms in our observable universe. The asymmetrical weak interaction comes from the formation of the current asymmetrical dual universe. Such 4-stage cosmology for our universe explains the origin of the four force fields in our observable universe.

Before the 4-stage universe, the universe was the zero-energy universe in the multiverse. In the zero-energy universe hypothesis, the total amount of energy in the universe is exactly zero. The conventional zero-energy universe hypothesis is based on quantum fluctuation and the exact cancellation of positive-energy matter by negative-energy gravity through pseudo-tensor [16] or the inflation [17] before the Big Bang. Quantum fluctuation provides a natural explanation for how that energy may have come out of nothing. Throughout the universe, from nothing, symmetrical particles and antiparticles spontaneously form and quickly annihilate each other without violating the law of energy conservation. Throughout the multiverse, from the zero-energy universe, symmetrical positive-energy and negative-energy universes spontaneously form and quickly annihilate each other. A negative universe becomes a negative energy gravitational field, and a positive energy universe becomes positive-energy matter as described by Stephen Hawking in A Brief History of Time [18]: "And in a sense the energy of the universe is constant; it is a constant whose value is zero. The positive energy of the matter is exactly balanced by the negative energy of the gravitational field. So the universe can start off with zero energy and still create matter."

In this paper, for our universe, the negative-energy universe is not in the form of negative-energy gravity that cancels out the positive-energy matter. The negative-energy universe is eventually in the form of dark energy that accelerates the cosmic expansion. For our universe, the zero-energy universe produced symmetrical positive-energy and negative-energy universes, which then underwent a symmetry breaking through the Higgs mechanism to generate eventually our baryonic-dark matter and dark energy, respectively. The Higgs boson can be mass-removing to convert massive particle into massless particle, or mass-giving to convert massless particle into massive particle. Before our universe, the symmetrical positive-energy and negative-energy universes coexisted. All particles were massive, the masses of all particles were equal, and our pre-universe was cold. At the beginning of our universe, the mass-removing Higgs boson converted massive particles in the positive-energy universe into massless particles, resulting in the very hot universe to initiate the Big Bang. The massive particles in the negative-energy universe remained massive. Afterward, the mass-giving Higgs boson converted some massless particles in the positive-energy universe back to massive particles. The negative-energy massive universe eventually becomes dark energy for the positive-energy universe.

### 3.1. The Strong Pre-Universe

| Dual universe | Object structure | Space structure | Force |
|---|---|---|---|
| dual | 11D membrane | attachment space | pre-strong |

The multiverse starts with the zero energy universe, which produces the positive energy 11D (space-time dimensional) membrane universe and the negative energy 11D membrane universe denoted as $3_{11}\ 3_{-11}$, as proposed by Mongan [19]. The only force among the membranes is the pre-strong force, s, as the predecessor of the strong force. It is from the quantized vibration of the membranes to generate the reversible process of the absorption-emission of the particles among the membranes. The pre-strong force mediates the reversible absorption-emission in the flat space. The pre-strong force is the same for all membranes, so it is not defined by positive or negative sign. It does not have gravity that causes instability and singularity [20], so the initial universe remains homogeneous, flat, and static. This initial universe provides the globally stable static background state for an inhomogeneous eternal universe in which local regions undergo expansion-contraction [20].

### 3.2. The Gravitational Pre-Universe

| Dual universe | Object structure | Space structure | Forces |
|---|---|---|---|
| dual | 10D string | attachment space | pre-strong, pre-gravity |

In certain regions of the 11D membrane universe, the local expansion takes place by the transformation from 11D-membrane into 10D-string. The expansion is the result of the vacuum energy difference between 11D membrane and 10D string. With the emergence of empty object ($0_{11}$), 11D membrane transforms into 10D string warped with virtue particle as pregravity.

$$3_{11}s \ + \ 0_{11} \longleftrightarrow 2_{10}\, s 1_1 = \ 2_{10}\, s\, g^+ \qquad (12)$$

where $3_{11}$ is the 11D membrane, s is the pre-strong force, $0_{11}$ is the 11D empty object, $2_{10}$ is 10D string, $1_1$ is one dimensional virtue particle as g, pre-gravity. Empty object corresponds to the anti-De Sitter bulk space in the Randall-Sundrum model [21]. In the same way, the surrounding object can extend into empty object by the decomposition of space dimension as described by Bounias and Krasnoholovets [22], equivalent to the Randall-Sundrum model. The g is in the bulk space, which is the warped space (transverse radial space) around $2_{10}$. As in the AdS/CFT duality [23] [24] [25], the pre-strong force has 10D dimension, one dimension lower than the 11D membrane, and is the conformal force defined on the conformal boundary of the bulk space. The pre-strong force mediates the reversible absorption-emission process of membrane (string) units in the flat space, while pregravity mediates the reversible condensation-decomposition process of mass-energy in the bulk space.

Through symmetry, antistrings form 10D antibranes with anti-pregravity as $2_{-10}$ $g^-$, where $g^-$ is anti-pregravity.

$$3_{-11}\, s \ + \ 0_{-11} \longleftrightarrow 2_{-10}\, s \quad 1_{-1} = \ 2_{-10}\, s\, g^- \qquad (13)$$

Pregravity can be attractive or repulsive to anti-pregravity. If it is attractive, the universe remains homogeneous. If it is repulsive, n units of $(2_{10})_n$ and n units of $(2_{-10})_n$ are separated from each other.

$$((s\,2_{10})\, g^+)_n\, (g^-\, (s\,2_{-10}))_n \qquad (14)$$

The dual 10D string universe consists of two parallel universes with opposite energies: 10D strings with positive energy and 10D antistrings with negative energy. The two universes are separated by the bulk space, consisting of pregravity and anti-pregravity. There are four equal regions: positive energy string universe, pregravity bulk space, anti-pregravity bulk space, and negative energy antistring universe. Such dual universe separated by bulk space appears in the ekpyrotic universe model [26] [27].

### 3.3. The Charged Pre-Universe

| Dual universe | Object structure | Space structure | Forces |
|---|---|---|---|
| dual | 10D particle | attachment space | pre-strong, pre-gravity, pre-electromagnetic |

When the local expansion stops, through the dimensional oscillation, the 10D dual universe returns to the 11D positive and negative universes, which coalesce to undergo annihilation and to return to the zero energy universe. The 10D positive and negative universe can also coalesce to undergo annihilation and to return to the zero energy universe. The first path of such coalescence is the annihilation, resulting in disappearance of the dual universe and the return to the zero energy universe.

The second path allows the continuation of the dual universe in another form without the mixing of positive energy and negative energy. Such dual universe is possible by the emergence of the pre-charge force, the predecessor of electromagnetism with positive and negative charges. The mixing becomes the mixing of positive charge and negative charge instead of positive energy and negative energy, resulting in the preservation of the dual universe with the positive energy and the negative energy. Our universe follows the second path as described below in details.

During the coalescence for the second path, the two universes coexist in the same space-time, which is predicted by the Santilli isodual theory [28]. Antiparticle for our positive energy universe is described by Santilli as follows, "this identity is at the foundation of the perception that antiparticles "appear" to exist in our space, while in reality they belong to a structurally different space coexisting within our own, thus setting the foundations of a "multidimensional universe" coexisting in the same space of our sensory perception" (Ref. [28], p. 94). Antiparticles in the positive energy universe actually come from the coexisting negative energy universe.

The mixing process follows the isodual hole theory that is the combination of the Santilli isodual theory and the Dirac hole theory. In the Dirac hole theory that is not symmetrical, the positive energy observable universe has an unobservable infinitive sea of negative energy. A hole in the unobservable infinitive sea of negative energy is the observable positive energy antiparticle.

In the dual 10D string universe, one universe has positive energy strings with pregravity, and one universe has negative energy antistrings with anti-pregravity. For the mixing of the two universes during the coalescence, a new force, the pre-charged force, emerges to provide the additional distinction between string and antistring. The pre-charged force is the predecessor of electromagnetism. Before the mixing, the positive energy string has positive pre-charge ($e^+$), while the negative energy antistring has negative pre-charge ($e^-$). During the mixing when two 10D string universes coexist, a half of positive energy strings in the positive energy universe move to the negative energy universe, and leave the Dirac holes in the positive energy universe. The negative energy antistrings that move to fill the holes become positive energy antistrings with negative pre-charge in the positive energy universe. In terms of the Dirac hole theory, the unobservable infinitive sea of negative energy is in the negative energy universe from the perspective of the positive energy universe before the mixing. The hole is due to the move of the negative energy antistring to the positive energy universe from the perspective of the positive energy universe during the mixing, resulting in the positive energy antistring with negative pre-charge in the positive energy universe.

In the same way, a half of negative energy antistrings in the negative energy universe moves to the positive energy universe, and leave the holes in the negative energy universe. The positive energy strings that move to fill the holes become negative energy strings with positive pre-charge in the negative energy universe. The result of the mixing is that both positive energy universe and the negative energy universe have strings-antistrings. The existence of the pre-charge provides the distinction between string and antistring in the string-antistring.

At that time, the space (detachment space) for radiation has not appeared in the universe, so the string-antistring annihilation does not result in radiation. The string-antistring annihilation results in the replacement of the string-antistring as the 10D string-antistring, ($2_{10}$ $2_{-10}$) by the 10D particle-antiparticle ($1_{10}$ $1_{-10}$). The 10D particles-antiparticles have the multiple dimensional Kaluza-Klein structure with variable space dimension number without the requirement for a fixed space dimension number for string-antistring. After the mixing, the dual 10D particle-antiparticle universe separated by pregravity and anti-pregravity appears as below.

$$((s1_{10}\, e^{+}\, e-\ 1_{-10}\ \ s)\, g^{+})_{n} \quad (g^{-}(s1_{10}\, e^{+}\, e-\ 1_{-10}\ \ s))_{\mathrm{n}}\ , \tag{15}$$

where s and e are the pre-strong force and the pre-charged force in the flat space, g is pregravity in the bulk space, and $1_{10}$ $1_{-10}$ is the particle-antiparticle.

The dual 10D particle universe consists of two parallel particle-antiparticle universes with opposite energies and the bulk space separating the two universes. There are four equal regions: the positive energy particle-antiparticle space region, the pregravity bulk space region, the negative energy particle-antiparticle space region, and the anti-pregravity bulk space region.

### 3.4. The Current Universe

| | Object structure | Space structure | Forces |
|---|---|---|---|
| The light universe | 4D particle | attachment space and detachment space | strong, gravity, electromagnetic, and weak |
| The dark universe | variable D between 4 and 10 particle | attachment space | pre-strong, gravity, pre-electromagnetic |

The formation of our current universe follows immediately after the formation of the charged pre-universe through the asymmetrical dimensional oscillations and the asymmetrical addition of detachment space, leading to the asymmetrical dual universe. The asymmetrical dimensional oscillation involved the immediate transformation of the positive-energy universe from 10D to 4D and the slow reversible transformation of the negative-energy universe between 10D and 4D. In the asymmetrical addition of detachment space, the mass-removing Higgs boson converted massive particles in the positive-energy universe into massless particles, and the massive particles in the negative-energy universe remained massive. Afterward, the mass-giving Higgs boson converted some massless particles in the positive-energy universe back to massive particles due to mainly the CP asymmetry (particle-antiparticle asymmetry). The result was the asymmetrical dual universe consisting of the positive-energy 4D light universe with kinetic energy and light and the negative-energy oscillating 10D-4D dark universe without kinetic energy and light. The light universe contains both attachment space and detachment space.

The four equal parts in the dual universe include the positive energy particle universe, the gravity bulk space, the antigravity bulk space, and the negative energy particle universe. The dark universe includes the negative energy particle universe, the antigravity bulk space, and the gravity bulk space. The light universe includes the positive energy particle universe. Therefore, the dark universe contains 75% of the total dual universe, while the light universe contains 25% of the total dual universe. The percentage (75%) of the dark universe later becomes the maximum percentage of the dark energy.

The asymmetrical dual universe is manifested as the asymmetry in the weak interaction in our observable universe as follows.

$$((s\,1_4\, e^+ w^+\, e^- w^-\, 1_{-4}\ \ s)\, g^+)_n\ \ (g^- (s\,1_{\leq 10}\, e^+ w^+\, e^- w^-\, 1_{\geq -10}\ \ s))_{\mathrm{n}} \qquad (16)$$

where s, g, e, and w are the strong force, gravity, electromagnetism, and weak interaction, respectively for the observable universe, and where $1_4 1_{-4}$ and $1_{\leq 10} 1_{\geq -10}$ are 4D particle-antiparticle for the light universe and variable D particle-antiparticle for the dark universe, respectively.

In summary, the whole process of the local dimensional oscillations leading to our observable universe is illustrated as follows.

$$\underset{3_{11} s\, s\, 3_{-11}}{\textit{membrane universe}} \xleftrightarrow{\textit{betwwen } 11D \textit{ and } 10D} \underset{((s\,2_{10})\, g^+)_n\, (g^- (s\,2_{-10}))_n}{\textit{dual string universe}} \xleftrightarrow{\text{coalescence, } \textit{annihilation}}$$

$$\underset{((s\,1_{10}\, e^+\, e^-\, 1_{-10}\ \ s)\, g^+)_n\ \ (g^- (s\,1_{10}\, e^+\, e^-\, 1_{-10}\ \ s))_{\mathrm{n}}}{\textit{dual } 10D \textit{ particle universe}} \xleftrightarrow{\textit{between } 10D \textit{ and } 4D} \underset{((s\,1_4\, e^+ w^+\, e^- w^-\, 1_{-4}\ \ s)\, g^+)_n\ \ (g^- (s\,1_{\leq 10}\, e^+ w^+\, e^- w^-\, 1_{\geq -10}\ \ s))_{\mathrm{n}}}{\textit{dual } 4D / \text{var}\textit{ible } D \textit{ particle universe}}$$

where s, e, and w are in the flat space, and g is in the bulk space. Each stage generates one force, so the four stages produce the four different forces: the strong force, gravity, electromagnetism, and the weak interaction, sequentially. Gravity appears in the first dimensional oscillation between the 11 dimensional membrane and the 10 dimensional string. The asymmetrical weak force appears in the asymmetrical second dimensional oscillation between the ten dimensional particle and the four dimensional particle. Charged electromagnetism appears as the force in the transition between the first and the second dimensional oscillations. The cosmology explains the origins of the four forces. To prevent the charged pre-universe to reverse back to the previous pre-universe, the charge pre-universe and the current universe overlap to a certain degree as shown in the overlapping between the electromagnetic interaction and the weak interaction to form the electroweak interaction.

| Four-Stage Universe | Universe | Object Structure | Space Structure | Force |
|---|---|---|---|---|
| **Strong Pre-Universe** | dual | 11D membrane | attachment space | pre-strong |
| **Gravitational Pre-Universe** | dual | 10D string | attachment space | pre-strong, pre-gravity |
| **Charged Pre-Universe** | dual | 10D particle | attachment space | pre-strong, pre-gravity, pre-electromagnetic |
| **Current Universe** | dual | | | |
| light universe | | 4D particle | attachment space and detachment space | strong, gravity, electromagnetic, and weak |
| dark universe | | variable D between 4 and 10 particle | attachment space | pre-strong, gravity, pre-electromagnetic, and weak |

The formation of the dark universe involves the slow dimensional oscillation between 10D and 4D. The dimensional oscillation for the formation of the dark universe involves the stepwise two-step transformation: the QVSL transformation and the varying supersymmetry transformation. In the normal supersymmetry transformation, the repeated application of the fermion-boson transformation carries over a boson (or fermion) from one point to the same boson (or fermion) at another point at the same mass. In the "varying supersymmetry transformation", the repeated application of the fermion-boson transformation carries over a boson from one point to the boson at another point at different mass dimension number in the same space-time number. The repeated varying supersymmetry 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

$$M_{\mathrm{d,F}} = M_{\mathrm{d,B}}\,\alpha_{\mathrm{d,B}}, \tag{17a}$$

$$M_{\mathrm{d-1,B}} = M_{\mathrm{d,F}}\,\alpha_{\mathrm{d,F}}, \tag{17b}$$

where $M_{\mathrm{d,B}}$ and $M_{\mathrm{d,F}}$ are the masses for a boson and a fermion, respectively, d is the mass dimension number, and $\alpha_{\mathrm{d,B}}$ or $\alpha_{\mathrm{d,F}}$ is the fine structure constant that is the ratio between the masses of a boson and its fermionic partner. Assuming $\alpha_{\mathrm{d,B}}$ or $\alpha_{\mathrm{d,F}}$, the relation between the bosons in the adjacent dimensions or n dimensions apart (assuming α's are the same) then can be expressed as

$$M_{\mathrm{d,B}} = M_{\mathrm{d+1,B}}\,\alpha_{\mathrm{d+1}}^{2}. \tag{17c}$$

$$M_{\mathrm{d,B}} = M_{\mathrm{d+n,B}}\,\alpha_{\mathrm{d+n}}^{2n}. \tag{17d}$$

$$N_{\mathrm{d-1}} = N_{\mathrm{d}}/\alpha^{2}. \tag{17e}$$

Eq. (18) show that it is possible to describe mass dimensions > 4 in the following way

$$F_5\, B_5\, F_6\, B_6\, F_7\, B_7\, F_8\, B_8\, F_9\, B_9\, F_{10}\, B_{10}\, F_{11}\, B_{11}, \tag{18}$$

where the energy of $B_{11}$ is the Planck energy. Each mass dimension between 4d and 11d consists of a boson and a fermion. Eq. (19) show a stepwise transformation that converts a particle with d mass dimension to d ± 1 mass dimension.

$$\text{D, d} \xleftrightarrow{\textit{stepwise varying supersymmetry}} \text{D, (d} \pm 1) \tag{19}$$

The transformation from a higher mass dimensional particle to the adjacent lower mass dimensional particle is the fractionalization of the higher dimensional particle to the many lower dimensional particles in such way that the number of lower dimensional particles becomes $N_{\text{d-1}} = N_{\text{d}} / \alpha^2$ . The transformation from lower dimensional particles to higher dimensional particle is a condensation. Both the fractionalization and the condensation are stepwise. For example, a particle with 4D (space-time) 10d (mass dimension) can transform stepwise into 4D9d particles. Since the supersymmetry transformation involves translation, this stepwise varying supersymmetry transformation leads to a translational fractionalization and translational condensation, resulting in expansion and contraction.

For the formation of the dark universe from the charged pre-universe, the negative energy universe has the 10D4d particles, which is converted eventually into 4D4d stepwise and slowly. It involves the stepwise two-step varying transformation: first the QVSL transformation, and then, the varying supersymmetry transformation as follows.

$$\begin{aligned} &\text{stepwise two-step varying transformation} \\ &(1)\quad \text{D, d} \xleftrightarrow{\text{QVSL}} (\text{D} \mp 1),\ (\text{d} \pm 1) \\ &(2)\quad \text{D, d} \xleftrightarrow{\text{varying supersymmetry}} \text{D, (d} \pm 1) \end{aligned} \tag{20}$$

The repetitive stepwise two-step transformations from 10D4d to 4D4d are as follows.

*The Hidden Dark Universe and the Observable Dark Universe with Dark Energy*

$$\begin{aligned} &\text{10D4d} \to \text{9D5d} \to \text{9D4d} \to \text{8D5d} \to \text{8D4d} \to \text{7D5d} \to \bullet\bullet\bullet\bullet \to \text{5D4d} \to \text{4D5d} \to \text{4D4d} \\ &\mapsto \textit{ the hidden dark universe } \longleftrightarrow\!\!\!\!\mapsto \textit{ dark energy} \leftarrow \end{aligned}$$

The dark universe consists of two periods: the hidden dark universe and the dark energy universe. The hidden dark universe composes of the > 4D particles. As mentioned before, particles with different space-time dimensions are transparent and oblivious to one another, and separate from one another if possible. Thus, > 4D particles are hidden and separated particles with respect to 4D particles in the light universe (our observable universe). The universe with > 4D particles is the hidden dark universe. The 4D particles transformed from hidden > 4D particles in the dark universe are observable dark energy for the light universe, resulting in the accelerated expanding universe. The accelerated expanding universe consists of the positive energy 4D particles-antiparticles and dark energy that includes the negative energy 4D particles-antiparticles and the antigravity.

Since the dark universe does not have detachment space, the presence of dark energy is not different from the presence of the non-zero vacuum energy. In terms of quintessence, such dark energy can be considered the tracking quintessence [29] from the dark universe with the space-time dimension as the tracker. The tracking quintessence consists of the hidden quintessence and the observable quintessence. The hidden quintessence is from the hidden > 4D dark universe. The observable quintessence is from the observable 4D dark universe with 4D space-time.

For the formation of the light universe, the dimensional oscillation for the positive energy universe transforms 10D to 4D immediately. It involves the leaping two-step varying transformation, resulting in the light universe with kinetic energy. The first step is the space-time dimensional oscillation through QVSL. The second step is the mass dimensional oscillation through slicing-fusion.

$$\begin{aligned}
&\textit{leaping two-step varying transformation} \\
&(1)\quad \mathrm{D},\, \mathrm{d} \xleftrightarrow{\text{QVSL}} (\mathrm{D} \mp n),\ (\mathrm{d} \pm n) \qquad (21) \\
&(2)\quad \mathrm{D},\, \mathrm{d} \xleftrightarrow{\text{slicing - fusion}} \mathrm{D}, (\mathrm{d} \pm n) + (11 - \mathrm{d} + n)\,\mathrm{DO's}
\end{aligned}$$

$$\begin{aligned}
&\text{The Light Universe} \\
&\text{10D4d} \xrightarrow{\textit{quick QVSL transformation}} \text{4D10d} \xrightarrow{\textit{slicing with detachment space, inflation}} \\
&\textit{dark matter } (\text{4D9d} + \text{4D8d} + \text{4D7d} + \text{4D6d} + \text{4D5d}) + \textit{baryonic matter } (\text{4D4d}) + \textit{cosmic radiation} \\
&\to \textit{thermal cosmic expansion (the big bang)}
\end{aligned}$$

In the charged pre-universe, the positive energy universe has 10D4d, which is transformed into 4D10d in the first step through the QVSL transformation. The second step of the leaping varying transformation involves the slicing-fusion of particle. The slicing is through detachment space. The Higgs boson converts rest mass in attachment space into kinetic energy in detachment space. Bounias and Krasnoholovets [30] propose another explanation of the reduction of > 4 D space-time into 4D space-time by slicing > 4D space-time into infinitely many 4D quantized units surrounding the 4D core particle. Such slicing of > 4D space-time is like slicing 3-space D object into 2-space D object in the way stated by Michel Bounias as follows: “You cannot put a pot into a sheet without changing the shape of the 2-D sheet into a 3-D dimensional packet. Only a 2-D slice of the pot could be a part of sheet”.

The slicing is by detachment space, as a part of the space structure, which consists of attachment space (denoted as 1) and detachment space (denoted as 0) as described earlier. Attachment space attaches to object permanently with zero speed. Detachment space detaches from the object at the speed of light. Attachment space relates to rest mass, while detachment space relates to kinetic energy. The cosmic origin of detachment space is the cosmic radiation from the particle-antiparticle annihilation that initiates the transformation. The cosmic radiation cannot permanently attach to a space.

The slicing of dimensions is the slicing of mass dimensions. 4D10d particle is sliced into six particles: 4D9d, 4D8d, 4D7d, 4D6d, 4D5d, and 4D4d equally by mass. Baryonic matter is 4D4d, while dark matter consists of the other five types of particles (4D9d, 4D8d, 4D7d, 4D6d, and 4D5d) as described later. The mass ratio of dark matter to baryonic matter is 5 to 1 in agreement with the observation [31] showing the universe consists of 22.7% dark matter, 4.56% baryonic matter, and 72.8 % dark energy.

Detachment space (0) involves in the slicing of mass dimensions. Attachment space is denoted as 1. For example, the slicing of 4D10d particles into 4D4d particles is as follows.

$$\underset{>4d\ \ attachment\ \ space}{\left(1_{4+6}\right)_i} \xrightarrow{slicing} \underset{4d\ \ core\ \ attachment\ \ space}{\left(1_4\right)_i} + \underset{6\ types\ \ of\ \ 4d\ units}{\sum_{1}^{6}\left(\left(0_4\right)\left(1_4\right)\right)_{j,6}} \tag{22}$$

The two products of the slicing are the 4d-core attachment space and 6 types of 4d quantized units. The 4d core attachment space surrounded by 6 types of many (j) 4D4d-quantized units corresponds to the core particle surrounded by 6 types of many small 4d particles.

Therefore, the transformation from d to d – *n* involves the slicing of a particle with d mass dimension into two parts: the core particle with d – *n* dimension and the *n* dimensions that are separable from the core particle. Such *n* dimensions are denoted as *n* "dimensional orbitals", which become gauge force fields as described later. The sum of the number of mass dimensions for a particle and the number of dimensional orbitals (DO's) is equal to 11 (including gravity) for all particles with mass dimensions. Therefore,

$$F_{\mathrm{d}} = F_{\mathrm{d}-n} + (11 - \mathrm{d} + n)\,\mathrm{DO's} \tag{23}$$

where $11 - \mathrm{d} + n$ is the number of dimensional orbitals (DO's) for $F_{\mathrm{d}-n}$. Thus, 4D10d particles can transformed into 4D9d, 4D8d, 4D7d, 4D6d, 4D5d, and 4D4d core particles, which have 2, 3, 4, 5, 6, and 7 separable dimensional orbitals, respectively. Baryonic matter particle 4D4d has gravity and six other dimensional orbitals as gauge force fields as below.

The six > 4d mass dimensions (dimensional orbitals) for the gauge force fields and the one mass dimension for gravity are as in Figure 1.

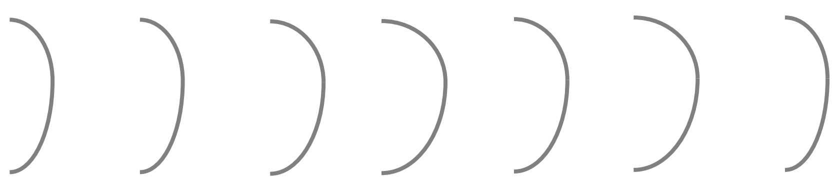

Figure 1. The seven force fields as > 4d mass dimensions (dimensional orbitals).

The dimensional orbitals of baryonic matter provide the base for the periodic table of elementary particles to calculate accurately the masses of all 4D elementary particles, including quarks, leptons, and gauge bosons as described later.

The lowest dimensional orbital is for electromagnetism. Baryonic matter is the only one with the lowest dimensional orbital for electromagnetism. With higher dimensional orbitals, dark matter does not have this lowest dimensional orbital. Without electromagnetism, dark matter cannot emit light, and is incompatible to baryonic matter, like the incompatibility between oil and water. The incompatibility between dark matter and baryonic matter leads to the inhomogeneity (like emulsion), resulting in the formation of galaxies, clusters, and superclusters as described later. Dark matter has not been found by direct detection because of the incompatibility.

In the light universe, the inflation is the leaping varying transformation that is the two-step inflation. The first step is to increase the rest mass as potential from higher space-time dimension to lower space-time dimension as expressed by Eq. (24a) from Eq. (11b).

$$\begin{aligned}&\mathrm{D,\ d}\xrightarrow{QVSL}(\mathrm{D}\mp n),\ (\mathrm{d}\pm n)\\&V_{\mathrm{D,d}}=V_{\mathrm{D}-n,\ \mathrm{d}+n}\,\alpha^{2n}\\&\varphi=collective\ \ n's\\&V(\varphi)=V_{4D10d}\alpha^{-2\varphi},where\,\varphi\leq 0\ from\ -6\ to\ 0\end{aligned} \tag{24a}$$

where α is the fine structure constant for electromagnetism. The ratio of the potential energies of 4D10d to that of 10D4d is $1/\alpha^{12}$. φ is the scalar field for QVSL, and is equal to collective n's as the changes in space-time dimension number for many particles. The increase in the change of space-time dimensions from 4D decreases the potential as the rest mass. The region for QVSL is φ ≤ 0 from -6 to 0. The QVSL region is for the conversion of the vacuum energy into the rest mass as the potential.

The second step is the slicing that occurs simultaneously with the appearance of detachment space that is the space for cosmic radiation (photon). The Higgs boson converts rest mass in attachment space into kinetic energy in detachment space. Potential energy as massive 4D10d particles is converted into kinetic energy as cosmic radiation and massive matter particles (from 10d to 4d). It relates to the ratio between photon and matter in terms of the CP asymmetry between particle and antiparticle. The slight excess particle over antiparticle results in matter particle. The equation for the potential (V) and the scalar field (ϕ) is as Eq. (24b) from Eq. (35) that expresses the ratio between photon and matter.

$$\begin{aligned}&\mathrm{D,\ d}\xrightarrow{\text{slicing}}\mathrm{D},(\mathrm{d}-n)\\&V(\phi)=V_{4D10d}\alpha^{2\phi}\ ,where\ \ \phi\ \geq 0\ from\, 0\, to\, 2\end{aligned} \tag{24b}$$

The ratio is $\alpha^4$, according to Eq. (35). The region for the slicing is ϕ ≥ 0 from 0 to 2. The slicing region is for the conversion of the potential energy into the kinetic energy.

The combination of Eq. (24a) and Eq. (24b) is as Eq. (24c).

$$\begin{aligned}&V(\varphi,\phi)=V_{4D10d}\,(\alpha^{-2\varphi}+\alpha^{2\phi}),\\&where\ \varphi\leq 0\ and\,\phi\geq\ 0\end{aligned} \tag{24c}$$

The graph for the two-step inflation is as Figure 2.

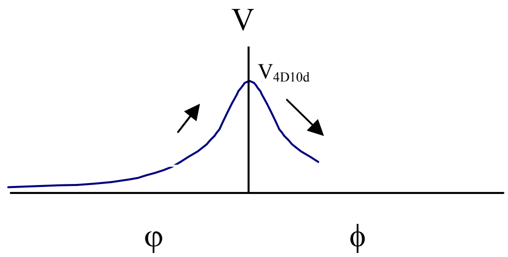


Figure 2. the two-step inflation

At the transition ($V_{4D10d}$) between the first step (QVSL) and the second step (slicing), the scalar field reverses its sign and direction. In the first step, the universe inflates by the decrease in vacuum energy. In the second step, the potential energy is converted into kinetic energy as cosmic radiation. The resulting kinetic energy starts the Big Bang, resulting in the expanding universe.

Toward the end of the cosmic contraction after the big crunch, the deflation occurs as the opposite of the inflation. The kinetic energy from cosmic radiation decreases, as the fusion occurs to eliminate detachment space, resulting in the increase of potential energy. At the end of the fusion, the force fields except gravity disappear, 4D10d particles appear, and then the scalar field reverses its sign and direction. The vacuum energy increases as the potential as the rest mass decreases for the appearance of 10D4d particles, resulting in the end of a dimensional oscillation as Figure 3 for the two-step deflation.

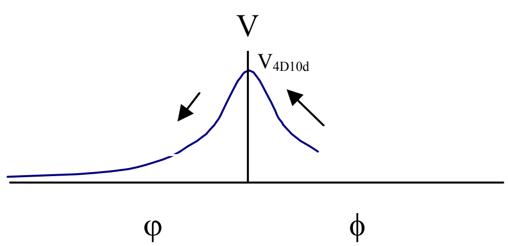


Figure 3. the two-step deflation

The end of the two-step deflation is 10D4d, which is followed immediately by the dimensional oscillation to return to 4D10d as the "dimensional bounce" as shown in Figure 4, which describes the dimensional oscillation from the left to the right: the beginning (inflation as 10D4d through 4D10d to 4D4d), the cosmic expansion-contraction, the end (deflation as 4D4d through 4D10d to 10D4d), the beginning (inflation), the cosmic expansion-contraction, and the end (deflation).

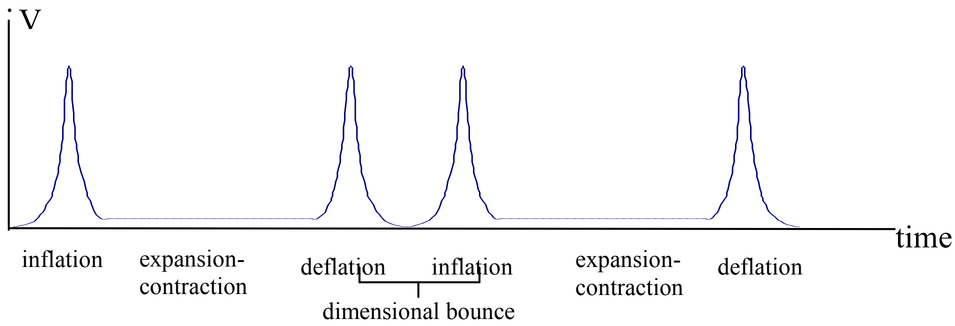


Figure 4. the cyclic observable universe by the dimensional oscillation

The two-step inflation corresponds to the quintom inflation. The symmetry breaking for the light universe can be described by quintom. Quintom [32] [33] [34] is the combination of quintessence and phantom. Quintessence describes a time-varying equation of state parameter, $w$, the ratio of its pressure to energy density and $w > -1$.

$$L_{quintessnec} = \frac{1}{2}(\partial_\mu \phi)^2 - V(\phi) \tag{25}$$

$$w = \frac{\dot{\phi}^2 - 2V(\phi)}{\dot{\phi}^2 + 2V(\phi)} \qquad -1 \le w \le +1 \tag{26}$$

Quintom includes phantom with $w < -1$. It has opposite sign of kinetic energy.

$$L_{phantom} = \frac{-1}{2}(\partial_\mu \varphi)^2 - V(\varphi) \tag{27}$$

$$w = \frac{-\dot{\varphi}^2 - 2V(\varphi)}{-\dot{\varphi}^2 + 2V(\varphi)} \qquad -1 \ge w \tag{28}$$

As the combination of quintessence and phantom from Eqs. (24), (25), (26), and (27), quintom is as follows.

$$L_{quintessnec} = \frac{1}{2}(\partial_\mu \phi)^2 - \frac{1}{2}(\partial_\mu \varphi)^2 - V(\phi) - V(\varphi) \tag{29}$$

$$w = \frac{\dot{\phi}^2 - \dot{\varphi}^2 - 2V(\phi) - 2V(\varphi)}{\dot{\phi}^2 - \dot{\varphi}^2 + 2V(\phi) + 2V(\varphi)} \tag{30}$$

Phantom represents the scalar field φ in the space-time dimensional oscillation in QVSL, while quintessence represents the scalar field ϕ in the mass dimensional oscillation in the slicing-fusion. Since QVSL does not involve kinetic energy, the physical source of the negative kinetic energy for phantom is the increase in vacuum energy, resulting in the decrease in energy density and pressure with respect to the observable potential, V(φ). Combining Eqs. (24c) and (30), quintom is as follows.

$$w = \frac{\dot{\phi}^2 - \dot{\varphi}^2 - 2V(\phi) - 2V(\varphi)}{\dot{\phi}^2 - \dot{\varphi}^2 + 2V(\phi) + 2V(\varphi)}$$

$$= \frac{\dot{\phi}^2 - \dot{\varphi}^2 - 2V_{4D10d}(\alpha^{-2\varphi} + \alpha^{2\phi})}{\dot{\phi}^2 - \dot{\varphi}^2 + 2V_{4D10d}(\alpha^{-2\varphi} + \alpha^{2\phi})} \quad (31)$$

*where* $\varphi \leq 0$ *and* $\phi \geq 0$

Figure 5 shows the plot of the evolution of the equation of state *w* for the quintom inflation.

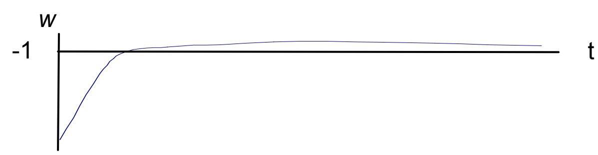


Figure 5. the *w* of quintom for the quintom inflation

Figure 6 shows the plot of the evolution of the equation of state *w* for the cyclic universe as Figure 4.

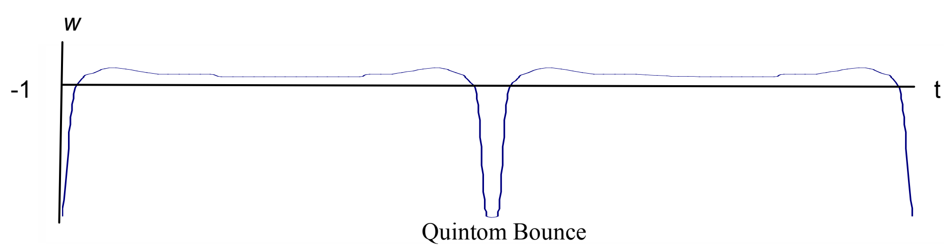


Figure 6. the cyclic universe by the dimensional oscillation as Figure 4

In the dimensional bounce in the middle of Figure 6, the equation of state crosses *w* = -1 twice as also shown in the recent development of the quintom model [35] [36] in which, for the Quintom Bounce, the equation of state crosses the cosmological constant boundary twice around the bounce point to start another cycle of the dual universe.

The hidden dark universe with D > 4 and the observable universe with D = 4 are the "parallel universes" separated from each other by the bulk space. When the slow QVSL transformation transforms gradually 5D hidden particles in the hidden universe into observable 4D particles, and the observable 4 D particles become the dark energy for the observable universe starting from about five billion years ago (more precisely 4.71 ± 0.98 billion years ago at z = 0.46 ± 0.13) [37]. At a certain time, the hidden universe disappears, and becomes completely observable as dark energy. The maximum connection of the two universes includes the positive energy particle-antiparticle space region, the gravity bulk space region, the negative energy particle-antiparticle space region, and the anti-gravity bulk space region. Through the symmetry among the space regions, all regions expand synchronically and equally. (The symmetry is necessary for the ultimate reversibility of all cosmic processes.)

The light universe includes the positive-energy particle-antiparticle universe, and the dark universe includes the negative-energy particle-antiparticle universe, the anti-gravity bulk space, and the gravity bulk space. The light universe occupies 25% of the total universe, while the dark universe occupies 75% of the total universe, so the maximum dark energy from the dark universe is 75%. The present observable universe about reaches the maximum (75%) at the observed 72.8% dark energy [31]. At 72.8% dark energy, the calculated values for baryonic matter and dark matter (with the 1:5 ratio) are 4.53% (= (100 – 72.8)/6) and 22.7% (= 4.53 x 5), respectively, in excellent agreement with observed 4.56% and 22.7%, respectively [31]. Our universe is 13.7 billion-year old. Dark energy as the transformation from 5D to 4D started in about 4.71 ± 0.98 billion years ago [37]. The ratio of the time periods for the transformations from D → D - 1 is proportional to ln of the total number of particles (Eqs. (11b) and (17e)) to be transformed from D → D – 1 for the exponential growth with time in each period.

**The Percentages of the Periods in the Dark Universe**

| | 10D → 9D | 9D → 8D | 8D → 7D | 7D → 6D | 6D → 5D | 5D → 4D |
|---|---|---|---|---|---|---|
| ratio of total numbers of particles | 1 | $\alpha^{-2}$ | $\alpha^{-4}$ | $\alpha^{-6}$ | $\alpha^{-8}$ | $\alpha^{-10}$ |
| ratio of ln (total number of particles) | 0 | $-2\alpha$ | $-4\alpha$ | $-6\alpha$ | $-8\alpha$ | $-10\alpha$ |
| ratio of periods | ~0 | 1 | 2 | 3 | 4 | 5 |
| percentages of periods | ~0 | 6.7 | 13.3 | 20 | 26.7 | 33.3 |

$\alpha$ is the fine structure constant for electromagnetism from Eq. (11b)

The period of the 5D → 4D is (0.333) (13.7)/ ((0.333) (72.8/75) + 0.667) = 4.61 billion years, and the dark energy as the 5D → 4D started in (4.61) (72.8/75) = 4.47 billon years ago that is in agreement with the observed value of 4.71 ± 0.98 billion years ago [37].

After the maximally connected universe, 4D dark energy transforms back to > 4D particles that are not observable. The removal of dark energy in the observable universe results in the stop of accelerated expansion and the start of contraction of the observable universe.

The end of dark energy starts another "parallel universe period". Both hidden universe and observable universe contract synchronically and equally. Eventually, gravity causes the observable universe to crush to lose all cosmic radiation, resulting in the return to 4D10d particles under the deflation. The increase in vacuum energy allows 4D10d particles to become positive energy 10D4d particles-antiparticle. Meanwhile, hidden > 4D particles-antiparticles in the hidden universe transform into negative energy 10D4d particles-antiparticles. The dual universe can undergo another cycle of the dual universe with the dark and light universes. On the other hand, both universes can undergo transformation by the reverse isodual hole theory to become dual 10D string universe, which in turn can return to the 11D membrane universe that in turn can return to the zero energy universe as follows.

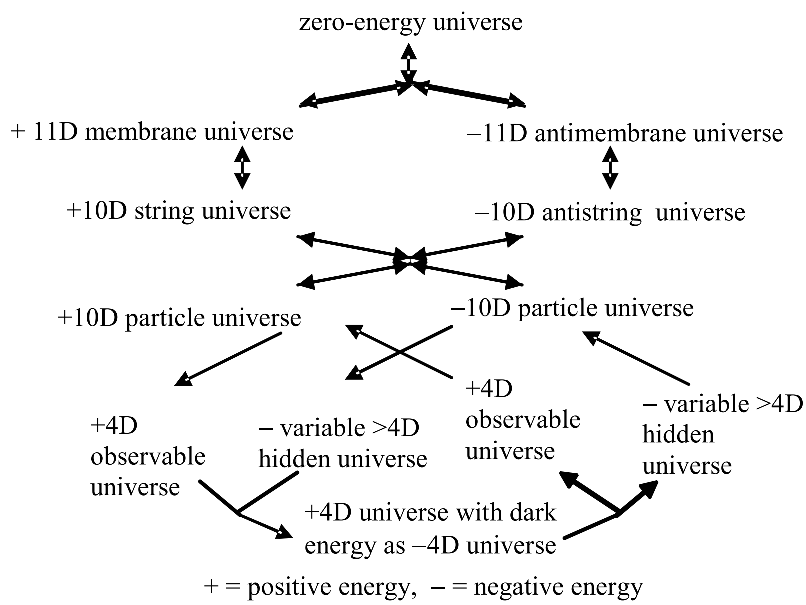


**Figure 7.** Cosmology

### 3.5. Summary

There are three stages of pre-universes in chronological order: the strong pre-universe, the gravitational pre-universe, and the charged pre-universe. The first universe from the zero-energy universe in multiverse is the strong pre-universe with the simplest expression of the space-object structures. Its object structure is 11D positive and negative membrane and its space structure is attachment space only. The only force is the pre-strong force without gravity. The transformation from 11D membrane to 10D string results in the gravitational pre-universe with both pre-strong force and pre-gravity. The repulsive pre-gravity and pre-antigravity brings about the dual 10D string universe with the bulk space. The coalescence and the separation of the dual universe result in the dual charged universe as dual 10D particle universe with the pre-strong, pre-gravity, and pre-electromagnetic force fields.

The asymmetrical dimensional oscillations and the asymmetrical addition of detachment space result in the asymmetrical dual universe: the positive-energy 4D light universe with light and kinetic energy and the negative-energy oscillating 10D-4D dark universe without light and kinetic energy. The light universe is our observable universe. The dark universe is sometimes hidden, and is sometimes observable as dark energy. The dimensional oscillation for the dark universe is the slow dimensional oscillation from 10D and 4D. The dimensional oscillation for the light universe involves the immediate transformation from 10D to 4D and the introduction of detachment space, resulting in light and kinetic energy. The asymmetrical dimensional oscillation and the asymmetrical addition of detachment space are manifested as the asymmetrical weak force field. When the dark universe becomes the 4D universe, the dark universe turns into dark energy. The calculated percentages of dark energy, dark matter, and baryonic matter 72.8, 22.7, and

4.53, respectively, in nearly complete agreement with observed 72.8, 22.7, and 4.56, respectively. According to the calculation, dark energy started in 4.47 billion years ago in agreement with the observed 4.71 ± 0.98 billion years ago.

# 4. THE PERIODIC TABLE OF ELEMENTARY PARTICLES

## 4.1. The CP Asymmetry

In the light universe, cosmic radiation is the result of the annihilation of the CP symmetrical particle-antiparticle. However, there is the CP asymmetry, resulting in excess of matter. Matter results from the combination of the CP asymmetrical particle-antiparticle. A baryonic matter particle (4d) has seven dimensional orbitals. The CP asymmetrical particle-antiparticle particle means the combination of two asymmetrical sets of seven from particle and antiparticle, resulting in the combination of the seven "principal dimensional orbitals" and the seven "auxiliary dimensional orbitals". The auxiliary orbitals are dependent on the principal orbitals, so a baryonic matter particle appears to have only one set of dimensional orbitals. For baryonic matter, the principal dimensional orbitals are for leptons and gauge bosons, and the auxiliary dimensional orbitals are mainly for individual quarks. Because of the dependence of the auxiliary dimensional orbitals, individual quarks are hidden. In other words, there is asymmetry between lepton and quark, resulting in the survival of matter without annihilation. The configuration of dimensional orbitals and the periodical table of elementary particles [38] are shown in Figure 8 and Table 1.

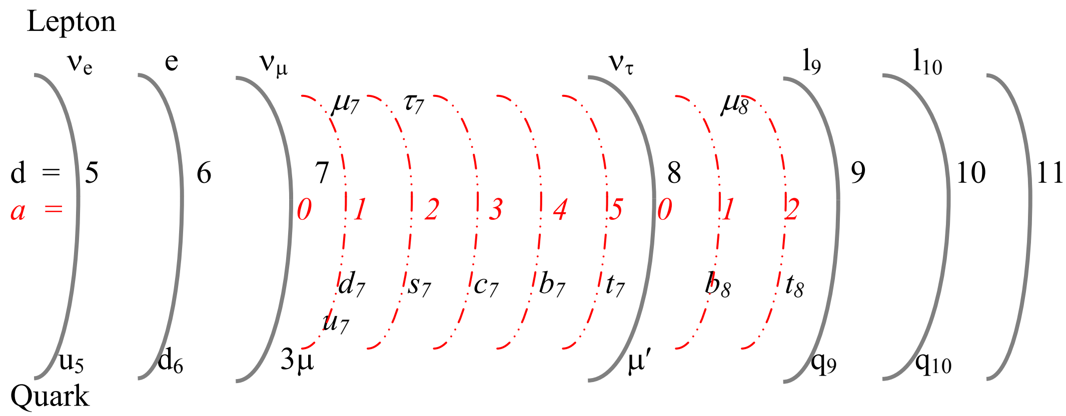


**Figure 8:** leptons and quarks in the principal and auxiliary dimensional orbitals d = principal dimensional orbital (solid line) number, a = auxiliary dimensional orbital (dot line) number

**Table 1.** The Periodic Table of Elementary Particles
d = principal dimensional orbital number, a = auxiliary dimensional orbital number

| D | a = 0 | 1 | 2 | a = 0 | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lepton | | | Quark | | | | | | Boson |
| 5 | $l_5 = \nu_e$ | | | $q_5 = u = 3\nu_e$ | | | | | | $B_5 = A$ |
| 6 | $l_6 = e$ | | | $q_6 = d = 3e$ | | | | | | $B_6 = \pi_{1/2}$ |
| 7 | $l_7 = \nu_\mu$ | $\mu_7$ | $\tau_7$ | $q_7 = 3\mu$ | $u_7/d_7$ | $s_7$ | $c_7$ | $b_7$ | $t_7$ | $B_7 = Z_L^0$ |
| 8 | $l_8 = \nu_\tau$ | $\mu_8$ (empty) | | $q_8 = \mu'$ | $b_8$ (empty) | $t_8$ | | | | $B_8 = X_R$ |
| 9 | $l_9$ | | | $q_9$ | | | | | | $B_9 = X_L$ |
| 10 | | | | | | | | | | $B_{10} = Z_R^0$ |
| 11 | | | | | | | | | | $B_{11}$ |

In Figure 8 and Table 1, d is the principal dimensional orbital number, and a is the auxiliary dimensional orbital number. (Note that $F_d$ has lower energy than $B_d$.)

### 4.2. The Boson Mass Formula

The principal dimensional orbitals are for gauge bosons of the force fields. For the gauge bosons, the seven orbitals of principal dimensional orbital are arranged as $F_5$ $B_5$ $F_6$ $B_6$ $F_7$ $B_7$ $F_8$ $B_8$ $F_9$ $B_9$ $F_{10}$ $B_{10}$ $F_{11}$ $B_{11}$, where B and F are boson and fermion in each orbital. The mass dimension in Eq. (17) becomes the orbitals in dimensional orbital with the same equations.

$$M_{\mathrm{d,F}} = M_{\mathrm{d,B}}\,\alpha_{\mathrm{d,B}}, \tag{32a}$$

$$M_{\mathrm{d-1,B}} = M_{\mathrm{d,F}}\,\alpha_{\mathrm{d,F}}, \tag{32b}$$

$$M_{\mathrm{d-1,B}} = M_{\mathrm{d,B}}\,\alpha_{\mathrm{d}}^2. \tag{32c}$$

where D is the dimensional orbital number from 6 to 11. $E_{5,B}$ and $E_{11,B}$ are the energies for the 5d dimensional orbital and the 11d dimensional orbital, respectively. The lowest energy is the Coulombic field,

$$E_{5,\mathrm{B}} = \alpha\, E_{6,F} = \alpha\, M_{\mathrm{e}}. \tag{33}$$

The bosons generated are the dimensional orbital bosons or $B_D$. Using only $\alpha_e$, the mass of electron ($M_e$), the mass of $Z^0$, and the number (seven) of dimensional orbitals, the masses of $B_D$ as the gauge boson can be calculated as shown in Table 2.

**Table 2.** The Masses of the dimensional orbital bosons:
$\alpha = \alpha_e$, d = dimensional orbital number

| $B_d$ | $M_d$ | GeV (calculated) | Gauge boson | Interaction, symmetry | Predecessor |
|---|---|---|---|---|---|
| $B_5$ | $M_e\, \alpha$ | $3.7 \times 10^{-6}$ | A | Electromagnetic, U(1) | Pre-charged |
| $B_6$ | $M_e/\alpha$ | $7 \times 10^{-2}$ | $\pi_{1/2}$ | Strong, SU(3) | Pre-strong |
| $B_7$ | $M_6/\alpha_w^2 \cos \theta_w$ | 91.177 (given) | $Z_L^0$ | weak (left), $SU(2)_L$ | Fractionalization (slicing) |
| $B_8$ | $M_7/\alpha^2$ | $1.7 \times 10^6$ | $X_R$ | CP (right) nonconservation | CP asymmetry |
| $B_9$ | $M_8/\alpha^2$ | $3.2 \times 10^{10}$ | $X_L$ | CP (left) nonconservation | CP asymmetry |
| $B_{10}$ | $M_9/\alpha^2$ | $6.0 \times 10^{14}$ | $Z_R^0$ | weak (right) | Fractionalization (slicing) |
| $B_{11}$ | $M_{10}/\alpha^2$ | $1.1 \times 10^{19}$ | G | Gravity | Pregravity |

In Table 2, $\alpha = \alpha_e$ (the fine structure constant for electromagnetic field), and $\alpha_w = \alpha/\sin^2 \theta_w$. $\alpha_w$ is not same as $\alpha$ of the rest, because as shown later, there is a mixing between $B_5$ and $B_7$ as the symmetry mixing between U(1) and SU(2) in the standard theory of the electroweak interaction, and $\sin\theta_w$ is not equal to 1. (The symmetrical charged dual pre-universe overlaps with the current asymmetrical universe for the weak interaction as shown earlier.) As shown later, $B_5$, $B_6$, $B_7$, $B_8$, $B_9$, and $B_{10}$ are A (massless photon), $\pi_{1/2}$ (half of pion), $Z_L^0$, $X_R$, $X_L$, and $Z_R^0$, respectively, responsible for the electromagnetic field, the strong interaction, the weak (left handed) interaction, the CP (right handed) nonconservation, the CP (left handed) nonconservation, and the P (right handed) nonconservation, respectively. The calculated value for $\alpha_w$ is 0.2973, and $\theta_w$ is $29.69^0$ in good agreement with $29.31^0$ for the observed value of $\theta_w$ [39]. The calculated energy for $B_{11}$ is $1.1 \times 10^{19}$ GeV in good agreement with the Planck mass, $1.2 \times 10^{19}$ GeV. The strong interaction, representing by $\pi_{1/2}$ (half of pion), is for the interactions among quarks, and for the hiding of individual quarks in the auxiliary orbital. The weak interaction, representing by $Z_L^0$, is for the interaction involving changing flavors (decomposition and condensation) among quarks and leptons.

There are dualities between dimensional orbitals and the cosmic evolution process. The pre-charged force, the pre-strong force, the fractionalization, the CP asymmetry, and the pregravity are the predecessors of electromagnetic force, the strong force, the weak interaction, the CP nonconservation, and gravity, respectively. These forces are manifested in the dimensional orbitals with various space-time symmetries and gauge symmetries. The strengths of these forces are different than their predecessors, and are arranged according to the dimensional orbitals. Only the 4d particle (baryonic matter) has the $B_5$, so without $B_5$, dark matter consists of permanently neutral higher dimensional particles. It cannot emit light, cannot form atoms, and exists as neutral gas.

The principal dimensional boson, $B_8$, is a CP violating boson, because $B_8$ is assumed to have the CP-violating $U(1)_R$ symmetry. The ratio of the force constants between the CP-invariant $W_L$ in $B_8$ and the CP-violating $X_R$ in $B_8$ is

$$\frac{G_8}{G_7} = \frac{\alpha\ E_7^2\ \cos^2\Theta_W}{\alpha_W\ E_8^2} \tag{34}$$
$$= 5.3\ X\ 10^{-10} \quad ,$$

which is in the same order as the ratio of the force constants between the CP-invariant weak interaction and the CP-violating interaction with $|\Delta S| = 2$.

The principal dimensional boson, $B_9$ ($X_L$), has the CP-violating $U(1)_L$ symmetry. $B_9$ generates matter. The ratio of force constants between $X_R$ with CP conservation and $X_L$ with CP-nonconservation is

$$\frac{G_9}{G_8} = \frac{\alpha E_8^2}{\alpha E_9^2}$$
$$= \alpha^4 \tag{35}$$
$$= 2.8\ X\ 10^{-9} \quad ,$$

which is the ratio of the numbers between matter (dark and baryonic) and photons in the universe. It is close to the ratio of the numbers between baryonic matter and photons about $5 \times 10^{-10}$ obtained by the Big Bang nucleosynthesis.

Auxiliary dimensional orbital is derived from principal dimensional orbital. It is for high-mass leptons and individual quarks. The combination of dimensional auxiliary dimensional orbitals constitutes the periodic table for elementary particles as shown in Figure 8 and Table 1.

There are two types of fermions in the periodic table of elementary particles: low-mass leptons and high-mass leptons and quarks. Low-mass leptons include $\nu_e$, e, $\nu_\mu$ , and $\nu_\tau$, which are in principal dimensional orbital, not in auxiliary dimensional orbital. $l_d$ is denoted as lepton with principal dimension number, d. $l_5$, $l_6$, $l_7$, and $l_8$ are $\nu_e$, e, $\nu_\mu$ , and $\nu_\tau$, respectively. All neutrinos have zero mass because of chiral symmetry (permanent chiral symmetry).

### 4.3. The Mass Composites of Leptons and Quarks

High-mass leptons and quarks include$\mu$, $\tau$, u, d, s, c, b, and t, which are the combinations of both principal dimensional fermions and auxiliary dimensional fermions. Each fermion can be defined by principal dimensional orbital numbers (d's) and auxiliary dimensional orbital numbers (a's) as $d_a$ in Table 3. For examples, e is $6_0$ that means it has d (principal dimensional orbital number) = 6 and a (auxiliary dimensional orbital number) = 0, so e is a principal dimensional fermion.

High-mass leptons, $\mu$ and $\tau$, are the combinations of principal dimensional fermions, e and $\nu_\mu$,, and auxiliary dimensional fermions. For example, $\mu$ is the combination of e, $\nu_\mu$,, and $\mu_7$, which is $7_1$ that has d = 7 and a = 1 .

Quarks are the combination of principal dimensional quarks ($q_d$) and auxiliary dimensional quarks. The principal dimensional fermion for quark is derived from principal dimensional lepton. To generate a principal dimensional quark in principal dimensional orbital from a lepton in the same principal dimensional orbital is to add the lepton to the boson from the combined lepton-antilepton. Thus, the mass of the quark is three times of the mass of the corresponding lepton in the same dimension. The equation for the mass of principal dimensional fermion for quark is

$$M_{q_d} = 3M_{l_d} \qquad (36)$$

For principal dimensional quarks, $q_5$ ($5_0$) and $q_6$ ($6_0$) are $3\nu_e$ and 3e, respectively. Since $l_7$ is massless $\nu_\mu$ , $\nu_\mu$ is replaced by μ, and $q_7$ is 3μ. Quarks are the combinations of principal dimensional quarks, $q_d$, and auxiliary dimensional quarks. For example, s quark is the combination of $q_6$ (3e), $q_7$ (3μ) and $s_7$ (auxiliary dimensional quark = $7_2$).

Each fermion can be defined by principal dimensional orbital numbers (d's) and auxiliary dimensional orbital numbers (a's). All leptons and quarks with d's, a's and the calculated masses are listed in Table 3.

**Table 3.** The Compositions and the Constituent Masses of Leptons and Quarks
d = principal dimensional orbital number and a = auxiliary dimensional orbital number

| | $d_a$ | Composition | Calculated Mass |
|---|---|---|---|
| Leptons | $d_a$ for leptons | | |
| $\nu_e$ | $5_0$ | $\nu_e$ | 0 |
| e | $6_0$ | e | 0.51 MeV (given) |
| $\nu_\mu$ | $7_0$ | $\nu_\mu$ | 0 |
| $\nu_\tau$ | $8_0$ | $\nu_\tau$ | 0 |
| μ | $6_0 + 7_0 + 7_1$ | $e + \nu_\mu + \mu_7$ | 105.6 MeV |
| τ | $6_0 + 7_0 + 7_2$ | $e + \nu_\mu + \tau_7$ | 1786 MeV |
| μ' | $6_0 + 7_0 + 7_2 + 8_0 + 8_1$ | $e + \nu_\mu + \mu_7 + \nu_\tau + \mu_{8\,(3/2\,Z^\circ)}$ | 136.9 GeV |
| $\mu'^\pm$ | $6_0 + 7_0 + 7_2 + 8_0 + 8_1^\pm$ | $e + \nu_\mu + \mu_7 + \nu_\tau + \mu_8^\pm{}_{(3/2\,W^\pm)}$ | 120.7 GeV |
| Quarks | $d_a$ for quarks | | |
| u | $5_0 + 7_0 + 7_1$ | $q_5 + q_7 + u_7$ | 330.8 MeV |
| d | $6_0 + 7_0 + 7_1$ | $q_6 + q_7 + d_7$ | 332.3 MeV |
| s | $6_0 + 7_0 + 7_2$ | $q_6 + q_7 + s_7$ | 558 MeV |
| c | $5_0 + 7_0 + 7_3$ | $q_5 + q_7 + c_7$ | 1701 MeV |
| b | $6_0 + 7_0 + 7_4$ | $q_6 + q_7 + b_7$ | 5318 MeV |
| t | $5_0 + 7_0 + 7_5 + 8_0 + 8_2$ | $q_5 + q_7 + t_7 + q_8 + t_8$ | 176.5 GeV |

### 4.4. The Lepton Formula

The principal dimensional fermion for heavy leptons (μ and τ) is e and $\nu_e$. Auxiliary dimensional fermion is derived from principal dimensional boson in the same way as Eq. (32) to relate the energies for fermion and boson. For the mass of auxiliary dimensional fermion (AF) from principal dimensional boson (B), the equation is Eq. (37).

$$M_{AF_{d,a}} = \frac{M_{B_{d-1,0}}}{\alpha_a} \sum_{a=0}^{a} a^4 \quad , \qquad (37)$$

where $\alpha_a$ = auxiliary dimensional fine structure constant, and a = auxiliary dimension number = 0 or integer. The first term, $\frac{M_{B_{D-1,0}}}{\alpha_a}$, of the mass formula (Eq.(37)) for the auxiliary dimensional fermions is derived from the mass equation, Eq. (32), for the principal dimensional fermions and bosons. The second term, $\sum_{a=0}^{a} a^4$, of the mass formula is for Bohr-Sommerfeld quantization for a charge - dipole interaction in a circular orbit as described by A. Barut [40]. As in Barut lepton mass formula, $1/\alpha_a$ is 3/2. The coefficient, 3/2, is to convert the principal dimensional boson mass to the mass of the auxiliary dimensional fermion in the higher dimension by adding the boson mass to its fermion mass which is one-half of the boson mass. Using Eq. (32), Eq. (37) becomes the formula for the mass of auxiliary dimensional fermions (AF).

$$\begin{aligned} M_{AF_{d,a}} &= \frac{3M_{B_{d-1,0}}}{2}\sum_{a=0}^{a} a^4 \\ &= \frac{3M_{F_{d-1,0}}}{2\alpha_{d-1}}\sum_{a=0}^{a} a^4 \\ &= \frac{3}{2}M_{F_{d,0}}\alpha_d\sum_{a=0}^{a} a^4 \end{aligned} \tag{38}$$

The mass of this auxiliary dimensional fermion is added to the sum of masses from the corresponding principal dimensional fermions (F's) with the same electric charge or the same dimension. The corresponding principal dimensional leptons for u (2/3 charge) and d (-1/3 charge) are $\nu_e$ (0 charge) and e (-1 charge), respectively, by adding –2/3 charge to the charges of u and d [41]. The fermion mass formula for heavy leptons is derived as follows.

$$\begin{aligned} M_{F_{d,a}} &= \sum M_F + M_{AF_{d,a}} \\ &= \sum M_F + \frac{3M_{B_{d-1,0}}}{2}\sum_{a=0}^{a} a^4 \end{aligned} \tag{39a}$$

$$= \sum M_F + \frac{3M_{F_{d-1,0}}}{2\alpha_{d-1}}\sum_{a=0}^{a} a^4 \tag{39b}$$

$$= \sum M_F + \frac{3}{2}M_{F_{d,0}}\alpha_d\sum_{a=0}^{a} a^4 \tag{39c}$$

Eq. (39b) is for the calculations of the masses of leptons. The principal dimensional fermion in the first term is e. Eq. (39b) can be rewritten as Eq. (39d).

$$M_a = M_e + \frac{3M_e}{2\alpha} \sum_{a=0}^{a} a^4 , \qquad (39d)$$

a = 0, 1, and 2 are for e, μ, and τ, respectively. It is identical to the Barut lepton mass formula.

**4.5. The Quark Mass Formula**

The auxiliary dimensional quarks except a part of t quark are $q_7$'s. Eq.(39c) is used to calculate the masses of quarks. The principal dimensional quarks include $3\nu_\mu$ , 3e, and 3μ., $\alpha_7 = \alpha_w$, and $q_7 = 3\mu$. Eq. (39c) can be rewritten as the quark mass formula.

$$M_q = \sum M_F + \frac{3\alpha_w M_{3\mu}}{2} \sum_{a=0}^{a} a^4 , \qquad (40)$$

where a = 1, 2, 3, 4, and 5 for u/d, s, c, b, and a part of t, respectively.

To match $l_8$ ($\nu_\tau$), quarks include $q_8$ as a part of t quark. In the same way that $q_7$ = 3μ , $q_8$ involves μ'. μ' is the sum of e, μ, and $\mu_8$ (auxiliary dimensional lepton). Using Eq. (39a), the mass of $\mu_8$ is equal to 3/2 of the mass of $B_7$, which is $Z^0$, and the mass of $\mu_8^\pm$ is equal to 3/2 of the mass of $B_7^\pm$, which is $W^\pm$.

$$\begin{aligned}
&\mu_8 = \frac{3}{2} Z^0 \\
&\mu' = 6_0 + 7_0 + 7_2 + 8_0 + 8_1 = \ e + \nu_\mu + \mu_7 + \nu_\tau + \mu_8 \\
&\mu_8^{\pm} = \frac{3}{2} W^{\pm} \qquad (41) \\
&\mu'^{\pm} = 6_0 + 7_0 + 7_2 + 8_0 + 8_1^{\pm} = \ e + \nu_\mu + \mu_7 + \nu_\tau + \mu_8^{\pm}
\end{aligned}$$

The masses of the forbidden leptons μ' and $\mu'^{\pm}$ are 136.9 GeV and 120.7 GeV, respectively. Because there are only three lepton families, μ' and $\mu'^{\pm}$ are the extra leptons, which are the forbidden leptons as described in Chapter 1, and they exist as the lepton condensate. The forbidden leptons derived the W boson and Z boson are partly responsible to the high mass of top quark.

The principal dimensional quark $q_8$ = μ' instead of 3μ', because μ' is hidden, and $q_8$ does not need to be 3μ' to be different. Using the equation similar to Eq.(40), the calculation for t quark involves $\alpha_8 = \alpha$ , μ' instead of 3μ for principal fermion, and a = 1 and 2 for $b_8$ and $t_8$, respectively. The hiding of μ' for leptons is balanced by the hiding of $b_8$ for quarks.

The calculated masses are in good agreement with the observed constituent masses of leptons and quarks [42]. The mass of the top quark [43] is 172.9±1.5 GeV in a good agreement with the calculated value, 176.5 GeV. All elementary particles (gauge bosons, leptons, and quarks) are in the periodic system of elementary particles with the calculated masses in good agreement with the observed values by using only four known constants: the number of the extra spatial dimensions in the eleven-dimensional membrane, the mass of electron, the mass of Z boson, and the fine structure constant.

With the masses of quarks calculated by the periodic table of elementary particles, the masses of all hardrons can be calculated [38] as the composes of quarks, as molecules are the composes of atoms. The calculated values are in good agreement with the observed values. For examples, the calculated masses of neutron and pion are 939.54MeV, and 135.01MeV in excellent agreement with the observed masses, 939.57 MeV and 134.98 MeV, respectively. At different temperatures, the strong force (QCD) among quarks in hadrons behaves differently to follow different dimensional orbitals [38].

### 4.6. Summary

For baryonic matter, the incorporation of detachment space for baryonic matter brings about "the dimensional orbitals" as the base for the periodic table of elementary particles for all leptons, quarks, and gauge bosons. The masses of gauge bosons, leptons, quarks can be calculated using only four known constants: the number of the extra spatial dimensions in the eleven-dimensional membrane, the mass of electron, the mass of Z°, and the fine structure constant. The calculated values are in good agreement with the observed values. The differences in dimensional orbitals result in incompatible dark matter and baryonic matter. The masses of the forbidden leptons μ' and $\mu'^{\pm}$ are 136.9 GeV and 120.7 GeV, respectively. Because there are only three lepton families, μ' and $\mu'^{\pm}$ are the extra leptons, which are the forbidden leptons, and they exist as the lepton condensate. The forbidden leptons derived the W boson and Z boson are partly responsible to the high mass of top quark.

## 5. SUMMARY

The observed Higgs boson at the LHC (Large Hadron Collider) is the Avatar Higgs boson as the dual SM (Standard Model) Higgs boson-forbidden lepton condensate. The SM Higgs boson is filled with the forbidden lepton condensate to become the Avatar Higgs boson. The forbidden lepton is outside of the SM three lepton families, so the single forbidden lepton cannot exist alone, and the forbidden lepton can exist only in the forbidden lepton condensate as the composite of forbidden lepton-antilepton. Unable to decay into the SM leptons and quarks, the forbidden lepton condensate decays into diphoton to account for the observed excess diphoton deviated from the Standard Model. Other decay modes of the Avatar Higgs boson follow the decay modes of the SM Higgs boson as observed. The calculated mass of the forbidden lepton condensate is 128.8 GeV in good agreements with the observed 125 or 126 GeV.

The Higgs boson is the Goldstone boson in the Standard Model for the electroweak interaction. The transformation (spontaneous symmetry breaking) between massive particle and massless particle is through the massless scalar Goldstone boson. The addition of the Goldstone boson to a massless particle results in a massive particle. Near the beginning of our universe, the addition of the Goldstone boson converted some massless particles to massive particles to differentiate different forces and particles. During this process for the symmetry breaking in the electroweak force, the remnant of the Higgs boson acquired the mass of the forbidden lepton condensate to become the Avatar Higgs boson.

In this paper, the space-object structures, cosmology, the periodic table of elementary particles are described. The unified theory of physics is based on the space-object structures: the space structure and the object structure. The space structure includes attachment space and detachment space. Relating to rest mass, attachment space attaches to object permanently with zero speed. Relating to kinetic energy, detachment space detaches from the object at the speed of light. The transformation between attachment space and detachment space is through the Goldstone boson. The combination of attachment space and detachment space brings about three different space structures: miscible space, binary lattice space, and binary partition space for special relativity, quantum mechanics, and the extreme force fields, respectively. The object structure consists of 11D membrane, 10D string, variable D particle, and empty object. The transformation among the objects is through the dimensional oscillation that involves the oscillation between high dimensional space-time with high vacuum energy and low dimensional space-time with low vacuum energy. The cosmology derived from the transformation from the 11-dimensional membrane universe to our 4D particle universe accounts for the origins of the four force fields, dark energy, dark matter, baryonic matter, and the Big Bang. The calculated percentages of dark energy, dark matter, and baryonic matter are in agreement with the observed values. The unified theory places all elementary particles in the periodic table of elementary particles with the calculated masses in good agreement with the observed values.

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