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The Clifford-Finslerian Linked-Field Leads Branching Multiverse

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Abstract

Focusing on the issue of multiverse, the physical linked-measure contributes the Clifford-Finslerian linked-field, which generates branching multiverse. While Clifford algebra supplies interior dynamics for generating inner branching structure, Finsler geometry provides catastrophic branches of space-time metric and curvature, as exterior dynamics. The branching multiverse is different from countless multiverse, as the branches are deterministic and based on mainstem, where all branches integrate and produce limited multiverse. The contribution let the multiverse get rid of puzzle from a non-scientific term, then return to the correct path for approaching real physics. Meanwhile, with keeping the tradition of analytical mechanics, the wave-particle duality is clearly interpreted at both micro-level and macro-level and the cosmological model is suggested to verify its curvature change.

Keywords

Clifford-Finslerian Unification, Linked-Field, Unified Field, Multiverse, Branching, Cosmological Model

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1. Introduction

After Everett contributed his relative state [1] and DeWitt subsequently introduced the "many-worlds interpretation (MWI)" [2] to describe a complete measurement history of an observer, the idea of multiverse had gradually developed to become a popular concept in the academic world [3], though it never became real physics. Physically, Everett's relative state formulation makes two assumptions. The first is that the wave function is not simply a description of the object's state, but that it actually is entirely equivalent to the object, a claim it has in common with some other interpretations. The second is that observation or measurement has no special laws or mechanics, unlike in the Copenhagen interpretation which considers the wave function collapse as a special kind of event which occurs as a result of observation. Instead, measurement in the relative state formulation is the consequence of a configuration change in the memory of an observer described by the same basic wave physics as the object being modeled. When one modelled an isolated quantum system subject to external observation, one could mathematically model an object as well as its observers as purely physical systems.

Following Everett's original work, there have appeared a number of similar formalisms as the many-worlds or multiple universes (multiverse) interpretation, where one had referred to the combined observer–object system as being split by an observation, each split corresponding to the different or multiple possible outcomes of an observation. The multiverse had been hypothesized in astronomy, cosmology, physics, philosophy, religion, as well as in science fiction and fantasy, with using various terms such as "parallel universes", "alternate universes", "quantum universes", "parallel worlds", "parallel dimensions", "alternate realities", "alternate timelines", "interpenetrating dimensions", "dimensional planes", and so on. Actually, the multiverse is only a hypothesis, in which there are a set of infinite or finite possible universes that together comprise everything that exists.

In representative multiverse "models", let us mention

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Tegmark's four levels [4] and Green's nine types [5].

The four level “model” gave a taxonomy of universes beyond the familiar observable universe, where the four levels are arranged such that subsequent levels can be understood to encompass and expand upon previous levels, including level I (where a generic prediction of chaotic inflation is an infinite ergodic universe, which, being infinite, must contain Hubble volumes realizing all initial conditions), level II (where there exist "Bubble universes", and each bubble universe has its special physical constants. The different bubbles cover Universe 1 to Universe 6, and they have different physical constants. Our universe is just one of the bubbles), level III (where multiverse does not contain more possibilities in the Hubble volume than a level I-II multiverse, and "Multiverse = Quantum Many Worlds"), and level IV (which is a mathematical universe hypothesis. This level considers equally real all universes that can be described by different mathematical structures as ultimate ensemble).

The nine type “model” told us there are nine parallel universes: 1) Quilted multiverse, which works only in an infinite universe. In the universe, every possible event may occur an infinite number of times, with an infinite amount of space. However, the speed of light prevents us from being aware of these other identical areas. 2) Inflationary multiverse, which is composed of various pockets where inflation fields collapse and form new universes. 3) Brane multiverse, which follows from M-theory and states that our universe is a 3-dimensional brane that exists with many others on a higher-dimensional brane or "bulk". Particles are bound to their respective branes except for gravity. 4) Cyclic multiverse, which has multiple branes (each a universe) that collided, causing Big Bangs. The universes bounce back and pass through time, until they are pulled back together and again collide, destroying the old contents and creating them anew, via the ekpyrotic scenario. 5) Landscape multiverse, which relies on string theory's Calabi–Yau manifolds. Quantum fluctuations drop the manifolds to a lower energy level, creating a pocket with a different set of laws from the surrounding space. 6) Quantum multiverse, which creates a new universe when a diversion in events occurs, as in the many-worlds interpretation of quantum mechanics. 7) Holographic multiverse, which is derived from the theory that the surface area of a space can simulate the volume of the region. 8) Simulated multiverse, which exists on complex computer systems that simulate entire universes. 9) Ultimate multiverse, which contains every mathematically possible universe under different laws of physics. Certainly, all things in different universe never meet each other.

However, the physics community continues to fiercely debate the multiverse hypothesis. Serious concerns have been raised about whether attempts to exempt the multiverse from experimental verification may erode public confidence in science and ultimately damage the nature of fundamental physics. Although there are some active proponents such as Brian Greene and Max Tegmark, there are also many skeptics including Roger Penrose [6] and Steven Weinberg [7], who disagree about whether the multiverse may exist, and whether it is even a legitimate topic of scientific inquiry.

Now, under the framework of multi-vector methodology [8-9], the multiverse would become deterministic and could be characterized by branching, if the Clifford algebraic structure and Finsler geometry provided the real description of the physical universe via the linked-measure and the linked-field [10-11], leading to branching construction[12]. Here we formulate a methodological approach for characterizing the branching multiverse.

2. The Clifford-Finslerian Construction

At first, let’s consider Clifford algebraic branching structure and Finsler geometric catastrophic structure respectively.

2.1. Clifford Algebra as Interior Dynamics

Supposing the space-time point x be based on Dirac frame $\{\gamma^{\mu}, \mu = 0,1,2,3\}$, there are

$$x = x_{\mu}\gamma^{\mu}, x_{\mu} = \gamma^{\mu} x \quad (1)$$

The coordinates’ transformation will be

$$x_{\mu} \to x'_{\mu} = \alpha^{\nu}_{\mu} x_{\nu}; \gamma^{\mu} \to \gamma'^{\mu} = \alpha^{\mu}_{\nu}\gamma^{\nu} \quad (2)$$

where four Dirac matrices are viewed as four orthonormal basis vectors for 4D Riemann-Finslerian space-time and $\alpha^{\mu}_{\nu}\alpha^{\nu}_{\lambda} = \delta^{\mu}_{\lambda}$, in which γ^{0} is time-like vector and $\gamma^{k}(k = 1,2,3)$ space-like vectors. Similarly, the three Pauli matrices $\sigma^{k} = (\sigma^{1}, \sigma^{2}, \sigma^{3})$ are viewed as three orthonormal basis vectors for 3D Euclidean space.

For a multi-vector M_k (k = 0, 1, 2, 3, 4), where M_k is a multi-vector of grade k. k=0 corresponds to scalar, k=1 to vector, k=2 to bivector, k=3 to pseudovector and k=4 to pseudoscalar, and the bases of 4D space-time is generated by four orthonormal vectors $\{\gamma^{\mu}, \mu = 0,1,2,3\}$ and spanned by 1(1 scalar at grade 0), $\{\gamma^{\mu}\}$(4 vectors at grade 1), $\{\sigma^{k}, i\sigma^{k}\}$ (6 bivectors at grade 2), $\{i\gamma^{\mu}\}$(4 pseudovectors at grade 3) and i(1 pseudoscalar at grade 4) orderly.

Now we write a multi-vector as

$$M = M_0 + M_1 + M_2 + M_3 + M_4 = \varphi + V + B + iU + i\theta = \psi + A + B = (\psi, A, B) \quad (3)$$

in which ψ=φ+iθ constructs a complex scalar function (wave-like function), while A=V+iU forms a complex vector function (particle-like function) and $B=(1/2)B_{\mu\nu}\gamma^{\mu}\wedge\gamma^{\nu}$ as a unique bivector (span-like function).

The space-time conjugation of M is $\overline{M}$

$$\overline{M}=-iMi=M_0-M_1+M_2-M_3+M_4=\psi-A+B=(\psi,-A,B) \quad (4)$$

The revised conjugation is denoted as $\widetilde{M}$

$$\widetilde{M}=\widetilde{M}_0+\widetilde{M}_1+\widetilde{M}_2+\widetilde{M}_3+\widetilde{M}_4=\varphi+V-B-iU+i\theta=(\psi,\overline{A},-B) \quad (5)$$

And M can be divided as even part M_+ and odd part M_-, as follows.

$$M_+=\varphi+B+i\theta=\psi+B=(\psi,B) \quad (6)$$

$$M_-=V+iU=A \quad (7)$$

These give asymmetry algebraic structure. If M is divided by following two parts

$$Q_+=\varphi+A=(\varphi,A) \quad (8)$$

$$Q_-=B+i\theta=(B,\theta) \quad (9)$$

These provide another asymmetry structure, where A represents a 3D vector and the set of four unit multi-vectors become {1, i, j, k}, with $i^2=j^2=k^2=ijk=-1$ and $ij=-ji=k, jk=-kj=i, ki=-ik=j$, making up a basis for (φ, A). The sub-algebra Q_+ constructs a linear space of four dimensions and its elements just are quaternions, and quaternions are spinors. Quaternions and spinors have equivalent algebraic properties as well as the same geometric significance, which all belong to multi-vectors M.

When we view the M as a root, M_+, M_-, Q_+, and Q_- look main stems, which may lead to interesting algebraic branch structure and produce branching multiverse.

Suppose ℝ, ℂ, and ℍ denote respectively real, complex, and quaternion fields. For a complex $Z=(X,X')$ with X∈ℝ, record Re(Z)=X and Im(Z)=X', called the real part and imaginary part respectively, so that a quaternion Q has its dual complex construction as

$$Q=(Z,Z')=q_0+q_1i+q_2j+q_3k\subset M \quad (10)$$

with Z∈ℂ, record Sa(Q)=Z and Pu(Q)=Z',

As scalar $q_0=\phi$ and the vector $(q_1,q_2,q_3)=A$, forming the scalar part and vector or pure quaternion part respectively, a quaternion Q has also its scalar-vector construction (φ, A), called Hamilton presentation, as follows

$$Q=(\varphi,A)=\varphi+A\subset M \quad (11)$$

And its conjugation is

$$\overline{Q}=(\overline{Z},-Z')=(\varphi,-A)\subset\overline{M} \quad (12)$$

with $\overline{\overline{Q}}=Q$ and norm $Q\overline{Q}=\overline{Q}Q=|Q|^2=\sum_{i=0}^{3}q_i^2$.

Meanwhile, a quaternion has also an equivalent scalar-vector construction which is called the Pauli representation as

$$Q=(\varphi,-A)=\varphi^0\sigma_0-A^1\sigma_1-A^2\sigma_2-A^3\sigma_3 \quad (13)$$

We see that Eq.(13) is the same to Eq. (12), the conjugation of Eq. (11), as $Q\sigma_i\overline{Q}=\sigma_i$, which means that the Pauli representation and Hamilton representation become conjugations each other. The algebraic structure shows that the Hamilton representation and Pauli representation exist naturally for a quaternion, which constructs a conjugation pair.

Then we have

$$Sa(Q)=\frac{1}{2}(Q+\overline{Q})\in\mathbb{R} \quad (14)$$

and

$$Pu(Q)=\frac{1}{2}(Q-\overline{Q})\in\mathbb{P} \quad (15)$$

where ℍ= ℝ⊕ℙ and ℙ constructs 3-dimentional Euclidean vector space.

When we do the multiplication and analysis of quaternion [13], there will generate a Cayley-Dickson branch and a Euclid-Grassmann branch further, in which the Cayley-Dickson branch is generated by the multiplication of quaternion Q_i and quaternion Q_j with the form of the dual complex function form as

$$Q_iQ_j=(Z_i,Z_i')(Z_j,Z_j')=(Z_iZ_j-Z_j'\overline{Z_i'},\overline{Z_i}Z_j'+Z_i'Z_j) \quad (16)$$

And the Euclid-Grassmann branch is produced by the multiplication of quaternion Q_i and quaternion Q_j with the form of scalar-vector form as

$$Q_iQ_j=(\varphi_i,A_i)(\varphi_j,A_j)=(\varphi_i\varphi_j-A_i\cdot A_j,\varphi_iA_j+A_i\varphi_j+A_i\wedge A_j) \quad (17)$$

or

$$Q_i*Q_j=(\varphi_i,A_j)*(\varphi_i,A_j)=(\varphi_i\varphi_j+A_i\cdot A_j,\varphi_iA_j-A_i\varphi_j-A_i\wedge A_j) \quad (18)$$

Where ∧ is Wedge product and a∧b=−b∧a.

Since (17) and (18) co-exist, we have

$$Q_iQ_j=(Z_iZ_j-Z_j'\overline{Z_i},\overline{Z_i}Z_j'+Z_i'Z_j)=(\varphi_i\varphi_j-A_i\cdot A_j,\varphi_iA_j+A_i\varphi_j-A_j\wedge A_i) \quad (19)$$

Both Cayley-Dickson branch and the Euclid-Grassmann branch belong to the Clifford algebraic branches, which are driven by interior sources, so that the Clifford algebra supplies inner branching structure as interior dynamics, which looks like gene action and establishes the foundations of branching.

2.2. Finsler Geometry and Catastrophic Theory Leads Space-Time Branching

In Finsler geometry, according to Chern's analysis [14], there is a Chern connection form ω_j^i in Finsler bundle p*TM→PTM as the unique solution of structural equations

$$d\omega^i = \omega^j \wedge \omega_j^i \tag{20}$$

and

$$\omega_{ij} + \omega_{ji} = -2A_{ijk}\omega_m^k \tag{21}$$

in which $\omega_{ij} = \omega_i^k \delta_{kj}$, and $A = A_{ijk}\omega^i \otimes \omega^j \otimes \omega^k$ is a Cartan tensor. The Finsler structure becomes Riemann structure if A=0. And the curvature of the Chern connection is

$$\Omega_k^i = \frac{1}{2}R_{kjl}^i\omega^j \wedge \omega^l + P_{kjn}^i\omega^j \wedge \omega_m^n = \Omega(R) + \Omega(P) \tag{22}$$

where R-part is horizon-horizon (1^{st} Chern) curvature and P-part is horizon-vertical (2^{st} Chern) curvature. When there is no P-part, a Finsler curvature becomes a Riemann curvature.

For a function f, there is its Hessian matrix as

$$H = [\frac{\partial^2 f}{\partial x_i \partial y_j}] \tag{23}$$

If $\det H = 0$, there is $\nabla f = 0$. If $\det H \neq 0$, there is $f = M_i^2$, i.e. Morse saddle.

Referring catastrophic theory [15-16], let's define Finsler space-time metric function as

$$f(t,x,y,z) = (ct)^4 + x^4 + y^4 + z^4 - 2(ct)^2x^2 + 2y^2z^2 \tag{24}$$

In its critical point, there is

$$f = \frac{\partial f}{\partial t} = \frac{\partial f}{\partial x} = \frac{\partial f}{\partial y} = \frac{\partial f}{\partial z} = 0 \tag{25}$$

which produces two branches $x = \pm ct$ and $t = x = y = x = 0$, leading to following two parts of the stable Hessian sub-matrices with

$$\det H(t,x) = -48[(ct)^4 + x^4 - 2(ct)^2x^2] = 0 \tag{26}$$

$$\det H(y,z) = 48(y^2+z^2)^2 \neq 0 \tag{27}$$

so that the space-time are concluded four parts: $(ct)^2 - x = 0$, which denotes critical plane; $(ct)^2 - x > 0$, which indicates time-like area; $(ct)^2 - x < 0$, which marks space-like area; $t = x = 0$, which is zero point.

Then the Finslerian space-time metric ds is characterized by the Lorentz-Cao formula [17]

$$ds^4 = c^4(1-\beta^2)^2 dt^4, \beta = v / c \tag{28}$$

in which we see that there is a fractal factor within a typical catastrophic branching

$$B = \lambda(\alpha^2 - \beta^2)^2 \tag{29}$$

If λ ≠0, (29) also includes four branches as

$$(\alpha^2 - \beta^2)^2 = (\alpha - \beta)^2(\alpha + \beta)^2 \tag{30}$$

Mathematically, catastrophe theory as a branch of bifurcation theory in dynamical systems just gave a special case of more general singularity theory in geometry, which constructs geometric bifurcation, leading to space-time branching.

The Clifford-Finslerian branching structure provides a general mathematical structure for multiverse, where it seems that Clifford algebraic branches engine interior branching dynamics and Finsler geometric branches determine exterior branching dynamics.

3. Analytical Structure and Wave-Particle Duality

Mathematically, a multi-vector contains a complex scalar, a complex vector and a bivector, which provides rich structural information. Physically, a multi-vector can be applied as linked-measure [11].

The differential operators of the derivatives can be introduced and defined as

$$\partial_\mu = \frac{\partial}{\partial x_\mu};\ D_\mu = (\partial_\mu - \omega_\mu) \tag{31}$$

$$\nabla = \gamma^\mu \partial_\mu; \nabla^2 = g^{\mu\nu}\partial_\mu\partial_\nu; g^{\mu\nu} = \gamma^\mu \cdot \gamma^\nu \tag{32}$$

where space-time metric $g^{\mu\nu}$ is naturally generated.

Then the linked-energy E and linked-momenta p_μ with linking Hamilton function H and Lagrangian function L can be defined as follows

$$H = \frac{\partial L}{\partial \dot{x}_\mu} \cdot x_\mu - L = p_\mu x_\mu - L = E(s,t) = \int_s (M/V)dt \tag{33}$$

$$L = p_\mu x_\mu - H; p_\mu = \frac{\partial L}{\partial x_\mu} \quad (34)$$

where V denotes volume of space so that M/V means density function of linked measure in space. So the energy-mass conservation is extended to energy-mass-momentum-angular momentum joint conservation, and Hamilton principle keeps in analytical center of physics.

3.1. Field Equations

For keeping gauge invariance, we suppose the transformations as

$$\psi \to \psi' = e^{i\omega}\psi; \overline{\psi} \to \overline{\psi}' e^{-i\omega} \quad (35)$$

$$A_\mu \to A'_\mu = A_\mu + \partial_\mu \omega; \overline{A}_\mu \to \overline{A}'_\mu = \overline{A}_\mu - \partial_\mu \omega \quad (36)$$

$$B_\mu \to B'_\mu = B_\mu + D_\mu \omega; \overline{B}_\mu \to \overline{B}'_\mu = \overline{B}_\mu - D_\mu \omega \quad (37)$$

So the linked-measures construct the linked-field. In Riemann-Einstein space-time, we had following field equation [11]

$$T_{\mu\nu} + p(\psi) - q(A) = G_{\mu\nu} = \Omega_{\mu\nu} = k(R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R) \quad (38)$$

where $G_{\mu\nu}$ is Einstein tensor, $\Omega_{\mu\nu}$ is curvature tensor and $T_{\mu\nu}$ denotes the total observational tensor (e.g. energy-momentum tensor), positive p(ψ) integrates all positive items of the linked-field and negative q(A) integrates all negative items of the linked-field, where the left side denotes physical effects while the right side indicates mathematical means.

When Finslerian curvature (22) is applied, the total observational tensor equals to the total curvature as

$$T_{\mu\nu} = \Omega(R)_{\mu\nu} + \Omega(P)_{\mu\nu} = k(R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R) + q(A) - p(\psi) \quad (39)$$

Eq. (39) shows that q(A) − p(ψ) contributes the P-part of space-time curvature, while the R-part supplies Riemann curvature of space-time, which is just the results of general relativity: when the P-part of Finslerian curvature is ignored, the field equation returns to Einstein equation

$$T_{\mu\nu} = G_{\mu\nu} = k(R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R) \quad (40)$$

Thus we see the analytical equation matches general relativity and standard cosmology.

3.2. An Interpretation of Wave-Particle Duality

Totally, micro-particle and macro-cosmos can be unitedly measured by measure M = (ψ, A, B), in which ψ=φ+iθ is just a complex scalar particle-bias (massive) function and A=V+iU looks a complex vector wave-bias (potential) function while B characterizes spin (rotation). Meanwhile, M is also the measure of total energy. When the energy distributes bias ψ, the particle looks like real particle and there is in M

$$\psi > A \subset M \quad (41)$$

When the energy distributes bias A, the particle looks wave and there is in M

$$\psi < A \subset M \quad (42)$$

So that the even part M_+ and odd part M_- just describe particle-bias distribution and wave-bias distribution respectively.

Since ψ and A are particle-bias function and wave-bias function respectively, the M will look like particle if ψ >> A; and the M will look like wave if ψ << A. As M =(ψ, A, B) becomes unified linked-measure for both micro-particle and macro-cosmos, all things have wave-particle duality. For micro-particle, the energy changes easily between ψ and A, so that the micro-particle looks obvious wave-particle duality. For macro-things, the mass-energy concentrates and keeps mostly in ψ, so that there is no obviously observed wave-particle duality. When vortex [18] becomes general methodological approach for both micro- and macro-things, the world can be naturally and unitedly approached by vortex-particles and vortex-fields.

4. Branching Multiverse

Synthesizing Clifford algebra and Finsler geometry, branching space-time is naturally derived.

Rooted by the linked-measure M, four types of main stems, M_+, M_-, Q_+, Q_-, can be generated. Stemmed by Q_+, the Cayley-Dickson branch and the Euclid-Grassmann branch can be produced, as shown as Figure 1, based on mainstem.

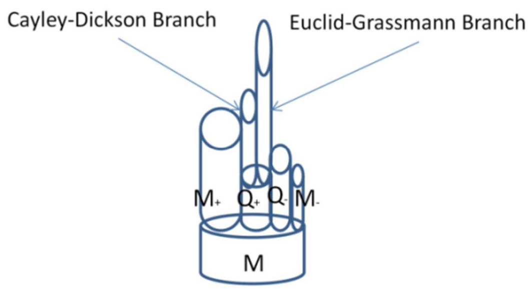

Fig. 1. The branching multiverse: limited branches.

So, there are only limited branches in the branching multiverse, where there are 1 (M), 2(M_+, M_- or Q_+, Q_-), 3(M, M_+, M_- or M, Q_+, Q_-), 4(M_+, M_-, Q_+, Q_-), 5(M_+, M_-, Q_+, Q_-, and Q_+ divides two sub-branches), or 6(M, M_+, M_-, Q_+, Q_-, and Q_+ divides two sub-branches) basic branches (more branches will be their multiples). Figure 1 looks a universe organ, on which it is expected to verify that our fingers are not occasional in the universe. This is a real universal holography.

Meanwhile, the branching multiverse belongs actually to a unified universe, where all branches have same "root". In different branches, there may be different physical constants. However, there are unified physical laws in the "root" universe. Otherwise, we cannot understand our universe and branching multiverse physically.

In the double-dynamic cosmos [11] and the branching universe, possible evolution of cosmological curvature should be changed from big to small and each branch might have its unique curvature, which could provide experimental ways for verifying the suggested cosmological model.

5. Discussion and Criticism

There were two artificial "principles" for interpreting the multiverse, holographic principle [19] and anthropic principle [20].

The holographic principle was inspired by black hole thermodynamics, which conjectures that the maximal entropy in any region scales with the radius squared, and not cubed as might be expected. In the case of a black hole, the insight was that the informational content of all the objects that have fallen into the hole might be entirely contained in surface fluctuations of the event horizon. The holographic principle resolves the black hole information paradox within the framework of string theory or M-theory [21], where a multiverse of a somewhat different kind has been envisaged within string theory and its higher-dimensional extension. These theories require the presence of 10 or 11 space-time dimensions, in which extra 6 or 7 dimensions may either be compactified on a very small scale and our universe may simply be localized on a dynamical (3+1)-dimensional object, a D-brane. As there exist classical solutions to the Einstein equations that allow values of the entropy larger than those allowed by an area law, hence in principle larger than those of a black hole. The holographic principle is a property of string theories and a supposed property of quantum gravity that states that the description of a volume of space can be thought of as encoded on a boundary to the region, preferably a light-like boundary like a gravitational horizon.

The anthropic principle is the philosophical consideration that observations of the universe must be compatible with the conscious and sapient life that observes it. Some proponents of the anthropic principle reason that it explains why the universe has the age and the fundamental physical constants necessary to accommodate conscious life. While the strong anthropic principle (SAP) states that this is all the case because the universe is compelled to eventually have conscious and sapient life emerge within it, the weak anthropic principle (WAP) states that the universe's ostensible fine tuning is the result of selection bias, i.e. only in a universe capable of eventually supporting life will there be living beings capable of observing and reflecting upon fine tuning. The key issue of anthropic principle concerns that other universes has been proposed to explain how our own universe appears to be fine-tuned for conscious life as we experience it. If there were a number of universes, each with possibly different physical laws or different fundamental physical constants, some of these universes, even if very few, would have the combination of laws and fundamental parameters that are suitable for the development of matter, astronomical structures, elemental diversity, stars and planets that can exist long enough for life to emerge and evolve. The weak anthropic principle could then be applied to conclude that we (as conscious beings) would only exist in one of those few universes that happened to be finely tuned, permitting the existence of life with developed consciousness.

However, above interpretations belong to philosophical views, unless we can find physical evidences. A data analysis from Wilkinson Microwave Anisotropy Probe (WMAP) claimed to find preliminary evidence suggesting that our universe collided with other parallel universes in the distant past, but a more thorough analysis of data from the Planck satellite [22], which has a resolution 3 times higher than WMAP, failed to find any statistically significant evidence of such a bubble universe collision. In addition, there is no evidence of any gravitational pull of other universes on ours.

Actually, the multiverse is philosophical rather than scientific because it lacks falsifiability, and the ability to disprove a theory by means of scientific experiment has always been part of the accepted scientific method. Not only there is no experiment that can rule out a theory if it provides for all possible outcomes, but also there exist too many possibilities [23-25].

According to the image of branching multiverse, physical even biological branches are generally natural phenomena in the universe, so that we see the rich branching phenomena in the world. Because there are different exterior environments, complete symmetry seldom happens in nature, even if the same "genes" drive as interior dynamics. Different genes and different environments will introduce different branching, various branches can be produced and form fractals at the ends, via the fundamental mathematical mechanism of the Clifford-Finslerian branching.

The situation shows that the multiverse is possible. However, the multiverse is branching from 1 to 6 basic types (others belong to their combination), not arbitrary or chaos. So, branching multiverse is different from the countless multiverse based on anthropic principle.

It is expected that this contribution get rid of puzzle that multiverse is only a non-scientific image, then return to the correct path for approaching real physics [26].

6. Conclusion

Conclusively, the Clifford-Finslerian linked-field generates branching multiverse. While Clifford algebra supplies interior dynamics for generating inner branching structure, Finsler geometry provides catastrophic branches of space-time metric and curvature, as exterior dynamics. Based on dual-complex representation, Hamilton representation and Pauli representation of quaternion, the multiplication of quaternions generates Cayley-Dickson branch and Euclid-Grassmann branch, which causes limited branching multiverse.

The branching multiverse is different from countless multiverse, as the branches are deterministic, where all branches integrate and produce limited multiverse. Although there might be different physical constants in different branches, there should follow unified physical laws in the "root" universe. Meanwhile, with keeping the tradition of analytical mechanics, the wave-particle duality can be clearly interpreted at both micro-level and macro-level. The branching multiverse looks a reasonable physical choice of multiverse rather than philosophical one, which provides a feasible theoretical framework for interpreting physical even biological branching phenomena in the universe. Furthermore, as the Clifford-Finslerian linked-field leads to branching multiverse, the multiverse can get rid of the puzzle from a non-scientific term then return to the correct path for approaching real physics. In the physical framework, deeper and wider issues could be explored further, and it is expected to find more solutions.

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