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The Linked-Measure and Linked-Field for Linking Micro-Particles to Macro-Cosmos with Dispelling Dark Matter and Dark Energy

Fred Y. Ye*

School of Information Management, Nanjing University, Nanjing, China

Abstract

A mathematical multi-vector consisted of a complex scalar, a complex vector and a bivector, which constructs a physical linked-measure, yielding a linked-field. When the linked-measure is applied as the world measure, its strong symmetric links generate electromagnetic field and its strong micro-inner links do strong field, while its weak micro-inner symmetric links synthesize electroweak field. With adding outer space-time metric, the linked-field leads to gravitational field with a new understanding of dark matter and dark energy. In the linked-field, the micro-particle standard model and the macro-cosmos standard model are unified, where double dynamic sources drive the universe, in which one initialized big-bang and another pushed rotation. Dark matter and dark energy are structural effects of the whole universe, caused respectively by rotation and big-bang. A rotated vacuum explosive experiment is suggested to verify the hypothesis.

Keywords

Linked-Measure, Linked-Field, Unified Field, Multi-Vector, Dark Matter, Dark Energy, Standard Model

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1. Introduction

In the 20 century, two great physical theories, quantum theory and relativity, led two standard models respectively, the micro-particle standard model characterized by $SU_C(3)\times SU_L(2)\times U_Y(1)$ gauge field based on quantum theory and the macro-cosmos standard model characterized by big-bang cosmology based on general relativity [1], which construct theoretical core of contemporary physics [2]. However, the two standard models are so different that they cannot be unified within a harmony theory, which caused a theoretical poser called as quantum gravity. On the other side, the physical experiments and observations support strongly the two standard models, so that any revised unified theory has to include the two standard models in it.

Meanwhile, the issues of dark matter and dark energy perplexed scientists [3-4]. If the problems keep in two standard models, it means that standard models mismatch to the real world or there exist logic faults in the theories.

Following a brief review of present achievements in physics, the linked-measure and linked-field approaching to the unified theory of micro-particle and the macro-cosmos are suggested in the article, with using the mathematical methodology of multi-vector [5-6].

2. Present Achievements as Constrains

We know that physics reached bright level with colorful achievements, where we especially mention quantum theory and relativity, with linking via the Hamilton principle (the least action principle, which provided a cornerstone of

* Corresponding author
E-mail address: yye@nju.edu.cn, blueyye@gmail.com

analytical physics). Also plus, in micro-fields, physicists have probed into "basic particles" that construct the natural world, where we especially mention the principle of particle-wave duality, which introduced the quantum mechanism. In macro-fields, physicists have explored the universe, where we especially mention the principle of gravity-curvature equivalence, which constructed general relativity as well as scientific cosmology. Certainly, all the theoretical principles matched physical observations and experiments very well. In more general, the principles of action, connection and construction had been suggested [7-8].

Facing the great physics, we have to inherit the physical achievements and develop the glorious tradition in future. At present, we have strong evidences that two standard models are good physical theories for approaching the world. The basic facts focus on that all substances consist of micro-particles, while the cosmic observations strongly support that the universe is spreading to expand, with acceleration.

2.1. Observational Evidences

It is well known that both standard models have their solid foundations of observational evidences. During 2012 to 2013, two large-scale important experimental observations bring us new physical updates. One is Higgs that is found by LHC (Large Hadron Collider), and another is CMB (Cosmic Microwave Background) that is exactly verified by Planck satellite.

In the micro-particle standard model, the greatest success was the prediction of the Higgs boson, which had been experimentally discovered in 2012 and verified in 2013 by LHC at energy 125.6 GeV/c^2 [9-10]. It is well known that the Higgs mechanism describes how the weak SU(2) gauge symmetry is broken and how fundamental particles obtain mass, which was also the last particle predicted by the micro-particle standard model to be observed, although efforts to confirm that it has all of the properties predicted by the standard model are ongoing.

Other great successes of the micro-particle standard model included the prediction of the W and Z bosons, the gluon, and the top and the charm quarks, before they had been observed. However, the worst disadvantage in the micro-particle standard model is the complete absence of gravity, and it predicts neutrinos to be massless while the observed evidence of neutrino oscillations implies that neutrinos have tiny mass [11].

In the macro-cosmos standard model, it is frequently referred to as the big bang cosmology, since it is the simplest model that provides a reasonably good account of the following observational evidences of the cosmos: 1) the existence of the cosmic microwave background and the large-scale structural distribution of galaxies; 2) the abundances of hydrogen (including deuterium), helium, and lithium, as famous BBN theory of elements synthesis [12-14]; and 3) the accelerating expansion of the universe observed in the light from distant galaxies and supernovas [15]. According to the Planck's satellite's newest observation report [16-17], we understand that there are 68.3% "dark energy", 26.8% "dark matter" and 4.9% matter-energy in the universe.

Also, there are challenges to the macro-cosmos standard model, in which we mention particularly dark matter and dark energy, where extensive searches for dark matter particles have so far shown no well-agreed detection and dark energy almost becomes impossible to detect in any laboratory.

Above observational evidences and great successes mean that we have to consider theoretical constrains or restrictions when we try to extend the two standard models or find new theory.

2.2. Theoretical Constrains with Characteristics

While the particle standard model supposes that gauge field theory is the best choice, the cosmos standard model assumes that general relativity is the correct theory of gravity on cosmological scales.

Because the two standard models are so successful, a complete unified theory should abide some theoretical constrains with following characteristics:

1) The theory could unify all interactions, including $SU_C(3)\times SU_L(2)\times U_Y(1)$ symmetry at micro-level and accelerating expansion at macro-level.

2) The theory should accord with analytical principles of physics, particularly the Hamiltonian principle, with incorporating quantum theory and relativity, and therefore it is quantum field theory, where local symmetries are described by Abelian and non-Abelian gauge theories.

3) The particle-wave duality should be maintained at micro-particle level, and the gravity-curvature equivalence should be kept at macro-cosmos level.

Totally, a perfect unified theory should be consistency of both micro-particle standard model and macro-cosmos standard model, abiding the principles of the least action, particle-wave duality and gravity-curvature equivalence, with interpreting dark matter and dark energy. So the unified theory is demanded by high standard, not only unifying quantum theory and gravity, but also matching experimental data and observational phenomena well.

Also, a good theoretical framework should keep math-physical balance, which means that, when we set up an equation, if the left side of the equation reflects mathematical structure, its right side should reveal physical essence, i.e. Mathematical structure = Physical essence. For approaching the object, space-time multi-vector [18-20] provided a good methodology, and the Clifford-type algebra can be united with Finsler-type geometry.

3. New Theoretical Structure

Let's consider space-time at beginning. For each space-time point x on Dirac frame { $\gamma^\mu, \mu = 0,1,2,3$ }, there exists

$$x = x_\mu \gamma^\mu, x_\mu = \gamma^\mu x \tag{1}$$

The coordinates' transformation will be $x_\mu \to x'_\mu = \alpha^\nu_\mu x_\nu ; \gamma^\mu \to \gamma'^\mu = \alpha^\mu_\nu \gamma^\nu \ with\ \alpha^\mu_\nu \alpha^\nu_\lambda = \delta^\mu_\lambda$, where four Dirac matrices are no longer viewed as four matrix-valued components

$$\gamma^0 = \begin{pmatrix} I & 0 \\ 0 & -I \end{pmatrix}, \gamma^k = \begin{pmatrix} 0 & -\sigma^k \\ \sigma^k & 0 \end{pmatrix} \tag{2}$$

of a single isospace vector but as four orthonormal basis vectors for real space-time, 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 no longer viewed as three matrix-valued components

$$\sigma^1 = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \sigma^2 = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \sigma^3 = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \tag{3}$$

of a single isospace vector, but as three orthonormal basis vectors for three dimensional Euclidean space. Both $\{\gamma^k\}$ and $\{\sigma^k\}$ are to be interpreted geometrically as meaningful space-time bivectors and not as operators.

Using multi-vector M_k (k = 0, 1, 2, 3, 4) as the world measure, 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 Clifford 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), { γ^μ }(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

$$\begin{aligned} M &= M_0 + M_1 + M_2 + M_3 + M_4 \\ &= \phi + V + B + iU + i\theta = \psi + A + B = (\psi, A, B) \end{aligned} \tag{4}$$

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

The revision (revised conjugation) is denoted as $\tilde{M}$

$$\begin{aligned} \tilde{M} &= \tilde{M}_0 + \tilde{M}_1 + \tilde{M}_2 + \tilde{M}_3 + \tilde{M}_4 \\ &= \phi + V - B - iU + i\theta = (\psi, \bar{A}, -B) \end{aligned} \tag{5}$$

And there are space-time conjugation $\bar{M}$, space conjugation M* and Hermitian conjugation $M^\dagger$ as follows

$$\begin{aligned} \bar{M} &= -iMi = M_0 - M_1 + M_2 - M_3 + M_4 \\ &= \psi - A + B = (\psi, -A, B) \end{aligned} \tag{6}$$

$$M^* = \gamma^0 M \gamma^0 ;\ M^\dagger = \gamma^0 \tilde{M} \gamma^0 \tag{7}$$

Then M^2 can be defined as

$$M^2 = M\bar{M} \tag{8}$$

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

$$M_+ = \phi + B + i\theta = \psi + B \tag{9}$$

$$M_- = V + iU = A \tag{10}$$

This is the origin of spiral and asymmetry in the world if we apply M as the world's physical measure.

3.1. Linked-Measure

Mathematically, a multi-vector consists of a complex scalar, a complex vector and a bivector, where one scalar ψ, one vector A and one bivector B contain rich structural information.

Physically, a multi-vector can be applied as linked-measure which link scalar mass (m), vector potential (V) and bivector strength (S) together.

So a mathematical multi-vector corresponds to a physical linked-measure, i.e. a multi-vector constructs a linked-measure.

The differential operators of one order derivatives can be introduced and defined as

$$\partial_\mu = \frac{\partial}{\partial x_\mu} ; \nabla = \gamma^\mu \partial_\mu \tag{11}$$

Its covariant derivative and the differential operators of two order derivatives can be introduced and defined respectively as

$$D_\mu = (\partial_\mu - \omega_\mu) ; \nabla^2 = g^{\mu\nu} \partial_\mu \partial_\nu ; g^{\mu\nu} = \gamma^\mu \cdot \gamma^\nu \tag{12}$$

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

For keeping gauge invariance, we suppose the transformations as

$$\psi \to \psi' = e^{i\omega}\psi; \overline{\psi} \to \overline{\psi}' e^{-i\omega} \tag{13}$$

$$A_\mu \to A'_\mu = A_\mu + \partial_\mu \omega ; \overline{A}_\mu \to \overline{A}'_\mu = \overline{A}_\mu - \partial_\mu \omega \tag{14}$$

$$B_\mu \to B'_\mu = B_\mu + D_\mu \omega ; \overline{B}_\mu \to \overline{B}'_\mu = \overline{B}_\mu - D_\mu \omega \tag{15}$$

So the linked-measures construct a complete math-physical system, which leads linked-field.

When we define linked-energy E and linked-momenta p_μ with linking Hamilton function H and Lagrangian function L, we obtain math-physical equations following Hamilton principle as follows

$$H = p_\mu x_\mu - L = E(s,t) = \int_s (M/V) dx_\mu ;$$
$$\frac{\partial H}{\partial p_i} = \frac{ds_i}{dt} ; \frac{\partial H}{\partial s_i} = -\frac{dp_i}{dt} \tag{16}$$

$$L = p_\mu x_\mu - H; p_\mu = \frac{\partial L}{\partial x_\mu} ; \quad \delta \int_s d^4 x L = 0 \tag{17}$$

where V denotes volume of space so that M/V means density function of linked measure in space and s_i marks space variables. While Greek subscripts μ, ν denote 1, 2, 3, 4, Latin subscripts i, j do 1, 2, 3.

The Eq. (16) is the differential form and Eq.(17) the integral form of multi-vector linked-field.

3.2. Linked-Field

When M (ψ, A, B) is viewed as physical linked-measure, fields are naturally generated in space-time.

If there exist strong links among ψ, A and B, as follows

$$\nabla A = \psi + \partial \phi ; \quad B_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu \tag{18}$$

The Maxwell's equations under gauge group U(1) will be obtained as

$$\nabla B = \nabla \cdot B + \nabla \wedge B = J \quad \text{or} \quad \partial_\mu B^{\mu\nu} = J^\nu \tag{19}$$

where $J = \nabla \cdot B$ is current and bivector B includes both electrical field E and magnetic field H as B=E+iH, which can be also derived by applying Hamilton principle

$$\delta S = \delta \int d^4 x L = 0 \tag{20}$$

to the QED Lagrangian

$$L_{QED} = -\frac{1}{4} B_{\mu\nu} B^{\mu\nu} - J^\mu A_\mu \tag{21}$$

Generally, electromagnetic field is both macro- and micro-phenomenon. At micro-level, when the complex scalar field (i.e. Higgs field) introduces mass (m) following Lagrangian

$$L_{Higgs} = (D_\mu \psi^*)(D^\mu \psi) - V(\psi^* \psi) \tag{22}$$

Then QED Lagrangian can be re-written as

$$L_{QED} = -\frac{1}{4} B_{\mu\nu} B^{\mu\nu} + \overline{\psi}(i\gamma^\mu D_\mu - m)\psi \tag{23}$$

If there exist strong micro-inner links as strong field, including 8 duplicates (a) in 3 generations, the field strength upgrades to inner higher symmetry

$$B_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu = B^a_{\mu\nu} \kappa_a ; a = 1, 2, ...8 \tag{24}$$

and the linked-field is extended as a new field F as

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu - g f_{abc} A^a_\mu A^a_\nu ; f_{abc} t^c = [t^a, t^b] \tag{25}$$

When A^a_μ correspond to the gluon fields (a=1,…,8, as there are eight kinds of gluon) and the $\psi_{q,c}$ are quark-field spinors for a quark of flavor q and mass m_q with a color-index c (c=1,2,3), where the $t^a_{\mu\nu}$ correspond to eight 3 × 3 matrices and are the generators of the $SU_c(3)$ group, the Lagrangian becomes

$$L_{QCD} = -\frac{1}{4} F^a_{\mu\nu} F^{a\mu\nu} + \overline{\psi_q}(i\gamma^\mu D_\mu - m_q)\psi_q \tag{26}$$

which leads to QCD under SU(3) invariance, where the first item describes gluons and second item quarks. So the strong interactions are included.

When the main field strengths break micro-inner strong symmetry to micro-inner weak symmetry, from F returning to B, the interactions are stemmed by group SU(2), replacing SU(3), with color-index c changing to b:

$$\begin{aligned} B_{\mu\nu} &= [\partial_\mu + (1g_2/2) B_\mu] B_\nu - [\partial_\nu + (1g_2/2) B_\nu] B_\mu \\ &= B^b_{\mu\nu} \tau_b ; b = 1, 2, 3 \end{aligned} \tag{27}$$

Combining Lagrangian

$$L = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} - \frac{1}{4} B^b_{\mu\nu} B^{b\mu\nu} \tag{28}$$

with QED Lagrangian Eq.(21), the electroweak Lagrangian is obtained under $SU_L(2) \times U_Y(1)$ symmetry, as follows

$$L = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{1}{4}B^{b}_{\mu\nu}B^{b\mu\nu} - J^{\mu}A_{\mu} \quad (29)$$

It is feasible to attach the outer space-time metric $g^{\mu\nu}$ to the linked-field, with introducing Riemann-Christoffel symbol

$$\Gamma^{\lambda}_{\mu\nu} = \frac{1}{2}g^{\lambda\rho}(\partial_{\nu}g_{\rho\mu} + \partial_{\mu}g_{\rho\nu} - \partial_{\rho}g_{\mu\nu}) = g^{\lambda}(D_{\mu}g_{\nu}) \quad (30)$$

Then the Riemann curvature tensor is kept as

$$R^{\lambda}_{\mu\nu\kappa} = \partial_{\nu}\Gamma^{\lambda}_{\mu\kappa} - \partial_{\kappa}\Gamma^{\lambda}_{\mu\nu} + \Gamma^{\rho}_{\mu\kappa}\Gamma^{\lambda}_{\nu\rho} - \Gamma^{\rho}_{\mu\nu}\Gamma^{\lambda}_{\kappa\rho} \quad (31)$$

where scalar curvature R is defined by Ricci tensor $R = g^{\mu\nu}R_{\mu\nu}$.

The Bianchi identity is also written as

$$D_{\mu}R_{\mu\lambda} + D_{\lambda}R_{\mu\nu} + D_{\nu}R_{\lambda\mu} = 0 \quad (32)$$

Let's recall gravity-curvature equivalence, we know

World's physical measure = World's mathematical curvature (33)

or

World's measure tensor Gμν = World's curvature tensor Ωμν (34)

Since

$$M\bar{M} = (\psi + A + B)(\psi - A + B) \quad (35)$$

whereas scalar and vector have no out products (M^M=B^B), we expect

$$L = \frac{1}{2}(\partial_{\mu}\psi \cdot \partial^{\mu}\bar{\psi} + \partial_{\mu}A \cdot \partial^{\mu}\bar{A} + \partial_{\mu}B \cdot \partial^{\mu}\bar{B}) + c.t. - \nabla \wedge B \quad (36)$$

where c.t. denotes coupling terms.

For fitting general relativity, geometrical curvature should be

$$\Omega_{\mu\nu} = k(R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R) \quad (37)$$

With applying Hamilton principle to Einstein-Hilbert-type action [21]

$$S = \int d^4x\sqrt{-g}M\bar{M}R \quad (38)$$

it is expected that varying S gives the field equation

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

in which $G_{\mu\nu}$ is Einstein tensor and $T_{\mu\nu}$ denotes the total observational tensor (e.g. energy-momentum tensor), positive p(ψ) integrates all positive items of Eq.(35) and negative q(A) integrates all negative items of Eq.(35), where the left side denotes physical effects while the right side indicates mathematical means.

Based on Eq. (39), we see total observational tensor becomes

$$\begin{aligned} T_{\mu\nu} &= G_{\mu\nu} - p(\psi) + q(A) \\ &= k(R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R) - p(\psi) + q(A) \end{aligned} \quad (40)$$

so that we can provide a theoretical interpretation of dark matter and dark energy [22], where p(ψ) item describes dark energy and q(A) item denotes dark matter. The dark matter and dark energy are structural effects in the physical unification of whole cosmos by linked-field.

Thus we see that all physical elements of two standard models can be concluded in multi-vector linked-field, where electromagnetic field originates from bivector field with strong links among scalar ψ, vector A and bivector B at both macro- and micro- levels; strong field acts as upgrade with strong micro-inner symmetry at micro- level; and electroweak field obtains from breaking strong micro-inner symmetry to weak micro-inner symmetry at micro- level. Then, after attaching outer space-time metric to linked-field, the gravity is realized via curvature at macro-level.

Totally, electroweak and strong fields are described by construction effects of the linked-field and gravity (phenomenological structural effects contain dark matter and dark energy) is caused by structure effects of the linked-field. The linked-field is a unified field of both micro-particles and macro-cosmos.

4. Dark Matter and Dark Energy: The Structural Effects

For understanding the universe, a qualitative model called "cosmos ball" model can be dynamically shown as Figure 1.

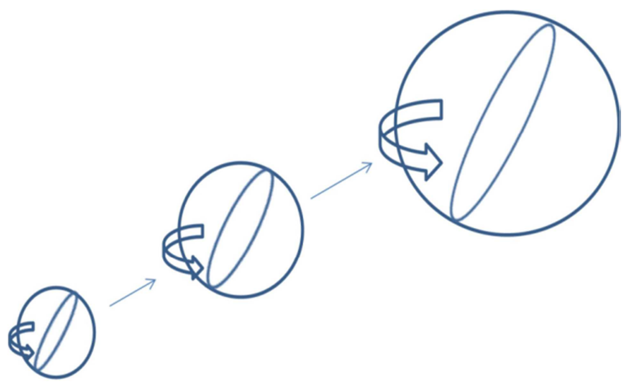

Fig. 1. The "cosmos ball": dynamic universe driven by double dynamic sources.

In Figure 1, the "cosmos ball" will synchronously rotational expand in both inside structure and outside surface, so that the whole synchronous rotation will be seen everywhere in the ball. In Newton's theory, one paid all attention to the center of masses, so that one found gravitation between masses. In Einstein's theory, local space-time curvature was linked with gravity, so that the gravity was equivalent to the curvature of space-time. Now whole universe is the rotated "cosmos ball", so that all are included in it.

For driving the "cosmos ball", double dynamic sources are demanded: one initialized big-bang and another pushed rotation. The model implies that "dark matter" and "dark energy" are structural effects, where "dark matter" is rotated kinetic effect and "dark energy" is vacuum expanded dynamic effect, in which "dark matter" is caused by the whole synchronous rotation and "dark energy" is the vacuum expansion originated by the beginning "big-bang". While "big-bang" as dynamic source leaded to "dark energy", the rotation as dynamic source caused "dark matter". So, "dark matter" and "dark energy" are deducted to structural effects originated by the double dynamic sources. The model supplies two images which can be checked by observation or experiment: (1) there is changeable curvature evolution of time-space; (2) there is a rotated center in the universe.

5. Experiment Suggestion

Any theory needs observation or experiment for double check and support as

Theoretical derivatives <=> Observational evidences

For verifying above hypothesis, I suggest to design a new experiment of vacuum explosion, for simulating cosmos evolution, as shown in Figure 2.

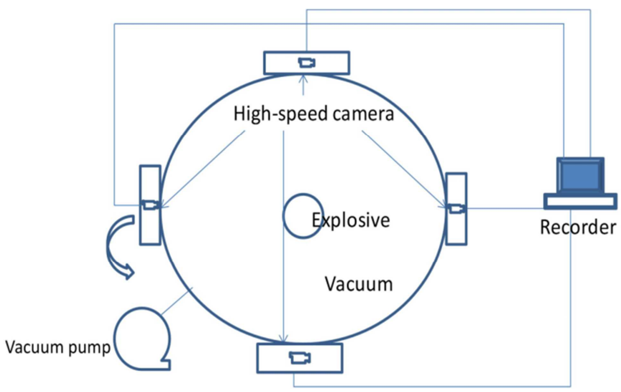

Fig. 2. Vacuum explosion: experiment design.

After explosive is set in the center, let vacuum pump starts to produce vacuum. When explosive starts to explore in vacuum, computer system may record the process of the vacuum explosion, with checking and analyzing the results.

In the experiment, rotation and exploration are human-controlled, so that it could help us to understand the double dynamic sources of the universe.

6. Discussion: Cosmological Image

Historically, a key prediction of the big bang cosmology, CMB was discovered in 1965. From that point on, big bang cosmology was generally accepted, where the universe started in a hot, dense state and had been expanding over time. The rate of expansion depends on the types of matter and energy present in the universe, and in particular, whether the total density is above or below the so-called critical density. During the 1970s, most attention focused on pure-baryonic models, but there were serious challenges explaining the formation of galaxies, given the small anisotropies in the CMB (upper limits at that time). In the early 1980s, it was realized that this could be resolved if cold dark matter dominated over the baryons, and the theory of cosmic inflation motivated models with critical density. During the 1980s, most researches focused on cold dark matter with critical density in matter, around 95% CDM (Cold Dark Matter) and 5% baryons: these showed success at forming galaxies and clusters of galaxies, but problems remained. Notably, the model required a Hubble constant lower than preferred by observations, and the model under-predicted observed large-scale galaxy clustering. These difficulties sharpened with the discovery of CMB anisotropy by COBE in 1992, and several alternatives including ΛCDM (Lambda Cold Dark Matter) and mixed cold + hot dark matter came under active consideration. The ΛCDM model can be extended by adding cosmological inflation, quintessence and other elements that are current areas of speculation and research in cosmology, and the model had become the standard following the observations of accelerating expansion since 1998. Much more precise measurements of the microwave background from WMAP in 2003-2010 have continued to support and refine the model.

Comparison of the ΛCDM model with observations is very successful on large scales (larger than galaxies, up to the observable horizon), but may have some problems on sub-galaxy scales, possibly predicting too many dwarf galaxies and too much dark matter in the innermost regions of galaxies. These small scales are harder to resolve in computer simulations, so it is not yet clear whether the problem is the simulations, non-standard properties of dark matter, or a more radical error in the model.

Now the cosmological standard model is mastered by three parts:

1) When the universe is supposed as perfect fluid, Einstein

equations become

$$T_{\mu\nu} = -pg_{\mu\nu} + (p+\rho)u_\mu u_\nu \quad (41)$$

where $T_{\mu\nu}$ is energy and momentum tensor, $g_{\mu\nu}$ metric tensor, p the isotropic pressure, ρ the energy density and u = (1, 0, 0, 0) is the velocity vector for the isotropic fluid in co-moving coordinates, which lead to Friedmann-Lemaitre equations

$$H^2 = (\frac{\dot{R}}{R})^2 = \frac{8\pi G\rho}{3} - \frac{k}{R^2} + \frac{\Lambda}{3} \quad (42)$$

$$\frac{\ddot{R}}{R} = \frac{\Lambda}{3} - \frac{4\pi G}{3}(\rho + 3p) \quad (43)$$

in which G is gravitational constant and Λ cosmological constant.

2) Cosmological state equation, if the cosmos possesses total matter (energy) density ρ and isotropic pressure p is linked by

$$p = p(\rho) = w\rho \quad (44)$$

the cosmic state is determined by w.

3) Robertson-Walker metric of space-time, which determined the cosmic structure

$$ds^2 = dt^2 - R^2(t)[\frac{dr^2}{1-kr^2} + r^2(d\theta^2 + \sin^2\theta d\phi^2)] \quad (45)$$

where (t, r, θ, φ) is comoving coordinate system and R(t) cosmic scale factor, while k is curvature index and $K=k/R^2$ as space curvature, with k = +1, 0 or −1 corresponding to closed (K>0), flat (K=0) or open (K<0) spatially geometries.

The Eqs. (42), (43) and (44) construct complete equations for variables R, ρ and p. After defining the critical density (when k=0 and Λ=0) as

$$\rho_c \equiv \frac{3H^2}{8\pi G} = 1.88\times10^{-26} h^2 (kg\cdot m^{-3}) = 1.05\times10^{-5} h^2 (GeV\cdot cm^{-3}) \quad (46)$$

and scaled Hubble parameter h as

$$H \equiv 100h(km\cdot s^{-1}\cdot Mpc^{-1}) \quad (47)$$

via Eq.(43), the Eq.(42) becomes

$$\rho_c = \rho - \frac{3k}{8\pi GR^2} + \frac{\Lambda}{8\pi G} \quad (48)$$

Introducing dimensionless density parameters for pressureless matter (Ω_m) and vacuum (Ω_v),

$$\Omega_m = \frac{\rho}{\rho_c}, \Omega_v = \frac{|\rho_\Lambda|}{\rho_c} \quad (49)$$

where $|\rho_\Lambda|=\Lambda/(8\pi G)$ indicates vacuum energy density, i.e. dark energy. Then we obtain Friedmann equation as follows

$$\Omega_m + \Omega_v - 1 = \frac{k}{R^2H^2} \quad (50)$$

Combining Eq. (43) with Eq. (44), we can also introduce a deceleration parameter as

$$q_0 \equiv -\frac{\ddot{R}R}{\dot{R}^2} = -\frac{\ddot{R}}{RH^2} = \frac{1}{2}\Omega_m + \Omega_r + \frac{(1+3w)}{2}\Omega_v \quad (51)$$

where Ω_r is the density parameter of relativistic particles.

Since the universe is evolutional and developing from high temperature and high pressure to low temperature and low pressure, it is key to probe into the cosmological state equation, which determines the cosmic dynamic evolution.

Comparing Eq. (40) with Eqs. (41)-(43), we see that the effect of "dark energy" is caused by scalar field p(ψ) and the effect of "dark matter" by vector field q(A), which just match that the p(ψ) is corresponding to a negative pressure and the q(A) is similar to a positive force.

If Riemann space-time is extended to Finsler space-time, the Clifford-Finslerian physical unification could be introduced and would produce more rich and colorful results in physical theories [13].

Although the universe is made out of mostly matter, the standard model predicts that matter and antimatter should have been created in (almost) equal amounts if the initial conditions of the universe did not involve disproportionate matter relative to antimatter. Yet, no mechanism sufficient to explain this asymmetry exists in micro-particle standard model. Now, Eqs. (9) and (10) imply the possibility while the linked-measure leads symmetric or asymmetric linked-field, which provides a unified interpretation of micro-particles and macro-cosmos. As a supposed unification, the vacuum experiment is suggested to verify the hypothesis.

7. Concluding Remarks

Conclusively, above linked-field theory are characterized as follows:

1) A mathematical multi-vector consists of a complex scalar, a complex vector and a bivector, which constructs a physical linked-measure, where scalar mass, vector potential and bivector strength generate linked-field.

2) In the linked-field, strong symmetric links generate

electromagnetic field and strong micro-inner links do strong field, while weak micro-inner symmetric links synthesize electroweak field. With adding outer space-time metric, the linked-field leads to gravitational field and a new understanding of dark matter and dark energy.

3) Both dark matter and dark energy are structural effects of geometrical dynamics in the whole universe, which are equivalent to double dynamic sources driving the universe, in which one initialized big-bang (leads to dark energy) and another pushed rotation (leads to dark matter).

With combining quantum field theory and general relativity, multi-vector linked-field did unify the two standard models together, which provided another way to consider physical unification, where physical achievements are kept and two standard models are save. The linked-field model looks consistent, on which it is expected that the essence of the physical world can be revealed and the unified physics can be approached.

Furthermore, the choice of measures determines scientific relations, so that the different measures would lead to difference discoveries of scientific laws. When linked-measure based on the mathematical multi-vector is introduced, the linked-field for physical unification is generated, in which the micro-particle standard model and the macro-cosmos standard model can be combined and unified, and the phenomena of dark matter and dark energy are naturally interpreted. The linked-field leads to both mathematically and physically simple unified theory, which might stimulate further studies.

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