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Article

The Unified Mechanism of Cosmic and Material Structure Based on the Ideal Model of Cosmic Continuum

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Abstract

The fundamental divergence in foundation of modern physics lies in the incompatibility between quantum theory and relativity. This study created a relative continuum, found a mathematical tool for the cosmic continuum; proposed dark particle hypothesis, filled gap on minimum existence quantity particle; discovered new equivalence principle, bridged differences in foundation of physics; and established an ideal model, revealed deep essence of cosmic and material structure. In this model, any cosmic system is a continuum composed of existence continuum relative to the wavelength of bosons energy waves and its dimension continuum. This model provides new perspectives on the fundamental problems of physics and cosmology. Firstly, it elucidated the physical mechanism of bosons in fundamental interactions. Secondly, it reconstructed the understanding of the basic unit of the cosmic and material structure. Thirdly, it updated the inherent concepts about the existence form and existence dimension. Fourthly, it restored the causality truth of wave function collapse in quantum mechanics.

Keywords: cosmic continuum; dark particle hypothesis; new equivalence principle; unified particle; existence field

1. Introduction

On the surface, the biggest dark clouds over modern physics and cosmology are dark matter and dark energy; in essence, the incompatibility between quantum theory and relativity is the deep contradiction in fundamental theory. The discussion in this article indicates that this contradiction can be eliminated using relative continuum theory.

The debate about infinity runs through the history of mathematics, physics, and astronomy [1]. The history of mathematics, in a certain sense, is the development history of the concepts of potential infinity and actual infinity. Calculus belongs to the theory of potential infinity, while set theory belongs to the theory of actual infinity. However, whether it is the theory of potential infinity or the theory of actual infinity, the troubles caused by many infinite paradoxes still cannot be completely eliminated.

In 1874, Cantor speculated that there was no other cardinality between the cardinality of the natural number set, \aleph_0 , and the cardinality of the real number set, C , which is the famous Hilbert's first problem, the "Continuum Hypothesis". According to cardinality theory, the cardinality of a real number set is the cardinality of a natural number set's power set, then: $C = 2^{\aleph_0} > \aleph_0$. In 1938, Gödel proved that the Continuum Hypothesis and the axiom set theory ZFC axiom system are not contradictory. In 1963, Cohen proved that the Continuum Hypothesis and the ZFC axiom system are independent of each other. Therefore, the assumption of continuity cannot be proven or falsified within the ZFC axiom system [2,3].

In 1900, Hilbert listed “axiomatization of physics” as the sixth of his 23 mathematical problems, which was also the only non pure mathematical problem in Hilbert’s mathematical problems. But the goal of axiomatization of physics were quickly shelved due to the emergence of relativity and quantum theory, as an irreconcilable logical barrier emerged between the two new theories, and sparked a debate between Einstein and the Copenhagen School about whether God rolls the dice or not [4–16].

The idea of cosmic continuum is derived from these two Hilbert’s problems. The ultimate goal of the Cosmic Continuum Theory is to find a solution to axiomatization of physics based on the cosmic continuum hypothesis, and to strictly construct a fundamental theory of physics that reflects the essential laws of nature using axiomatic methods [17–24].

This article explores some fundamental problems of mathematical and physical such as the continuum paradox, the cosmic and material elementary particles, the existence field and its dimension field, proposes the concept of relative continuum, introduces the hypothesis of dark particle and unified particle, derives a New equivalence principle, and establishes an ideal model on the cosmic continuum.

2. Relative Continuum

Since the beginning of this century, Sergeyev has introduced the Grossone method from the principle of “the whole is greater than the part”, which has achieved a leap from qualitative calculation to quantitative calculation in infinite computation [25–28]. From the perspective of the Grossone method, it is not difficult to find a “continuum paradox” in Cantor’s cardinality theory: either points have sizes or distances between points, otherwise the cardinality of the continuum is equal to the cardinality of countable infinity [24].

According to the cardinality method, if the elements in two sets satisfy a 1-1 correspondence, then the cardinality of the two sets is the same. From this, it can be inferred that the cardinality of the interval number set and the real number set on the real number axis are both \mathbb{C} . If the points on interval $[0,1]$ are continuous, i.e., the distance between points is zero, then the size of any point in that interval is $\frac{1}{\mathbb{C}}$. And the cardinality method is a theory of actual Infinity, the reciprocal of the actual infinite cardinality cannot be zero, otherwise the reciprocal of the cardinality of both the real number set and the natural number set is zero, that is, $\frac{1}{\mathbb{C}} = \frac{1}{\aleph_0} = 0$, thus obtaining $\mathbb{C} = \aleph_0$, which obviously contradicts conclusion, $\mathbb{C} = 2^{\aleph_0} > \aleph_0$.

The continuum paradox states that the Continuum Hypothesis is not a matter of proof and falsification, but rather that the proof in set theory that the continuum is “dense without holes” cannot guarantee the continuity of the real number axis.

Sergeyev believed that the continuity of objects in physics is related to unit of measure. The same set is continuous for one unit of measure, but discrete for another unit of measure [28]. For example, there are some gaps on a road that adults can cross, but for children, some gaps cannot be crossed. So this road is continuous for adults and discrete for children. Here, the span of adults and children can be regarded as two different units of measure. So we obtain the following definition of relative continuum:

Definition 1. If any two adjacent elements a^+ and a^- in set A have $|a^+, a^-| \leq R$, then set A is called a continuum relative to the unit of measure R . Where $|a^+, a^-|$ is the distance between a^+ and a^- , and R is the unit of measure.

According to this definition, a relative continuum can be either an infinite set or a finite set. The “continuum paradox” in Cantor’s cardinality theory no longer exists. The real number axis is

continuum relative to unit of measure $\frac{1}{C}$; the natural number axis is continuum relative to unit of measure $\frac{1}{\aleph_0}$, but not continuum relative to unit of measure $\frac{1}{C}$. The relative continuum is different from the traditional absolute continuum, which is a special case of the relative continuum when the limit of the unit of measure R is zero.

If the universe is viewed as a set, then as long as an appropriate unit of measure can be found, the universe is a continuum relative to that unit of measure. The key to establishing a cosmic continuum model is whether the appropriate unit of measure can be found.

In the cosmic continuum, existence bodies are coupled with each other by energy, and at different structural levels of the existence body, they are coupled by corresponding energy quanta [18]. Therefore, this unit of measure must be related to the coupled energy quantum.

3. Unified Particles

The gravitational constant G , the speed of light c , and the Planck constant h are the most basic three physical constants. In 1899, Planck discovered a series of new physical constants based on these three constants, namely the Planck unit [29,30].

According to $E = h\nu$, the Planck constant h represents the energy per unit frequency, which is the energy possessed by a single vibration. So the physical meaning of the Planck constant is the minimum energy $E_h = h$ in the universe, because the vibration of the energy quantum is less than once, which means there is no vibration. According to $E = mc^2$, then $m_h = \frac{h}{c^2}$ is the minimum mass in the universe. According to quantum theory, the Planck time t_p and Planck length $l_p = t_p c$ are the minimum time and minimum length in the universe, respectively.

Einstein discovered in relativity that mass and energy are unified, and space and time are unified. This indicates that the minimum mass is equivalent to the minimum energy, and the minimum time is equivalent to the minimum space: $m_h \equiv E_h$, $l_p \equiv t_p$. In order to distinguish between mass, energy, and time, space, we call the former the existence quantity, and the latter the dimension quantity. So we obtained the minimum existence quantity $m_h \equiv E_h = h$ and the minimum dimension quantity $l_p \equiv t_p$. But we have not yet found the corresponding minimum mass particle and minimum energy quantum.

The Planck particle is a hypothetical limit particle defined as a micro black hole with a reduced Compton wavelength equal to half a Schwarzschild radius. The Planck particle frequency is a maximum $\frac{1}{t_p}$, with a diameter of Planck length l_p , with an existence quantity of Planck energy E_p , with Planck pressure p_p . Due to the fact that Planck particles are the maximum fundamental particles in the universe, with their density, temperature, and pressure reaching their limits, it is either formed by the collapse of a black hole or by a singularity eruption. If formed by the collapse of a black hole, the Planck particle will continue to collapse to a singularity. Due to the insurmountable Planck pressure and Planck length, it can only enter an new dimension after continuing to collapse. If formed by a singularity eruption, Planck particles will undergo a strong explosion under Planck pressure, producing cosmic and material structure particles.

Dark particle hypothesis: Dark particles refer to a elementary particle in the form of a dark mass formed by phase transition in the collapse of a Planck particle to a singularity, with a minimum existence quantity h . Its existence dimension is dark space.

The dark space is an existence dimension beyond space-time. Set the dark mass of a dark particle is D_h and its dark space dimension quantity is g_p , then: $D_h \equiv m_h \equiv E_h = h$, $g_p \equiv l_p \equiv t_p$. One

Planck particle can be transformed into $\frac{1}{t_p}$ dark particles. Dark particles fill the gap of minimum existence quantity particles. According to relativity, mass and energy have a unified essence. And dark matter particles are formed by the collapse of Planck particles, so dark mass, mass, and energy also have a unified essence.

Definition 2. A unified particle is the minimum existence quantity particle unified three existence forms of mass, energy, and dark mass.

Clearly, dark particles are the dark mass form of a unified particles. Unified particles have three forms of phase transition: mass form m_h , energy form E_h , and dark mass form D_h .

4. New Equivalence Principle

According to the particle physics standard model, there are currently 61 recognized elementary particles, adding the three hypothetical elementary particles: Planck particles, gravitons, and dark particles, totaling 64 types. If Planck particles and dark particles are classified as fermions, and gravitons are classified as bosons, then there are 50 fermions and 14 bosons in the elementary particles. 64 elementary particles play different roles, among which 14 bosons couple the existence body in the universe into a whole in the form of energy waves. If the 61 discovered elementary particles are elementary particles of Material structure, then Planck particles, dark particles, and gravitons are actually elementary particles of cosmic structure.

All elementary particles in the universe are coupled by bosons energy waves, so each elementary particle has an energy support system composed of coupled bosons.

Definition 3. The existence field is an energy support system composed of coupled bosons.

The existence field is the energy support system of the existence body, and without the energy support system, the existence body cannot exist independently. When an existence body is in motion, the existence field will generate energy radiation in the form of bosons energy waves. The wave energy of the elementary particle existence field with zero rest mass is equivalent to its moving mass, while the wave energy of the elementary particle existence field with non-zero rest mass is equivalent to its dynamic energy.

According to the effects of mass increase, time dilation and length contraction in general relativity, the dimension quantity of an existence body changes with the changes of existence quantity:

$$m = m_0 / \sqrt{1 - \frac{v^2}{c^2}}, \quad E = m_0 c^2 / \sqrt{1 - \frac{v^2}{c^2}};$$

$$\Delta t = \Delta t_0 \sqrt{1 - \frac{v^2}{c^2}}, \quad l = l_0 \sqrt{1 - \frac{v^2}{c^2}}.$$

It can be seen that the existence quantity and dimension quantity are unified. In fact, when light passes near a massive celestial body, we cannot distinguish whether the deflection of light is due to gravity or spatial curvature. So we obtained the following new equivalence principle:

New Equivalence Principle: The existence quantity of an existence body is equivalent to its dimension quantity: $m_h \equiv l_p$, $E_h \equiv t_p$, $D_h \equiv g_p$. Among them, m_h , E_h , and D_h are the minimum mass, minimum energy, and minimum dark mass, respectively; l_p , t_p and g_p are the minimum length, minimum time, and minimum dark space, respectively.

Quantum theory and relativity have different starting points in gravitational problems. Quantum field theory starts from particles, while general relativity starts from space-time [31,32]. Quantum gravitational field is an existence field, and general relativistic gravitational field is a dimension field. According to the new equivalence principle, quantum gravitational field theory and general relativity are equivalent physical theories.

5. Ideal Model

The wavelength of boson energy waves in the cosmic and material structure is $\lambda = ct$, so the minimum wavelength of boson energy waves is $\lambda_{\min} = \lim_{t \rightarrow t_p} ct$, and the maximum wavelength is $\lambda_{\max} = \lim_{t \rightarrow \infty} ct$, where t is the period. This means that any entity in the universe, regardless of its location, is within the wavelength range of boson energy waves.

According to the definition of relative continuum, if wavelength of the boson energy waves are used as the unit of measure, then the set of all existence bodies in the universe is a existence continuum relative to the wavelength of bosons energy waves.

Set C_e is the existence continuum in the universe, M is the set of mass bodies, E is the set of energy bodies, and D_m is the set of dark mass bodies, then: $C_e = M \cup E \cup D_m$. Due to the fact that the elementary particles of the universe are divided into fermions and bosons, the existence of a continuum can be expressed in another form. Set A is the set of all fermions in the universe and B is the set of all bosons in the universe, then: $C_e = A \cup B$.

Space, time, and dark space are the dimensions of mass, energy, and dark mass, respectively. Mass, energy, and dark mass are three phase transitions of the existence forms, and space, time, and dark space are also the three phase transitions of existence dimensions. Space, time, and dark space phase transition with the phase transitions of mass, energy, and dark mass. Because the form of existence constitutes a existence continuum, according to the new equivalence principle, the dimension of existence also constitutes a dimension continuum. Set C_d is a dimensional continuum, S is the set of spaces, T is the set of times, and D_s is the set of dark spaces, then $C_d = S \cup T \cup D_s$.

Due to the wavelength of energy waves of photons and gravitons can be infinitely extended, so there exist coupling energy waves of corresponding wavelengths between any two existence bodies in the universe. This means that any cosmic system can form a continuum. So we obtained the following definition:

Definition 4. *The ideal model of the cosmic continuum means that any cosmic system is a continuum composed of the existence continuum relative to the wavelength of bosons energy waves and its dimension continuum.*

It is not difficult to see from the above definition that any existence body and its existence field is a continuum, and elementary particles and their existence fields are the basic units of the continuum. The various structural levels of the universe and matter have corresponding structural forces and bosons. If we compare the universe to a spring bed, then bosons are those springs.

6. Application Examples

Example 1. *The fundamental interaction force-range depends on the wavelength of the boson energy waves. According to the thought of relative continuum, the four fundamental interactions form a continuum relative to the wavelength of the corresponding boson energy wave, respectively. Strong interactions form a nuclear continuum relative to the wavelength of gluon energy waves, weak interactions form a nuclear continuum relative to the wavelength of W and Z boson energy waves. The wavelength of energy waves of gluons and W,*

Z bosons are extremely short, so strong and weak interactions are short-range forces. Electromagnetic interactions form an electromagnetic continuum relative to the wavelength of photon energy waves, and gravitational interactions form a gravitational continuum relative to the wavelength of graviton energy waves. The wavelength of energy waves of photons and gravitons can be infinitely extended, so electromagnetic and gravitational interactions are long-range forces.

Example 2. The root of the inverse square law lies in the wavelength of boson energy waves. According to the thought of relative continuum, the interaction between two existence bodies m_1 and m_2 with a distance of r means that m_1 and m_2 form a continuum relative to the wavelength r of the energy wave of coupled bosons. And the wavelength $r = \frac{c}{\nu}$, therefore the larger the wavelength r , the smaller the frequency ν of the energy wave of the coupled bosons. According to $E = h\nu$, the smaller the frequency ν , the smaller the energy E of energy wave, and the smaller the ability to interact. So the ability of an existence body to interact with the outside world is inversely proportional to the wavelength r of the energy wave of the coupled bosons. If E_r and E'_r are used to represent the ability of the existence bodies m_1 and m_2 to interact with the outside world, separately, then when m_1 and m_2 interact, E_r and E'_r are all inversely proportional to the wavelength of the energy wave of the coupled bosons, namely: $E_r \propto \frac{1}{r}$, $E'_r \propto \frac{1}{r}$. The magnitude of the interaction force f between two existence bodies m_1 and m_2 is directly proportional to their ability to interact with the outside world, E_r and E'_r , namely: $f \propto E_r E'_r \propto \frac{1}{r^2}$.

7. Discussion

The essence of the cosmic continuum is the existence body and its existence field. Due to the fact that the existence field is an energy support system composed of coupled bosons, the wavelength of coupled boson energy waves determines the range of continuum of different cosmic systems. The energy wave of a single period's wavelength constitutes a single energy quantum, which can manifest as either a particle in the form of moving mass or a wave in the form of dynamic energy. In this sense, the cosmic continuum is actually a cosmic system trapped in a single boson energy wave, whether it is a macroscopic system of the universe or a microscopic system of matter.

The four fundamental interactions have different functional roles in the cosmic and material structure. The two short-range forces, strong and weak interaction, belong to the fundamental structural forces of matter, and the two long-range forces of electromagnetic force and gravity are both fundamental structural forces of matter and fundamental structural forces of the universe. In the microscopic structure of matter, the corresponding bosons that couple elementary particles include both gluons and W, Z bosons, as well as photons and gravitons, so the microsystem of matter is an existence continuum constituted of four basic interactions. In the macroscopic structure of the universe, the corresponding bosons that couple celestial bodies or various existence bodies are photons and gravitons, so the macroscopic system of the universe is an existence continuum constituted of electromagnetic forces and gravity. The existence continuum can be a single continuum constituted of a fundamental interaction, or a composite continuum constituted of multiple fundamental interaction.

The wave-particle duality is a phenomenon of overall conservation of boson's moving mass and dynamic energy in quantum continuum. Moving mass and dynamic energy are two forms of phase transitions of boson, when bosons are in the form of moving mass, they exhibit particle property, while when bosons are in the form of dynamic energy, they exhibit wave property. The continuum structure model indicates that the essence of wave-particle duality is wave-particle oneness. The quantum non-locality is due to the interactions in multi-quantum continuum involve the participation of dark particles. Gravitational continuum is a continuum that can transcend space-time

because dark particles can also participate in gravitational interactions, and the existence dimension of dark particles is dark space. The collapse of wave function is due to the combination of quantum continuum and interference quantum continuum to form a new continuum. Any changes in the structure of the universe and matter are the result of quantum continuum changes. When a quantum continuum is disturbed by other quantum continuum, a new continuum is formed, which is the true reason for the collapse of wave functions in quantum mechanics.

The observable universe is generated by the explosion of Planck particles erupted from a cosmic singularity. Dark particle is a type of dark mass particle in the dark space dimension, dark matter is a dark mass body composed of dark particles. The singularity is a dark matter celestial body formed by collapse of black hole, the singularity and its existence field constitute an existence continuum of singularity. The Big Bang theory suggests that a singularity is a dense, hot, and high-pressure point. In fact, this dense, hot, and high-pressure point is not a singularity, but a Planck particle erupted by the singularity. The cosmic singularity did not experience a so-called Big Bang, but rather a strong explosion of Planck particles under dense, hot, and high-pressure conditions. Dark energy is actually the Planck pressure released by the explosion of Planck particles. This suggests that the influence of dark energy will progressively diminish as spacetime expands. This model breaks the cosmic fatalism that the Big Bang cosmology inevitably leads to heat death.

8. Conclusions

The ideal model of the cosmic continuum means that any cosmic system is a continuum composed of the existence continuum relative to the wavelength of bosons energy waves and its dimension continuum. This model provides new perspectives on the fundamental problems of physics and cosmology.

Firstly, it elucidated the physical mechanism of bosons in fundamental interactions. In this model, four fundamental interactions form a continuum relative to the wavelength of corresponding bosons energy waves, respectively, which have different functional roles in the cosmic and material structure, and the force-range of fundamental interaction and the inverse-square law both depend on the wavelength of boson energy waves.

Secondly, it reconstructed the understanding of the fundamental unit of the cosmic and material structure. In this model, the basic unit of the cosmic continuum is elementary particle and its existence field. The uncertainty principle receives a reasonable explanation here, as the fundamental units constituting the universe and matter are not point particles. Therefore, they inherently cannot be described by properties of point particles, such as position and momentum. And the dark particle hypothesis filled the gap on particle of minimum existence quantity in cosmic structure. Singularity is a dark matter celestial body composed of dark particles, singularity and its existence field constitute an existence continuum of singularity.

Thirdly, it updated the inherent concepts about the existence form and existence dimension. In this model, the relationship between the existence form and the existence dimension is a mirror relationship between objective reality and subjective reflection. The new equivalence principle indicates that the existence quantity of an existence body is equivalent to its dimension quantity. Quantum gravitational field theory and general relativity are equivalent theories on existence field and dimension field, which together constitute the gravitational continuum theory.

Fourthly, it restored the causality truth of wave function collapse in quantum mechanics. In this model, the wave-particle duality is a phenomenon of overall conservation of boson's moving mass and dynamic energy in quantum continuum, and the quantum non-locality is due to the interactions in multi-quantum continuum involve the participation of dark particles, and the collapse of the wave function is due to the combination of quantum continuum and interference quantum continuum to form a new continuum. This indicates that more fundamental law of nature than quantum mechanics are still deterministic.

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