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Quantum Gravity Theory of Space: Conservation Basis, Origin of Microscopic Gravity and Cosmological Unity

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Abstract

This study proposes a unified physical framework integrating conservation-based spatial foundations with discrete spatial quantum mechanics. By leveraging spatial quantum's localized splitting, adjacent capture, and density gradient effects, we develop a coherent explanation for the microscopic origins of gravity, cosmic expansion, dark matter, dark energy, and vacuum energy divergence. The theoretical mechanism posits that the total spatial volume remains strictly conserved, with space composed of indivisible fundamental units called spatial quantum. To maintain energy, momentum, and angular momentum conservation, bound matter continuously undergoes virtual particle processes—quantum information exchanges that require spatial quantum as the minimal physical degree of freedom, leading to their gradual increase over time. Gravity emerges as a geometric dynamics effect driven by spatial quantum density gradients, while cosmic expansion manifests as the continuous fragmentation of this conservation-based foundation into quantum units, observable through the light-cone causality structure. This model serves as a microscopic extension and refinement of general relativity, effectively addressing black hole singularities and Big Bang singularities. Without introducing dark matter particles, dark energy scalar fields, or additional gravitational corrections, it provides a self-consistent explanation for observed phenomena including galactic rotation curves, gravitational lensing, bullet clusters, and super-diffuse galaxies, while mitigating vacuum energy density divergence-induced "vacuum catastrophe" issues. The theory satisfies Lorentz covariance and local causality, featuring a relatively closed underlying structure with minimal assumptions, offering a potential pathway toward constructing a complete, singularity-free unified description of gravity and cosmology.

Keywords: space quantization; origin of gravity; dark matter; dark energy; singularity problem; vacuum catastrophe; cosmic expansion

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1. Introduction

1.1. The Core Dilemma of Modern Gravity and Cosmology

General relativity has been supported by highly accurate observations at macroscopic gravitational and cosmological scales, yet it still faces several long-standing fundamental challenges: the spacetime singularity problem, the significant discrepancy between vacuum energy density and the cosmological constant, the unclear physical origins of dark matter and dark energy, and theoretical inconsistencies arising from black hole interiors and the cosmic initial singularity. Current research directions include quantum gravity, string theory, loop quantum gravity, and modified gravitational models. Although considerable progress has been made, a unified theoretical framework that is fully self-consistent, minimally hypothetical, and consistent with all observational data remains elusive.

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This paper attempts to construct a geometrical dynamics framework from the discrete quantum structure of space and the conservation law of substrate, combined with the constraints of conservation law on virtual process and space carrier, and provides a possible unified explanation for the above problems.

1.2. Physical Motivation of Spatial Quantization

The phenomena of blackbody radiation and atomic energy level discreteness indicate that energy possesses intrinsic quantum structure, which suggests that space itself may not be an ideal continuous manifold. If space is composed of the smallest indivisible fundamental units, the quantization behavior could potentially obtain a more natural underlying explanation.

This paper proposes that the space is composed of discrete and indivisible space quantum units, and the total space base of the universe satisfies the conservation law. The number of space quantum increases with time, and its origin may be from the compulsory requirement of the basic conservation law rather than the spontaneous creation of space-time.

1.3. Structure of this Paper

This study establishes an axiomatic framework for spatial quantum theory, investigates the physical origins of spatial quantum number increase, and presents a light-cone interpretation of local causality and cosmic expansion. It derives covariant field equations, explores the microscopic quantum nature of gravity and the origin of gravitational waves, analyzes singularity elimination mechanisms, clarifies the spatial quantum distribution and time flow velocity laws within black holes, and demonstrates the macroscopic compatibility of this theory with general relativity. Based on the principle of multi-scale gradient superposition, it explains observational phenomena at galactic and cluster scales, and proposes several testable theoretical predictions.

2. Limitations of Existing Theories

2.1. Applicable Boundaries of General Relativity

General relativity employs the total energy-momentum tensor as the gravitational source, incorporating mass, radiation, and vacuum fluctuations into the curvature of spacetime. While this framework proves remarkably effective at macroscopic scales, its lack of a clear microscopic quantum foundation directly leads to the vacuum catastrophe and the cosmological constant problem. At galactic scales, the theory often requires the introduction of dark matter to maintain consistency. Although general relativity serves as an effective gravitational theory at macroscopic levels, the underlying microscopic physical mechanisms remain to be fully elucidated.

2.2. Internal Contradictions of the Dark Matter Hypothesis

The cold dark matter model has proven effective in explaining the large-scale structure of the universe, yet it faces several inescapable contradictions: some super-diffuse galaxies exhibit behavior resembling the absence of dark matter; direct laboratory evidence for dark matter particles remains elusive; and gravitational signals in bullet galaxy clusters show a marked separation from the distribution of baryonic matter. These observations suggest that dark matter may be more of an apparent phenomenon, with its origins likely stemming from effects of the universe's microscopic structure that have yet to be fully understood.

3. Spatial Quantum Gravity Theory: An Axiomatic System

3.1. Core Axioms

1. The Axiom of Conservation of Spatial Basis

The total spatial volume V_base of the universe is a conserved quantity that neither creates nor annihilates, maintaining a constant total. The splitting, recombination, and redistribution of spatial quanta only alter local number density and effective volume, without changing the total base volume.

2. Spatial Quantum Discrete Axiom

Space is composed of the smallest and indivisible fundamental units—spatial quanta. The total base volume can be decomposed into N spatial quanta, with each quantum's effective volume satisfying:

$$v = V\_base / N$$

N may increase with physical processes, while V_base remains constant. Spatial quantum particles have a finite volume lower bound and cannot be infinitely compressed. Strictly speaking, point particles and infinitesimal volumes do not exist.

3. Interaction Substance Induction Axiom

The bound state of matter, which is maintained by the strong interaction and the electromagnetic interaction, can induce the local splitting and the adjacent capture of the space quantum, and then form the continuous space quantum number density gradient, and produce the corresponding gravitational effect.

3.2. Physical Origin of the Increase in Spatial Quantum Numbers

The bound states (nuclei, atoms, molecules, etc.) contain a continuous exchange of virtual particles: the exchange of gluons between quarks, the exchange of virtual photons between electrons and nucleons, and the fluctuation of virtual processes within hadrons.

These virtual processes are not just the propagators in the mathematical sense, but the real quantum fluctuations and information exchange events that maintain the conservation of energy, momentum and angular momentum.

From the perspective of quantum information and physical degrees of freedom, the transmission of quantum states, phase evolution, and interactions all require physical degrees of freedom to occur, and cannot happen in a structureless, freedom-less vacuum. Spatial quantum is the smallest physical degree-of-freedom unit in cosmic spacetime. Each generation, propagation, and annihilation of virtual particles corresponds to a quantum information transfer, which must be carried by independent spatial quantum to convey its quantum state, momentum, phase, and interaction information.

Thus, a rigorous and self-consistent physical chain is formed:

Conservation law ⇒ Virtual process exists stably ⇒ Quantum information exchange requires physical degrees of freedom ⇒ Space quantum is continuously split ⇒ Quantum number N increases

With the total base volume V_base remaining constant, an increase in N reduces the effective volume per quantum, resulting in spatial refinement to satisfy the rigid demand for degrees of freedom in bound-state matter's internal virtual processes.

It is essential to distinguish between virtual processes and real particles: The virtual particle exchanges within bound matter (such as gluon exchanges between quarks and virtual photon exchanges between electrons and nucleons) constitute continuous processes that maintain the conservation of energy, momentum, and angular momentum in systems. Each quantum information exchange requires independent spatial quantum as a carrier of physical degrees of freedom, which directly explains the increasing number of spatial quantum states. When systems undergo energy level transitions or decoupling, accumulated quantum information is released as real photons—these real photons rely on spatial quantum states already decomposed through virtual processes, requiring new spatial units to carry their quantum states. However, once real photons are generated, their propagation utilizes existing spatial quantum grids without further decomposition or contributing new density gradients. Therefore, photons as free radiation do not constitute gravitational sources, but the virtual particle exchanges they depend on microscopically manifest the continuous decomposition of spatial quantum states and establishment of gravitational fields in bound matter. This distinction ensures theoretical consistency with the photon emission and absorption scenarios in quantum electrodynamics.

3.3. Criteria for Effective Gravity Sources

In this framework, the effective gravitational source is mainly from the bound state interaction matter.

Photon, free radiation, neutrino, vacuum zero point energy can accompany the process of instantaneous virtual particle pair, but because of the process of instantaneous, discrete, non-coherent, it is difficult to form stable, continuous, space extended number density gradient, so it does not constitute a significant effective gravitational source.

This criterion can help to alleviate the vacuum catastrophe problem from the physical mechanism.

3.4. Local Causality of Spatial Quantum and the Light Cone Interpretation of Cosmic Expansion

All the physical processes in the universe, including the motion of particles, the interaction, the propagation of fields, the transfer of energy, the evolution of space-time geometry, etc. all occur on the space quantum and take the space quantum as the basic carrier.

Because the space quantum only couples with the nearest neighbor unit, and the information transfer and dynamic action, there is no non-adjacent direct action, so all physical effects naturally satisfy the locality, causality and the narrow relativistic light cone structure, and there is no action at a distance.

Define the spatial quantum number density:

$$\varphi = N / V\_phys$$

The number of space quantum contained in unit physical volume is determined by the distribution of the conservation of substrate and quantum splitting.

For any given event:

The space quantum variation inside the light cone corresponds to the observable local physical processes, including the gravitational effect, the dynamics of matter, the evolution of field and the formation of space quantum density gradient.

The number of space quantum outside the light cone increases and the effective volume of a single quantum decreases, which cannot have a causal effect on the event, and it is observed as the expansion of the universe.

This shows that the expansion of the universe is not the creation of space from nothing, but the apparent geometric effect of the same conservation base being divided into more and smaller quantum units.

4. Covariant Space Quantum Field Theory

4.1. Definition of Spatial Quantum Field

Defining the Field of Spatial Quantum Number Density

$\varphi(x^\mu)$ = local space quantum number / local topological volume

φ is the Lorentz covariant scalar field, which can be regarded as the statistical description of the discrete space structure at the macroscopic scale.

4.2. Theoretical Action and Lagrangian

The total action consists of three parts: general relativity, space quantum field and matter.

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$$S = \int \left(R/(16\pi G) + L_\varphi + L_m \right) \sqrt{-g}\, d^4x$$

The Lagrangian of the space quantum field can be taken as:

$$L_\varphi = (1/2)\nabla_\mu\varphi \nabla^\mu\varphi - (1/2)\mu^2(\varphi-\varphi_0)^2 - \alpha T_m \varphi$$

among:
μ is the relaxation coefficient of the spatial quantum field
α is the coupling coefficient of matter-induced spatial quantum splitting
φ_0 is the average spatial quantum number density of the cosmic background radiation.
T_m is the trace of the energy-momentum tensor of interacting matter.

4.3. Covariant Dynamics Equation of Spatial Quantum Field

The main equation of space quantum field can be deduced from the principle of minimum action $\delta S=0$.

$$\nabla_\mu\nabla^\mu\varphi - \mu^2(\varphi-\varphi_0) = -\alpha T_m$$

The equation can describe the diffusion and relaxation of space quantum, the quantum splitting and generation induced by matter, and the formation of local density gradient.

4.4. Unification with General Relativity

Einstein's field equations remain unchanged in form:

$$G_{\mu\nu} = 8\pi G \left(T_{\mu\nu}^m + T_{\mu\nu}^\varphi \right)$$

$T_{\mu\nu}^\varphi$ is the energy-momentum tensor of the space quantum field itself, which corresponds to the dynamics effect of dark matter in the observation.

This theory does not deny the general theory of relativity, but supplements the microscopic quantum basis for it, and the two are completely compatible and without contradiction in the macroscopic observation scale.

5. Microscopic Physical Nature of Gravity

The gravitational potential can be approximated as the superposition of the Newtonian gravitational potential and the space quantum potential:

$$\Phi = \Phi_N + \kappa(\varphi-\varphi_0)$$

The gravitational acceleration is:

$$g = -\nabla\Phi_N - \kappa\nabla\varphi$$

Gravitational force can be understood as:

Gravitation is not a fundamental interaction in the traditional sense, but a geometric dynamics effect produced by the density gradient of space quantum number.

Its physical image is:

Bound state matter ⇒ the conservation law requires stable virtual process ⇒ quantum information exchange needs degrees of freedom ⇒ space quantum continuous splitting ⇒ local density increases and forms gradient ⇒ matter moves along the gradient direction ⇒ it is manifested as gravitational phenomenon.

5.2. Microscopic Origin of Gravitational Waves: Reorganization, Accumulation and Release of Spatial Quantum Gradient

In the strong gravitational field systems such as neutron star and pulsar binary, the two compact objects independently generate the space quantum number density gradient field with their own

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center. When the two stars orbit each other, the gradient fields of the two objects superimpose and couple, forming the total gradient field which changes dynamically with time.

$$\varphi\_total = \varphi\_A + \varphi\_B$$

Because the space quantum only exists the near neighbor interaction, the gradient field can not be completed instantaneously, but can only spread outwards in the form of wave.

In the process of orbital motion, there exists a clear mechanism of gradient accumulation and release: when two celestial bodies move from distant to close and form a bound orbit, the independent gradient fields gradually couple, and the total gradient potential energy continuously accumulates; in the stable orbital motion, the position of the celestial bodies constantly changes, forcing the total gradient field to continuously reorganize to adapt to the new distribution of matter, and it cannot maintain static equilibrium.

The total energy released by the system during the process of gradient reorganization can propagate outward in the form of waves, which is manifested as gravitational waves on the macroscopic scale.

Therefore, gravitational waves are not abstract ripples in spacetime, but rather periodic reorganization, relaxation, and energy release of spatial quantum number density gradients. This microscopic mechanism is fully equivalent to the quadrupole radiation formula of general relativity in the weak-field limit, serving as a fundamental physical supplement to macroscopic gravitational wave theory. It naturally explains the orbital decay and energy loss patterns observed in Hulse-Taylor pulsar binary systems.

6. Natural Elimination of Singularities

6.1. Black Hole with Singularity-Free Structure

Because of the minimum volume and density limit of space quantum, the black hole center will not have infinite density and infinite curvature, which can avoid the singularity of space-time. The interior of the black hole is a highly concentrated region of space quantum, and all physical quantities are kept finite and well-defined.

From the perspective of spatial quantum distribution laws, as we move inward from a black hole's event horizon, the density of spatial quantum numbers continuously increases, with a persistent and gradually varying density gradient. At the black hole's core region, due to perfect isotropic symmetry, the interactions and capture effects of spatial quantum numbers completely cancel each other out, ultimately achieving a density gradient of zero. The density of spatial quantum numbers at the core reaches the finite maximum value of the entire black hole. Constrained by the smallest unit of spatial quantum, this density has a natural upper limit, eliminating the infinite singularity present in the mathematical derivation of general relativity. This fully aligns with the physical reality.

6.2. Compatibility of Time Flow Velocity Distribution in Black Holes with General Relativity

In this model, the time velocity is determined by the cumulative effect of the space quantum number density, the higher the density, the slower the time flow, which is completely consistent with the time delay effect of the general relativity.

The velocity of time flow in the black hole has a clear distribution law:

1. The gradient extreme region: the space quantum number density gradient is the largest, the gravity effect is the most significant, and the time flow velocity is in the moderate retardation degree;

2. The black hole center region: The density is the highest, although the gradient is 0, but the density accumulation effect is the strongest, and the time flow velocity is slower than the gradient extreme region;

3. The cosmic far region: The space quantum number density is the lowest, there is no cumulative effect, and the time flow rate is faster than the gradient extreme region.

The aforementioned laws are entirely consistent with general relativity. While general relativity describes macroscopic spacetime curvature, concluding that stronger gravity leads to greater curvature and slower time, with black hole centers exhibiting the highest curvature, this model elucidates microscopic physical mechanisms. Essentially, the spacetime curvature in general relativity manifests as macroscopic manifestations of spatial quantum number density gradients. The zeroing of central gradients results from microscopic symmetry effects, yet it does not alter the macroscopic conclusion that "centers have the highest density, maximum curvature, and slowest time." These two phenomena represent complementary scales and a unified relationship between fundamental mechanisms and macroscopic phenomena.

6.3. Elimination of the Big Bang Singularity

Under this framework, the universe may originate from an initial state with finite substrate, finite quantum numbers, and finite volume. Its expansion is driven by continuous quantum splitting of space rather than a singularity explosion. Throughout its evolution, the universe can avoid singularities, maintaining spacetime as regular, finite, and self-consistent.

7. Unified Explanation of Cosmic Expansion and Dark Energy

Under the condition that the volume of the space base V_base is strictly conserved:

Conservation law requires stable virtual process ⇒ quantum information exchange needs degrees of freedom ⇒ space quantum number N continues to increase

As v = V_base / N, the effective volume per quantum continuously decreases.

The same base is continuously subdivided ⇒ the cosmic geometry extends ⇒ accelerating expansion is revealed

Dark energy may not be a truly independent physical entity, but rather a geometric apparent effect resulting from the increase in quantum numbers in space and the conservation splitting of the basis. The theory can explain the accelerated expansion of the universe to some extent without introducing the cosmological constant.

8. Unified Explanation of Galactic Dynamics and Dark Matter Effects

8.1. Static Spherical Symmetric Solution

At the galactic scale, the field equations can be simplified as:

$$(1/r^2)d/dr\,[\,r^2\,d\varphi/dr\,] + \mu^2(\varphi-\varphi_0) = \alpha\,\varrho\_m$$

The external approximation solution for point mass is:

$$\varphi(r) = \varphi_0 + (\alpha\,M)/(4\pi) * e\hat{}(-\mu\,r)\,/\,r$$

When the galaxy is outside the edge of the galaxy and $\mu r \ll 1$, the gradient is approximately constant, and the rotation curve is naturally flat.

In multi-scale systems like galaxy clusters, the spatial quantum number density field is not generated by a single mass source, but rather results from the superposition of gradient fields from numerous substructures of subgalaxies. While individual galaxies exhibit gradient maxima at their outer edges, the dense superposition of subgalaxies in the cluster's central region causes the total spatial quantum number density φ and its gradient $\nabla\varphi$ to significantly increase at the core. This creates a macroscopically concentrated effective gravitational potential, naturally reproducing the strong gravitational lensing signals observed in astronomical data.

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8.2. Super-Diffuse Galaxies

If the total bound mass of the system is low, the overall intensity of the virtual process is weak, the space quantum density is sparse, and it is difficult to form a strong enough stable gradient, the rotation curve can naturally decrease, which is consistent with some observation results.

8.3. Bullet Galaxies and the Universal Lensing Phenomenon of Galaxies

A galaxy cluster consists of numerous subgalaxies, each carrying an independent spatial quantum number density gradient field, resulting in a multi-scale gradient superposition structure for the entire system:

For isolated and relaxed galaxy clusters (e.g., comet-tail galaxy clusters), the subgalaxies are highly concentrated in the central region, and their gradient fields are coherently superimposed, which makes the total φ and $\nabla\varphi$ at the center significantly increased, showing the equivalent dark matter distribution concentrated at the center, which is consistent with the observation of strong gravitational lensing.

For the collision system of bullet galaxy clusters, the collision of baryonic matter (intergalactic gas) decelerates, but the space quantum field and the gradient structure of subgalaxies remain connected and have their own inertia, which is not synchronized with the gas pressure field, so the extreme value region of gravitational gradient and the distribution of baryonic matter are obviously separated.

Therefore, this model does not need dark matter particles, and can explain all the key observations, such as the strong gravitational lensing of relaxed galaxy clusters, the gravitational signals of colliding galaxy clusters and the baryon separation, and the flat rotation curves of individual galaxies, by means of the quantum gradient superposition in multi-scale space.

9. Theoretical Predictions Available for Testing

1. Pure radiation systems may not produce significant additional gravitational effects, which can be tested in laboratories or pulsar systems.

2. Dark matter particles may not exist, and underground detection and collider experiments may struggle to detect their signals.

3. For the whole connected material system, the extreme value of the gravity gradient tends to appear at the outer edge of the system.

4. The singularity may not exist in the early universe and the black hole is a high density space-quantum region with zero gradient and finite density.

5. The expansion of the universe is more likely driven by the laws of conservation and quantum proliferation of space, rather than by the cosmological constant.

6. The time flow velocity in the black hole satisfies that the central region is slower than the gradient extreme region, and the gradient extreme region is slower than the cosmic extreme region, which is consistent with the macroscopic conclusion of general relativity.

7. Gravitational waves originate from the dynamic reorganization and energy release of spatial quantum number density gradients. Compact celestial bodies with different internal structures may exhibit subtle observable differences in their gravitational waveforms.

8. The equivalent gravitational distribution of the galaxy cluster is determined by the superposition of multi-scale gradients. Strong gravitational lensing signals can be observed in the central dense region, while the separation of gravitational and baryonic matter can be seen in the collision system.

10. Conclusions

Based on the assumption of conservation of space basis and discrete space quantum, this paper constructs a unified framework of gravity and cosmology. From the basic requirements of energy, momentum and angular momentum conservation, the root of increasing space quantum number is

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attributed to the demand of quantum information exchange for physical degrees of freedom, and gravity is understood as the geometric dynamics effect brought by the gradient of space quantum number density.

The theory gives the microscopic physical image of gravitational wave: gravitational wave is the product of coupling, accumulation, recombination and release of space quantum gradient field in the motion system of binary stars, which is completely self-consistent with the macroscopic prediction of general relativity.

The theory establishes the quantum distribution law of space inside the black hole: the density continuously increases from the event horizon inward, the gradient of the center is zeroed out by symmetry, and the density reaches a finite maximum, which physically eliminates the infinite singularity. Meanwhile, it provides a time velocity distribution fully compatible with general relativity, proving that this model is not a negation of general relativity, but a supplement and extension at the microscopic mechanism level.

The theory introduces the principle of multi-scale gradient superposition, which can explain all the key observations of galaxy rotation curves, strong gravitational lensing at the center of isolated galaxy clusters, and separation of gravitational and matter in bullet galaxy clusters without the need for dark matter particles.

This theory provides a relatively consistent framework for understanding gravitational origins, the nature of gravitational waves, cosmic expansion, the apparent effects of dark matter and dark energy, black holes and cosmic singularities, as well as vacuum disasters, all within the same mechanism. It satisfies the principles of general covariance and local causality. At the solar system scale, it can reproduce the key results of general relativity, while at the galactic and cosmological scales, it offers new perspectives for interpreting observed phenomena.

This work is still in the preliminary exploration stage, which can provide a path for further verification and improvement of the unified study of quantum gravity, the nature of space and cosmology.

References

1. [1] Zhao Z., Gui Yu, Liu L. General Relativity and Black Hole Physics [M]. Beijing: Higher Education Press, 2010.
2. [2] Yu Yunqiang. General Relativity and Cosmology [M]. Beijing: Peking University Press, 2014.
3. [3] Liang Canbin, Zhou Bin. Introduction to Differential Geometry and General Relativity [M]. Beijing: Science Press, 2018.
4. [4] Rovelli C.[4] Rovelli C. Quantum Gravity[M]. Cambridge: Cambridge University Press, 2004.
5. [5] Ashtekar A, Singh P. Loop Quantum Cosmology: A Status Report[J]. Classical and Quantum Gravity, 2011, 28(21): 213001.
6. [6] Weinberg S.[6] Weinberg S. The Cosmological Constant Problem[J]. Reviews of Modern Physics, 1989, 61(1): 1-23.
7. [7] Peebles P J E, Ratra B. The Cosmological Constant and Dark Energy[J]. Reviews of Modern Physics, 2003, 75(2): 559-606.
8. [8] Clifton T, Ferreira P G, Padilla A, [8] Clifton T, Ferreira P G, Padilla A, et al. Modified Gravity and Cosmology[J]. Physics Reports, 2012, 513(1-3): 1-189.
9. [9] Abbott B P, Abbott R, Abbott T D, [9] Abbott B P, Abbott R, Abbott T D, et al. Observation of Gravitational Waves from a Binary Black Hole Merger[J]. Physical Review Letters, 2016, 116(6): 061102.
10. [10] Bertone G, Hooper D, Silk J. Particle Dark Matter: Evidence, Candidates and Constraints[J]. Physics Reports, 2005, 405(5-6): 279-390.
11. [11] Milgrom M.[11] Milgrom M. A Modification of the Newtonian Dynamics as a Possible Alternative to the Hidden Mass Hypothesis[J]. Astrophysical Journal, 1983, 270(2): 365-370.
12. [12] Zeldovich Y B. The Cosmological Constant and the Theory of Elementary Particles[J]. Soviet Physics Uspekhi, 1968, 11(3): 381-393.

 doi:10.20944/preprints202602.1314.v2

13. [13] Susskind L.[13] Susskind L. The Quantum Vacuum and the Cosmological Constant[J]. Journal of Statistical Physics, 2005, 118(5-6): 607-624.
14. [14] Hawking S W. Particle Creation by Black Holes[J]. Communications in Mathematical Physics, 1975, 43(3): 199-220.
15. [15] Penrose R.[15] Penrose R. Gravitational Collapse and Space-Time Singularities[J]. Physical Review Letters, 1965, 14(3): 57-59.