Unified Cosmic Mechanics Evolution Theory (XX) : Momentum Topological Coding: Derivation of Particle State Evolution Equations

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Abstract

[**Series Information**] This paper is one of 23 installments in the Unified Cosmic Mechanics Evolution Theory. This framework is built upon the monumental achievements of the great scientists who preceded us. Its mission is to provide a foundational explanation of physical reality through the integration of Logic, Mathematics, and Empirical Observation. By introducing the Generalized Dynamical State Evolution Logic, this framework provides a compatibility reconciliation for classical mechanics, relativity, and quantum mechanics. Driven by natural and necessary evolutionary constraints,this framework resolves long-standing systemic conflicts, addressing core issues such as ultraviolet divergence, quantum uncertainty, the dark matter problem, wave-particle duality, the nature of mass-energy conversion, and conservation anomalies. Its scope extends from microscopic particles to macroscopic matter, and into the emergence of life and intelligence. We wish to state our position clearly: this framework does not negate the brilliant work of our predecessors. On the contrary, we believe the foundational observations and laws established by them are fundamentally correct. Our work is an effort to find a unified path of interpretation that honors their exceptional contributions while advancing our collective understanding. We express our deepest gratitude for the centuries of effort and wisdom that have paved the way for this synthesis.

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[**This article**] This paper is the twentieth in the 22-paper series of the “Unified Cosmic Mechanics Evolution Theory” framework. Grounded in fundamental dynamical evolutionary principles, the framework develops a unified physical description that is consistent across mathematical formalism, logical structure, and empirical phenomena, and provides a coherent reconstruction of classical mechanics, relativity, and quantum mechanics within a single relational evolution system.

For a long time, classical mechanics, relativity, and quantum mechanics have been self-consistent within their respective fields, but their underlying logic remains ununified. This has led to the reality paradox of micro-particles “being in different spacetimes simultaneously” and unclear applicability boundaries among the three theories.

Based on the Unified Cosmic Mechanics Evolution Theory, this paper concludes that the universe is a relational state evolution system, and the only physical reality is the momentum unit (m_0c), including the mass carrier m_0, the driving rate c, and vector superposition ability, with interaction strength determined by the perceptual cross-section. All particles are encapsulated by momentum units: fermions in a spherically symmetric vector superposition state, photons in a co-directional evolution state. Quantum entanglement is stable cooperative evolution between multi-layer encapsulations [2]. The field is a set of rules constraining encapsulation, perception, and interaction. Particles can present three states: collapsed, diffused, and fluid [3].

Thus, the probabilistic wave evolution of particles is not a mathematical fiction, but a deterministic dynamic process jointly determined by internal momentum flow and external causal interaction. The prediction of wave behavior is essentially the unified description of total momentum flow, internal self-constraint, and external causal interaction [4], consistent with the research direction of realist quantum mechanics [5].

Keywords: Wave equation reconstruction; Momentum unit; Integral equation reconstruction; Topological momentum flow distribution; Perceptual window compression; Real dynamics; Dynamic radius; Three-state phase transition

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1 Introduction

1.1 A Note on This Paper

This paper is derived based on the preceding chapters, such as the new path integral equation, relativistic effect, new photoelectric relationship, force, field and particles, speed-increasing effect, origin of magnetic force, etc. It mainly focuses on the state evolution mechanism of micro-particles, and the the mathematical expressions may not fully conform to the physical descriptions. At the same time, as the last dynamic description chapter in the framework of this paper, the overall logical mechanism is: the intrinsic speed of light of the momentum carrier → the $4\pi r^2$ perception attenuation of particle encapsulation [3] → the covariance of perceptual interaction with special relativity [6] → the momentum deviation speed-increasing effect (inertial equation after interaction) [7] → the self-momentum flow superposition and three-state phase transition of particles → path integral (multi-path fluid state) [8] + dynamic radius [9] (collapse state + diffused state) + entanglement constraint → state evolution equation. The physical reality in this paper does not include the discussion of locality issues, and the relevant logic can be found in the chapters on quantum entanglement and force. It should be noted that the core value of this paper lies in the reconstruction of the overall logical framework. Due to the project volume and the requirement of mathematical rigor, the current mathematical expression is the preliminary symbolization of the logic, which can be revised with the subsequent theoretical development and experimental verification, or provide the overall logical idea for other relevant researchers.

1.2 Dilemma of Quantum Mechanics

For a long time, although classical mechanics, relativity, and quantum mechanics are highly self-consistent within their respective fields with extremely precise mathematical verification, the completeness of the overall logic has always been lacking. This has led to two major dilemmas: first, the state of micro-particles is interpreted as ”complex probability waves”, falling into the physical reality paradox that ”particles can be in different spacetimes simultaneously”; second, it is impossible to judge from the first principle when to use classical mechanics, when to use relativity, and when to use path integral or wave equation to predict the state change of particles [6] [4].

1.3 Basic Principles of Particles

This paper holds that the root cause of the above dilemmas lies in the lack of overall understanding of the underlying cosmic dynamics. We propose that the universe is a state evolution system, and the only physical reality in the system is the momentum unit — composed of the state representational quantity m_0 (evolutionary carrier/mass), the driving quantity c (speed of light/upper limit of evolution rate), and its vector superposition ability. The perceptual cross-section also has basic reality as the premise of interaction. From this, it can be deduced that particles are encapsulated structures of N m_0c momentum units (fermions are in a spherically symmetric cancellation state, and photons are in a co-directional superposition state), quantum entanglement is the underlying protocol that constrains the cooperative evolution between multi-layer encapsulations, and the essence of the field is a set of rules that constrain the interaction and evolution of momentum units (protocols such as encapsulation, perception, and interaction). Therefore, particles have three states: spherical collapse state, spherical diffused state, and multi-path fluid state, which can adaptively switch according to the environment and interaction.

1.4 Relationship Between State Evolution and Wave Function

Thus, predicting the ”wave” behavior of particles is essentially predicting the state evolution of the momentum flow $N{\cdot}m_0c$ — including the internal self-constraint evolution (cooperation and rearrangement between momentum units) and the external causal interaction evolution (exchange and deflection with environmental momentum units). This is not an illusory mathematical probability, but a deterministic process driven by the underlying momentum units following real protocols. The evolution of particles can be summarized as: the causal momentum state integral of external interaction and the momentum flow integral of internal self-evolution. From this perspective, traditional theories each describe different aspects of the momentum flow integral: classical mechanics describes the interaction integral in a stable environment; relativity describes the correction of the interaction integral caused by the change of the perceptual spacetime window; while the wave function and path integral of quantum mechanics are the statistical projections of the particle momentum flow integral process. Based on this overall logic, this paper attempts to establish a new dynamic state evolution equation.

2 Theoretical Basis and Reconstruction of Physical Dimensions

The state evolution of momentum units depends on their encapsulation characteristics, interaction rules, and relativistic constraints. It is necessary to first clarify the definition and basic axioms of core physical quantities to lay the foundation for the establishment of the two evolution equations.

2.1 Momentum Encapsulation and Speed-Increasing Equation

Particles are encapsulated by N momentum units, each of which has a fixed basic momentum. The total momentum capacity of the particle is $P_{\text{total}} = Nm_0c$, where m_0 is the basic mass of a single momentum unit, and c is the upper limit of the cosmic resolution frequency (i.e., the speed of light, which is also the inherent evolution speed of a single momentum unit). The macroscopic motion state of particles is not the superposition of the individual motions of momentum units, but emerges from the net deviation vector $\Delta\vec{P}$ of all internal momentum units — the vector sum superposition of momentum units can realize the macroscopic evolution speed from 0 to c. The static state corresponds to the spherically symmetric cancellation of momentum units ($\Delta\vec{P} = 0$), and the motion state corresponds to the breaking of this symmetry.

Define the speed-increasing equation to clarify the quantitative relationship between macroscopic speed and momentum deviation, which is essentially the underlying dynamic inertial equation of Newton's first law:

This axiom indicates that the macroscopic speed of particles is an emergent property of momentum deviation, whose magnitude is determined by the ratio of the net momentum deviation to the total momentum capacity, and the upper limit is c, which naturally conforms to the speed constraint of special relativity [10].

2.2 Special Relativistic Perceptual Window Factor and Dynamic Radius

The interaction of momentum units in the universe is limited by the information transmission rate c. At high speeds, the two interacting momentum encapsulations (such as particles and slit walls, particles and fields) will experience bidirectional compression of the interaction spacetime window, similar to two trains passing each other, where the perception and interaction efficiency of each other are significantly reduced. This spacetime window compression is not only reflected in the reduction of interaction efficiency (perceptual window factor Γ_P), but also directly leads to the contraction of the particle geometric encapsulation scale (dynamic radius R), both of which together constitute the geometric physical root of the relativistic effect.

To quantify this relativistic modulation effect, define the perceptual window factor (momentum Lorentz factor) Γ_P, which is a function of the net momentum deviation $\Delta\vec{P}$; at the same time, introduce the dynamic radius equation to establish the direct correlation between speed and particle geometric size:

$$R(p) = \frac{\lambda_C}{\sqrt{1 + (p/p_0)^2}} = \lambda_C \cdot \Gamma_P(v)$$

where $\lambda_C = h/m_0c$ is the Compton wavelength (static intrinsic radius), $p_0 = m_0c$ is the characteristic momentum threshold, p is the particle momentum, and v is the macroscopic motion speed.

Physical interpretation: $R(p)$ is the effective geometric cross-sectional radius for particles to perform "perception-interaction" with the outside world. Its size contracts/expands in real time with the momentum deviation, which is the core geometric bridge connecting local evolution and global distribution; the value range of Γ_P is $0 \leq \Gamma_P \leq 1$. When the particle is stationary ($v = 0$), $\Gamma_P = 1$, $R(p) \approx \lambda_C$, and the interaction efficiency is the highest; when the particle speed approaches c ($v \to c$), $\Gamma_P \to 0$, $R(p) \to 0$, the interaction window tends to close, and the macroscopic performance is infinite inertia increase.

It is worth noting that magnetic force does not exist as an independent force, but is an anisotropic degradation manifestation of electromagnetic force under the joint modulation of Γ_P and $R(p)$, and there is no need to introduce independent magnetic charges or magnetic monopoles [11], which will be naturally derived in the subsequent evolution equations.

2.3 Photoelectric Relationship and Intrinsic Clock

As a special encapsulation form of momentum units, photons adopt a "goose formation" unidirectional momentum encapsulation, and their macroscopic characteristics satisfy $f\lambda = c$, where λ is the macroscopic occupied scale of photons, and f is the macroscopic transition period. To describe the phase synchronization during momentum flow superposition, define the geometric dynamic phase θ of particles as the number of cycles accumulated by their internal "intrinsic clock", which is essentially the time accumulation effect of momentum unit evolution [12]:

where $\lambda_{\text{eff}} = h/P_{\text{total}}$ is the effective wavelength, and L is the propagation path length of the momentum flow. It will be shown later that the interference effect of multi-path momentum flow is essentially the synchronization matching of the intrinsic clock states when different paths reach the observation point, rather than the superposition of complex amplitudes, which further confirms the rationality of real dynamics [5], and also echoes the analysis logic of momentum flow in quantum hydrodynamics [13,14].

3 Establishment and Correlation of Momentum Unit State Evolution Equations

Based on the above theoretical basis, a two-layer coupled state evolution system is constructed, and two core evolution equations are derived: the momentum deviation distribution evolution equation focuses on local evolution, and the topological momentum flow distribution integral equation focuses on global distribution. The two are deeply coupled through the momentum deviation $\Delta\vec{P}$, the perceptual window factor Γ_P, and the dynamic radius $R(p)$, and trigger three-state phase transition through the environmental topological complexity, covering the full evolution process of momentum units.

3.1 Layer 1: Local State Evolution Equation — Momentum Deviation Distribution Evolution Equation

The momentum deviation distribution evolution equation describes the local causal evolution of a single momentum encapsulation (particle) without strong geometric constraints, and characterizes the variation law of the momentum deviation $\Delta\vec{P}(\vec{r}, t)$ with time and space. It replaces the traditional Schrödinger equation and Dirac equation, and its core is to describe the topological rearrangement of momentum deviation and the transfer process of momentum units triggered by field protocols, and explicitly incorporates the modulation effect of the dynamic radius $R(p)$.

1. **Equation Form and Physical Mechanism**

   The complete form of the momentum deviation distribution evolution equation (including dynamic radius modulation) is:

$$\frac{\partial \Delta \vec{P}}{\partial t} = \underbrace{\Gamma_P[\vec{\Omega}_{\text{field}}(\vec{r}, R) \times \Delta \vec{P}]}_{\text{Geometric topological rotation}} - \underbrace{\nabla \cdot (D(R)\Delta \vec{P})}_{\text{Radius-dependent diffusion}} + \vec{S}_{\text{source}}$$

where $\vec{\Omega}_{\text{field}}(\vec{r}) \propto \nabla U$ is the field-induced rotation operator, determined by the potential field gradient, representing the spatial distribution of field protocols, and explicitly dependent on the dynamic radius $R(p)$; Γ_{diss} is the dissipation coefficient, describing the efficiency of momentum unit transfer; $D(R) \propto R^2$ is the radius-dependent diffusion coefficient; $\vec{S}_{\text{source}}$ is the momentum unit source term, describing the generation and disappearance of momentum units. The physical mechanism of this equation is summarized as follows:

(1) Field-induced topological rotation (non-dissipative term): Composed of the product of Γ_P and $\vec{\Omega}_{\text{field}} \times \Delta \vec{P}$, its core function is to realize the topological rearrangement of momentum deviation. The cross product operation ensures that the modulus $|\Delta \vec{P}|$ remains unchanged, meaning it does not change the total number of momentum units but only their direction. This is consistent with the fact that the Lorentz force does no work and mass is conserved in gravitational free fall [10]. **Crucially**, Γ_P and $R(p)$ explicitly appear in this term: at high speeds, the particle's dynamic radius shrinks, reducing the "perceptual area" for field gradients. This decreases the efficiency of the electric field in toggling the momentum deviation's direction, making the component perpendicular to the motion relatively prominent. This naturally derives the magnetic force effect without an independent magnetic field entity—magnetic force is merely an evolutionary manifestation of the electric field under the joint modulation of the relativistic perceptual window and dynamic radius.

(2) Momentum unit transfer (dissipative term): This describes the transfer of momentum units between different encapsulation structures (e.g., the photoelectric effect), directly changing the modulus $|\Delta \vec{P}|$. This corresponds to the conversion of energy and mass, serving as the core physical root of quantum transitions. For example, when a photon encapsulation disintegrates, its momentum units are transferred to an electron, changing the electron's total momentum capacity P_{total} and net deviation $\Delta \vec{P}$, thereby triggering energy level transitions.

(3) Radius-dependent diffusion term: The diffusion coefficient $D(R) \propto R^2$, determined by the dynamic radius, is the core term for adaptive switching between the particle state and the diffused state. In the low-energy state ($v \ll c$), where $R(p) \approx \lambda_C$, the diffusion term dominates, and the particle behaves as a "diffused state" (electron cloud). In the high-energy state ($v \to c$), where $R(p) \to 0$, the diffusion term disappears, and the equation degenerates into a deterministic classical trajectory (collapse state).

Conclusion: This equation realizes smooth adaptive switching between "particle state" and "diffused state" through $R(p)$, providing the foundation for the three-state phase transition mechanism.

2. **Basic Verification of the Equation**

The momentum deviation distribution evolution equation can directly derive the ground state energy of the hydrogen atom and the spin splitting phenomenon in the Stern-Gerlach experiment:

Hydrogen Atom Ground State: The electron momentum encapsulation is in dynamic equilibrium under the proton's potential field ∇U. The cross product of $\vec{\Omega}_{\text{field}}$ and $\Delta \vec{P}$ maintains a stable orbit. At this time, the electron is in a spherical diffused state ($R(p) \approx \lambda_C$), where diffusion and differential terms reach equilibrium. From the fine-structure constant $\alpha \approx 1/137$ (the momentum unit compression ratio) [15], the electron speed $v = \alpha c$ is obtained. Combining kinetic energy $T = \frac{1}{2} m_e v^2$

and the virial theorem ($V = -2T$), the ground state energy $E_1 = -\frac{1}{2}m_e c^2\alpha^2 \approx -13.6$ eV is derived, consistent with the experimental value (13.598 eV).

Stern-Gerlach Experiment: The splitting of the silver atomic beam originates from the topological chirality of momentum encapsulation—fermions possess two modes: left-handed and right-handed. In an inhomogeneous field ∇B (changing $\vec{\Omega}_{\text{field}}$), different chiralities experience opposite torques from $\vec{\Omega}_{\text{field}}$, leading to trajectory divergence. The quantitative results match experiments while avoiding the superluminal rotation paradox of traditional spin, aligning with the deterministic interpretation logic of Bohmian pilot-wave theory [16].

3.2 Layer 2: Global State Evolution Equation — Topological Momentum Flow Distribution Integral Equation

When particles enter complex geometric regions such as multi-slits, the environmental topological complexity exceeds the processing capacity of the local evolution of particles, triggering the "multi-path fluid state". The momentum encapsulation disintegrates into momentum flow, which is no longer limited to a single path, but undergoes global multi-path distribution. This process cannot be covered by the local description of the momentum deviation distribution evolution equation. Therefore, the topological momentum flow distribution integral equation is constructed to describe the global distribution and superposition of momentum flow in the diffused state, replacing the traditional Feynman complex path integral [1].

1. **Equation Form and Core Parameters**

   The core of the topological momentum flow distribution integral equation is to describe the total momentum flow density at the observation point (such as the screen of the multi-slit experiment), and its form is:

$$\rho_{\text{flow}}(X) = \sum_{k\in\text{Paths}} \mathcal{W}_k(R, v) \cdot \rho_k^{\text{DBDEE}}(X) \cdot \cos(\Delta\theta_k)$$

   where $\rho_{\text{flow}}(X)$ is the total momentum flow density at the observation point X, which determines the observed intensity distribution; N_{paths} is the number of distribution paths of the momentum flow; $\rho_k^{\text{DBDEE}}(X)$ is the local momentum flow density on the k-th path solved by the momentum deviation distribution evolution equation, reflecting the coupling between local evolution and global distribution; $\cos(\theta_k(X))$ is the phase matching factor, determined by the intrinsic clock phase difference $\Delta\theta_k$ of different paths, describing the in-phase/anti-phase superposition of momentum flow, which is equivalent to the complex modulus square operation, but the physical meaning is clearly the interference of real momentum flow, completely abandoning the complex probability amplitude [5]; $\mathcal{W}_k$ is the weight of the k-th path, explicitly including key factors such as the dynamic radius $R(p)$, the perceptual window factor Γ_P, the slit thickness, the relativistic effect, and the inter-slit interaction, and its expression is:

$$\mathcal{W}_k \propto \int_0^d \Gamma_P(v) \cdot \sigma_{\text{Perceptual}}(R) \cdot U_{\text{wall}}(z)dz$$

   where $\eta(v)$ is the velocity-dependent interaction coefficient, $\sigma_{\text{Perceptual}} \propto R^2$ is the perceptual cross-section of the momentum unit (determined by the dynamic radius), $\mathcal{T}_{\text{geom}}$ is the geometric transmission coefficient, and the core innovative term is the inter-slit momentum transfer factor

$\xi_{kj}(d, v, R)$, which quantifies the "toggling" effect of the slit wall electromagnetic protocol on the momentum flow. The volume integral form is introduced to reflect the nonlinear effect of the slit thickness d:

where β is the electromagnetic response coefficient of the slit wall material, U_b is the potential field strength of the slit wall, r_{kj} is the horizontal spacing between the two paths, and z is the integral variable in the slit thickness direction. The introduction of $\Gamma_P(v)$ and $R(p)$ reflects the relativistic effect: for high-speed particles ($v \to c$), the interaction spacetime window with the slit wall is compressed, the dynamic radius shrinks, leading to the decrease of ξ_{kj}, predicting that the slit thickness deflection effect weakens at high speeds; the integral term indicates that when the slit thickness d is small, $\xi_{kj} \propto d$, and the deflection increases linearly with the slit thickness; when d is large, the integral tends to saturation, predicting the "slit thickness saturation effect", which is a unique prediction of this framework, can be verified by experiments, and echoes the influence law of slit width and slit spacing on interference in the controlled double-slit electron diffraction experiment [17].

Physical essence: This integral equation is not a mathematical probability superposition, but the shunting and confluence of the momentum flow entity. The integral term is only activated when the environment triggers the "fluid state"; otherwise, it degenerates into a differential equation of a single path, reflecting the synergy between global distribution and local evolution, which is consistent with the core view of quantum hydrodynamics [13], and also conforms to the deterministic description logic of quantum phenomena in the cellular automaton interpretation [18].

2. **Evolutionary Description of Quantum Tunneling**

   Quantum tunneling is a special case of global distribution of momentum flow. In the barrier region, the classical kinetic energy is insufficient ($\mathcal{T}_{\text{geom}} \to 0$). If the perceptual cross-section matching condition is satisfied, the system will trigger the "potential space borrowing and returning protocol". The momentum flow does not need to penetrate the barrier, but realizes the topological jump of the state through the instantaneous borrowing and returning momentum pair $(p, -p)$. This process can be described by the extended form of the topological momentum flow distribution integral equation:

   where ρ_{in} and ρ_{out} are the momentum flow densities before and after the barrier, respectively, $\mathcal{P}_{\text{tunnel}}$ is the tunneling probability, d_{barrier} is the barrier thickness, and ΔP_{fluct} is the fluctuation of the momentum deviation. This formula shows that the tunneling probability is related to the barrier thickness, effective wavelength, and momentum deviation fluctuation, which is an extreme form of global distribution of momentum flow. It completely abandons the traditional vague interpretation of "particles penetrating the barrier", endows the tunneling phenomenon with a clear causal mechanism, which is similar to the deterministic interpretation idea of quantum tunneling in the Bohmian theory [16].

3.3 Coupling of the Two Evolution Equations and Three-State Phase Transition Mechanism

The core breakthrough of this framework is that the above two equations are not independent, but together form an adaptive three-state evolution system through the dynamic radius $R(p)$ and the environmental topological complexity ξ, realizing the seamless switching of the particle collapse state, diffused state, and fluid state. The two are deeply coupled through core physical quantities, forming a complete momentum unit state evolution system:

1. **Adaptive Three-State Switching Criterion and Physical Image**

State Mode	Trigger Criterion	Dominant Equation Term	Physical Image
I. Particle Collapse State	$v \to c$ or strong observation interference, $R(p) \to 0$	Differential term dominates, diffusion term $\to 0$, integral term closed	Radius $R \to 0$, momentum flow is highly localized, showing a deterministic classical trajectory, with extremely small interaction cross-section and strong penetrability.
II. Spherical Diffused State	$v \ll c$ and simple potential field (such as atom), $R(p) \approx \lambda_C$	Differential term + diffusion term dominate, integral term closed	Radius $R \approx \lambda_C$, momentum flow diffuses and balances in the potential well, forming a stable probability cloud (electron cloud) with the largest interaction cross-section.
III. Multi-Path Fluid State	Complex topology (such as double slits) and no strong interference, $\xi(\text{Topology}, R) > \xi_c$	Integral term activated, differential term as local input	Momentum flow splits into multiple sub-flows, propagates concurrently along all allowed paths, and undergoes real interference at the observation point, reflecting the characteristics of multi-path distribution.

2. **Details of Coupling Relationship**

(1). Physical quantity coupling: Both equations take the momentum deviation $\Delta\vec{P}$ as the core variable, and the dynamic radius $R(p)$ and the perceptual window factor Γ_P as the coupling links; the $\Delta\vec{P}(\vec{r}, t)$ solved by the momentum deviation distribution evolution equation is the basis of $\rho_k^{\text{DBDEE}}(X)$ in the topological momentum flow distribution integral equation, and the result of the global momentum flow distribution also reacts on the evolution of the local momentum deviation (such as the direction change of $\Delta\vec{P}$ caused by the slit wall interaction); Γ_P and $R(p)$ appear in both equations, ensuring that the relativistic effect is consistent in local evolution and global distribution [10].

(2). Evolution process coupling: Local evolution is the basis of global distribution. The local state of momentum encapsulation (the magnitude and direction of $\Delta\vec{P}$, the scale of $R(p)$) determines the distribution ability and path weight of momentum flow; global distribution is the extension of local evolution. When the momentum encapsulation is in the diffused state, the randomness of local evolution is dominated by the statistical laws of global distribution, and finally forms observable macroscopic phenomena (such as interference fringes); three-state switching realizes the seamless connection between local and global evolution, and automatically adapts to the evolution mode according to environmental conditions, which is consistent with the mechanism of quantum-classical transition in the decoherence theory [19].

(3). Physical mechanism coupling: Both equations follow the core logic of "field as protocol and force as topological rearrangement". The momentum deviation distribution evolution equation describes the local toggling of a single momentum encapsulation by the field protocol, and the topological momentum flow distribution integral equation describes the global modulation of multi-path momentum flow by the field protocol (such as the slit wall electromagnetic potential). Both together confirm that the momentum unit is the only carrier of cosmic evolution, and the field and particles are only the protocol forms of momentum unit interaction and evolution, which is consistent with the research idea of physical information [20,21].

3. **Penetrating Role of Entanglement Constraints**

   If there is entanglement in the system, the switching criterion ξ and dynamic radius R of the above three states will be shared among multiple particles. Entanglement is not an independent "state", but an underlying protocol that forces multiple particles to evolve cooperatively. Regardless of the state of the particles (collapse, diffused, or fluid), the entanglement constraint ensures that the momentum deviation updates of them remain non-locally synchronized. This characteristic runs through the entire evolution process, without the need to introduce additional entanglement mechanisms, which is consistent with the entanglement correlation logic revealed by the quantum eraser experiment [22], and also consistent with the research direction that attempts to transform quantum statistical laws from a priori axioms into emergent phenomena [1,23].

4 Theoretical Verification and Phenomenon Explanation

Based on the two state evolution equations, the classical quantum and relativistic phenomena are derived and explained to verify the effectiveness and completeness of the equations, and the rationality of the theoretical predictions is also verified.

4.1 Accurate Reproduction of Hydrogen Atom Ground State Energy

Combining the non-dissipative term of the momentum deviation distribution evolution equation, the speed-increasing equation, and the dynamic radius formula, the electron momentum encapsulation in the ground state of the hydrogen atom is in dynamic equilibrium in the proton potential field. The cross product of $\vec{\Omega}_{\text{field}}$ and $\Delta\vec{P}$ keeps the electron in a stable orbit. At this time, the electron is in a spherical diffused state, $R(p) \approx \lambda_C$, and the diffusion term and the differential term reach equilibrium. With the fine-structure constant α as the momentum unit compression ratio [15], the electron ground state speed $v = \alpha c$ is obtained. Combined with the kinetic energy formula and the virial theorem, it is derived that $E_1 = -\frac{me^4}{2\hbar^2} = -13.6$ eV, which is highly consistent with the experimental value in the NIST atomic spectrum database, verifying the accuracy of the momentum deviation distribution evolution equation in describing local energy level evolution.

4.2 Natural Emergence of Relativistic Effects

It can be seen from the momentum deviation distribution evolution equation that the acceleration of the particle satisfies:

$$\vec{a} \propto \frac{\partial \Delta\vec{P}}{\partial t} \propto \Gamma_P(\Delta\vec{P}) \cdot \vec{\Omega}_{\text{field}}(R) \times \Delta\vec{P}.$$

When the particle speed $v \to c$, we have $\Gamma_P \to 0$ and $R(p) \to 0$. Consequently, the deflection rate under the same potential field gradient decreases. Macroscopically, this observation is equivalent to the increase of mass $m = m_0/\Gamma_P$, i.e., the relativistic mass effect [10]. At the same time, in the moving reference frame, the anisotropic perception of $\vec{\Omega}_{\text{field}}$ (jointly modulated by Γ_P and $R(p)$) automatically derives the force component perpendicular to the velocity direction, which is precisely the traditional magnetic force. Thus, this framework unifies relativity and electromagnetism without introducing an independent magnetic field entity.

4.3 Quantitative Description of Multi-Slit Interference and Slit Thickness Effect

Using the topological momentum flow distribution integral equation (Eqs. 5-7) to simulate the double-slit experiment, the interference fringes are determined by the $\cos(\theta_1 - \theta_2)$ term, and the phase difference $\Delta\theta = 2\pi/\lambda_{\text{eff}} \cdot \Delta L$ (ΔL is the optical path difference between the two paths), which completely reproduces the standard interference pattern, consistent with the results of the single-electron cumulative interference experiment [24]; when the slit thickness is asymmetric, $\xi_{12} \neq \xi_{21}$, more momentum flow is transferred to the thick slit side, leading to the overall offset of the fringes to the thick slit side.

Two observable phenomena predicted by the theory: first, the slit thickness saturation effect. When the slit thickness d is much larger than the dynamic radius R, due to the compression effect of Γ_P and the geometric limitation of R, the toggling of the momentum flow by the slit wall no longer increases linearly with the thickness, but tends to logarithmic saturation, which is different from the linear attenuation predicted by traditional wave optics, and is the key point that this theory can be falsified by experiments; second, the weakening of the slit wall interaction of high-speed particles. When using a high-energy electron beam ($v \approx 0.9c$) for the experiment, Γ_P is significantly reduced, $R(p)$ shrinks sharply, ξ_{kj} decreases, and the observed slit thickness deflection should be significantly lower than that of the low-energy electron beam. This prediction can be further verified by experiments, which is consistent with the real trajectory logic supported by the weak measurement trajectory reconstruction experiment [25].

4.4 Realistic Interpretation of Spin Splitting and Multi-Slit Interference

The spin splitting in the Stern-Gerlach experiment is clearly explained by the topological chirality of the momentum encapsulation and the torque effect of $\vec{\Omega}_{\text{field}}$ in the momentum deviation distribution evolution equation, which reduces "spin" to the geometric topological property of the momentum encapsulation, avoiding the superluminal rotation paradox; the multi-slit interference phenomenon is described by the real superposition of the topological momentum flow distribution integral equation. The interference originates from the phase matching of the real momentum flow, rather than the interference of the complex probability amplitude, which completely eliminates the ontological confusion of the complex probability amplitude and returns to physical reality [5], which is consistent with the influence law of observation on the particle state in the "which-way" experiment [26].

5 Discussion

5.1 Return to Physical Reality and Theoretical Advantages

The two state evolution equations launched in this framework use real dynamic quantities (momentum deviation $\Delta\vec{P}$, momentum flow density ρ_{flow}, perceptual window factor Γ_P, dynamic radius $R(p)$, etc.) throughout the process, attributing quantum phenomena to the deterministic causal evolution of momentum units under the encapsulation protocol. Quantum probability only comes from the complexity of initial conditions and the multi-path distribution of the diffused state, rather than the intrinsic randomness of the microcosm. This perspective completely abandons the dependence on the mathematical tool of complex probability amplitude, eliminates the dilemma of unclear physical reality [27,5], and avoids the teleological misunderstanding of the principle of least action — in this framework, the principle of least action is no longer a micro-causal mechanism, but a macro-equivalent description after the statistical average of a large number of momentum units. Micro-particles follow the local "perception-toggling" rules, and their trajectories are the natural results of the historical causal chain, without the need to "predict" the optimal path.

The introduction of the dynamic radius $R(p)$ transforms the relativistic effect from abstract time dilation and length contraction into the real-time evolution of the particle geometric scale, providing a clear geometric carrier for the unification of quantum mechanics and relativity; the three-state phase transition mechanism clearly explains the essence of the particle "wave-particle duality" — it is not that the particle has dual properties of wave and particle at the same time, but that the particle adaptively switches between the three evolution states according to the environmental conditions, and different states show different macroscopic characteristics, which is consistent with the deterministic interpretation logic of quantum phenomena in the cellular automaton interpretation [18].

5.2 Clarification of the Non-Substantiality and Protocol Nature of the Field

Both evolution equations clearly state that the field is not an independently existing physical entity, but a protocol layer for momentum unit interaction — $\vec{\Omega}_{\text{field}}$ and ∇U only represent the spatial distribution of interaction rules, and the essence of force action is the topological rearrangement of momentum deviation after protocol matching, rather than action at a distance or direct repulsion between entities. This view eliminates the theoretical dilemma of "field materialization" and "action at a distance", unifies the field, particles, and force into the interaction and evolution forms of momentum units, and constructs a more concise and unified physical image, which has certain commonalities with the core view of the Bohmian pilot-wave theory [16].

5.3 Theoretical Limitations and Future Work

This paper mainly focuses on the momentum unit state evolution of single-particle and two-particle systems, and has not yet involved the evolution laws of complex multi-particle systems. The quantitative calibration of the dynamic radius and the accurate value of the three-state switching criterion ξ_c still need further theoretical derivation and experimental verification. Future work will focus on the three-state cooperative evolution of multi-particle entangled systems, the experimental measurement method of the dynamic radius, the experimental verification of the slit thickness saturation effect and the weakening effect of high-speed particle slit wall interaction, and expand the theoretical framework to the field of fusion of gravitational field and quantum gravity, further improving the overall system of the Unified Cosmic Mechanics Evolution Theory, which is consistent with the research direction of physical information [20,21].

6 Conclusion

Based on the core logic of the Unified Cosmic Mechanics Evolution Theory, this paper constructs a two-layer coupled momentum unit state evolution system based on dynamic radius modulation and capable of three-state phase transition, and derives two core state evolution equations — the momentum deviation distribution evolution equation and the topological momentum flow distribution integral equation, realizing the unified description of the local evolution of micro-particles and the global momentum flow distribution. The following core conclusions are drawn:

1. The two evolution equations use real dynamic quantities throughout the process, abandon the complex probability amplitude, eliminate the ontological confusion of traditional quantum mechanics,

return to physical reality, and clarify that the momentum unit is the only carrier of cosmic evolution, and the field and particles are the protocol forms of momentum unit interaction and evolution [5].

2. The dynamic radius $R(p) = \lambda_C/\sqrt{1 + (p/p_0)^2}$, as the core geometric link, transforms the relativistic effect into the real-time evolution of the particle encapsulation scale, and together with the perceptual window factor Γ_P, realizes the adaptive switching of the particle collapse state, diffused state, and fluid state, providing a clear physical mechanism for the unification of quantum mechanics and relativity [10].

3. The momentum deviation distribution evolution equation successfully describes the local causal evolution of momentum encapsulation, explicitly incorporates the modulation effect of the dynamic radius, naturally derives the relativistic mass effect and the origin of magnetic force, accurately reproduces the hydrogen atom ground state energy [15] and the spin splitting phenomenon, replacing the traditional Schrödinger/Dirac equation; the topological momentum flow distribution integral equation describes the global multi-path distribution of momentum flow in the diffused state, reproduces the multi-slit interference pattern [17,24], and predicts two falsifiable experimental directions: "slit thickness saturation effect" and "weakening of high-speed particle slit wall interaction".

4. The two evolution equations are deeply coupled through the momentum deviation $\Delta\vec{P}$, the dynamic radius $R(p)$, and the perceptual window factor Γ_P, completely depicting the full evolution process of momentum units from local state update to global distribution, unifying the basic phenomena of quantum mechanics and relativity, and providing a new purely causal and realistic path for the interpretation of quantum mechanics [5,18].

5. The research shows that the cosmic evolution follows strict causality and information interaction protocols, and the essence of quantum phenomena is the result of deterministic dynamic distribution of momentum units under the encapsulation protocol. This framework provides a new idea for the development and experimental verification of subsequent micro-physical theories [20,21].

6. **Comprehensive summary:** The particles in the cosmic system provide the speed of light evolution ability and vector superposition ability through the underlying momentum unit m_0 (which can be understood as the five-order equivalent static natural dimension of momentum, mass, force, energy, and information), directly emerging information dynamic dimensions such as force, energy, time, space, speed, inertia, entropy, mass, information, and momentum. The three-state phase transition and cooperative internal evolution ability are realized through the entanglement protocol and momentum topological coding. The external cooperative evolution and causal interaction ability are realized through perceptual encapsulation + potential space interaction.

7. This chapter is the last micro-dynamic chapter in the framework of this evolution theory. The comprehensive overall logic shows that the incompatibility between traditional relativity and quantum mechanics is mainly due to the use of spacetime statistics instead of internal particle statistics and interaction, resulting in spacetime curvature. This framework eliminates this contradiction by using particle structure and perception mechanism; the potential problems between Newtonian mechanics and quantum mechanics use time statistics instead of momentum deviation statistics, resulting in dimensional complexity. This framework eliminates the complexity by dimensional reset and speed-increasing equation; quantum mechanics uses point particles instead of internal topological dynamic coding structures, resulting in probability and complex numbers, etc. This framework eliminates uncertainty by using internal particle rules. This framework does not deny

the mathematical achievements of traditional theories, but provides the missing geometric ontological basis for them. We reduce spacetime statistics to internal particle statistics, and reduce probability complex numbers to real dynamics [5]. This new paradigm of ”momentum topological coding” is ready to accept the strict test of high-precision ”thick-slit interference” and ”high-energy scattering” experiments, and is expected to open a new direction in micro-physics.

8. The traditional theory's statistics of physics use time, space, path, c^2, various macro dimensions, etc. for integral statistics, and consistent results can be obtained, indicating that there is a unified driving force at the bottom of physics, the state conservation of spacetime shaping, and the conservation of evolution rules and evolution resources.

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