Unified Cosmic Mechanics Evolution Theory (XVIII) : Indirect Relationship Between Charge and Mass

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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.

[**This article**] This paper is the eighteenth 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.

In traditional theory, electrons and protons differ in mass by a factor of 1836 but exhibit identical electromagnetic force intensities. This contradiction is attributed to the assumption that "charge is an intrinsic property independent of mass," yet the physical origin of charge remains unexplained. Based on the framework of the Unified Cosmic Mechanics Evolution Theory and combined with new inferences, this paper proposes that charge and color charge are not intrinsic properties of particles, but may be manifestations of fixed-proportion momentum units emerging from the combined effects of momentum conservation constraints and geometric encapsulation, with no direct proportional relationship to mass. The core mechanism is speculated to be the particle's effective momentum flow—a geometric compression factor multiplied by the particle's spacetime shaping capability—which may eventually take a constant value under the constraint of momentum conservation. This could be the fundamental reason for the equal electromagnetic forces of electrons and protons. This paper further explores the geometric factors related to electromagnetic force, formula derivation, celestial energy conversion, and the underlying logic of angular momentum conservation, attempts to clarify the essence of the mass-energy equation, and provides a new theoretical reference path for the unification of electromagnetic force and gravity. It should be noted that the complete unification mechanism of the four fundamental forces still requires reconstructing the standard model based on this framework, which is highly technically challenging and can be further improved and supplemented by relevant colleagues in the future.

Keywords: Nature of electric charge; Nature of force; Topological quantum mechanics; Origin of electromagnetic force; Nature of magnetic monopole; Baryon disappearance; Velocity increment equation; Unified mechanics

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Introduction

Electromagnetic force is one of the four fundamental forces in nature, and its correlation with particle mass has long been a core puzzle in the physics community: electrons and protons differ in mass by a factor of 1836, yet the intensities of the electromagnetic repulsion and attraction they generate are completely identical. To explain this contradiction, traditional theory proposes the hypothesis that "charge is an intrinsic property of particles," treating charge and mass as separate entities. However, it has never been able to clarify the physical origin of charge, nor can it connect the underlying logic of momentum conservation and geometric evolution, making it difficult to explain the non-proportional relationship between charge, color charge, and mass.

The *Unified Cosmic Mechanics Evolution Theory* provides a new framework to solve this dilemma. This theory holds that the universe is a relational state evolution system, and all evolutions are encoded or emerge on the geometric topology of momentum units. Based on this core viewpoint, this paper supplements and improves the theoretical system with new inferences, focusing on exploring the origin of charge and color charge, and the essential mechanism by which electromagnetic force is independent of mass.

By introducing core concepts such as geometric compression factor and effective momentum flow, combined with the space-time equivalent exchange mechanism under momentum conservation constraints [1,2], this paper attempts to explain the fundamental reason for the equal electromagnetic forces of electrons and protons; further explores the physical significance of the 4π geometric factor in the electromagnetic force formula, derives the charge-free electromagnetic force formula through the velocity increment equation, connects the laws of micro-particle interaction and macro-celestial evolution, attempts to clarify the dual connotation of the mass-energy equation, and ultimately seeks to reduce charge and color charge to the momentum breaking amount during the evolution of momentum units, improving the physical image of particle evolution and force action, and providing a theoretical reference for the unification of the four fundamental forces. It should be pointed out that the complete unification mechanism of the four fundamental forces still requires reconstructing the standard model based on this framework, which is highly technically challenging and can be further improved and supplemented by relevant colleagues in the future.

1 Theoretical Basis: Momentum Encapsulation and Momentum Conservation — Dual Core of Matter Dynamics

1.1 Momentum Unit: The Only Physical Reality and Evolutionary Carrier of the Universe

Our core hypothesis is that the only physical realistic evolutionary resource in the cosmic system is the momentum unit m_0 [1]. All particles are encapsulations of momentum units, and their dynamic behaviors originate from the evolution and interaction of internal momentum units [3]. As a relational state evolution system and a many-to-many autonomous evolution system [6], all evolution-related quantities (representational quantity m_0, driving quantity c [4], evolution rule r) of the universe are encoded or emerge on the geometric topology of momentum units [5]; for example, chirality can determine the common evolution direction of both particles [3].

Momentum units are based on the minimum unit m_0, and the total mass of a particle is essentially the total number of internal momentum units, i.e., total momentum

$$P_{\text{total}} = mc$$

It is necessary to clarify the essence of the mass-energy equation:

Space-time state shaping equation:

$$E = mc^2$$

— $c^2 = (l_P/t_P)^2$ indicates that the space unit l_P and time unit t_P emerge synchronously and separately but are jointly coupled, i.e., $mcc = m \times$ (space emergence sampling) $\times$ (time emergence sampling).

Dynamic eigen equation:

$$E = mc$$

— realizing the unification of energy, momentum, and force (energy = momentum = force) [1].

It should be emphasized that c^2 is not an underlying fundamental dimension, but a secondary occurrence of the intrinsic velocity c of momentum units in space-time state shaping. This understanding is particularly crucial in electromagnetic interaction: the effective momentum flow

$$Q_{\text{eff}} = \xi(m) \cdot mc^2$$

is precisely the result of the combined effect of geometric modulation of $P_{\text{total}} \cdot c$ and momentum conservation constraints. This view echoes Barut (1993)'s proposal that "electron mass and electromagnetic moment originate from internal light-speed circular motion, and charge is a dynamic effect rather than an inherent property" [7].

1.2 Velocity Increment Equation: Underlying Dynamic Unification Mechanism

The dynamic behavior of particles is unified by the velocity increment equation — this is the underlying mechanism established in the chapter "The Nature of Force":

$$\Delta\vec{v} = \frac{\Delta\vec{p}}{P_{\text{total}}} \cdot c$$

This equation indicates that any velocity change (i.e., force effect) originates from the proportional relationship between the momentum deviation $\Delta\vec{p}$ and the intrinsic total momentum P_{total}. As a specific form of force, electromagnetic force still follows this mechanism at the underlying level; the only difference is that the source of $\Delta\vec{p}$ is determined by the electromagnetic protocol and is constrained by momentum conservation ($\Delta p_A = -\Delta p_B$).

1.3 Two Encapsulation Protocols: Photons and Fermions

Particle encapsulation follows two core protocols, which also determine the differences in their interaction characteristics. The stability of encapsulation protocols gives rise to conservation laws and CPT symmetry (CPT transformation: $\Theta\psi(t,\vec{x})\Theta^{-1} = \psi^*(-t,-\vec{x})$; conservation: $dQ/dt = 0$):

Photons: Adopt "V-formation coding" encapsulation, i.e., a large number of momentum units evolve collaboratively in a single direction, like a flock of geese flying in the same direction. Their wavelength λ and frequency f always satisfy

$$f\lambda = c$$

corresponding to the macro-occupancy scale and transition period. From the perspective of traditional theory, photons are "V-formation single-direction momentum flow encapsulated states," with the energy relationship

$$E = h\nu = pc$$

(total amplitude of one-way momentum flow).

Fermions (e.g., electrons, protons): Adopt "spherically symmetric cancellation state multi-layer protocol" encapsulation. Through multi-layer encapsulation protocols such as SU(1), SU(2), and SU(3) (corresponding to the gauge groups in the standard model, which are symmetry encodings of different levels of momentum encapsulation protocols), the symmetric cancellation of internal momentum units is achieved, so that static fermions have no net momentum outflow but possess enormous internal energy mc^2. Each layer of stable encapsulation gives rise to conservatism and CPT symmetry, while the overall encapsulation gives rise to rotatability, static mass, and perceptual attenuation characteristics — i.e., the spherical perceptual law of $4\pi r^2$. From the perspective of traditional theory, fermions are "symmetric multi-layer momentum encapsulated bodies, with radius inversely proportional to momentum deviation (the larger the deviation, the more compact the encapsulation)," and the radius relationship is

$$R \propto \hbar/\Delta p$$

This geometric attenuation characteristic is inherently consistent with the conclusion proposed by Kovács et al. (2024) in the Weyl geometry framework that "charge = local space-time compression, a purely geometric derivation" [8].

1.4 Electromagnetic Interaction: Effective Momentum Flow and Momentum Conservation Constraints

Particles achieve self-correlation and collaborative evolution through interaction protocols and entanglement protocols, and the potential sustainable evolution state quantity emerging after encapsulation is mc^2 (based on the space-time state shaping equation), which is also the energy basis for interactions between particles.

The core of electromagnetic interaction between particles is the effective momentum flow interaction based on this energy basis, which is inevitably accompanied by spherical geometric attenuation and constrained by momentum conservation — the interacting parties obtain opposite momentum deviations ($\Delta p_A = -\Delta p_B$), i.e., opposite time or space shaping capabilities, whose sum is zero. This mechanism can be understood as space-time equivalent exchange, which is more fundamental than geometric encapsulation and directly determines the proportion of action and reaction force leakage under geometric encapsulation (i.e., the physical quantities we call color charge and charge). Among them, momentum leakage is specifically manifested in two forms: changes in momentum distribution state or radiation. The former is a non-dissipative process that only changes the direction distribution of internal momentum evolution, while the latter is a dissipative process accompanied by the outward transmission of momentum units.

This view is consistent with Wheeler (1955)'s geon theory (electromagnetic field and gravitational field are self-consistently bound, with no independent charge source) [9], and further supports Misner and Wheeler (1957)'s core claim that "charge is a macroscopic manifestation of space-time topology, not an intrinsic property" [10]. From the perspective of traditional theory, electromagnetic force is an "external interaction protocol, whose core mechanism is the internal/external toggle of momentum units (repulsion is inward toggle, attraction is outward toggle)," with a unified form of

$$F \propto (Q_1 Q_2)/r^2$$

(where Q is the protocol encoding charge of different layers).

1.5 Geometric Compression Factor and the Emergence of Color Charge and Charge

However, the total mass mc^2 alone cannot explain the observational fact that electrons and protons differ in mass by a factor of 1836 but have completely equal electromagnetic forces. Combined with new inferences, charge and color charge are not intrinsic properties of particles, but may be manifestations of fixed-proportion momentum units emerging from the combined effects of momentum conservation constraints (action and reaction forces) and geometric encapsulation, with no direct proportional relationship to mass.

Therefore, it is necessary to introduce the geometric compression factor $\xi(m)$ — it describes the "shielding" or "release" efficiency of the spherically symmetric encapsulation structure of fermions on the leakage of internal momentum units. The denser the encapsulation (the larger the mass), the lower the effective proportion of momentum units leaking outward; the looser the encapsulation (the smaller the mass), the higher the effective leakage proportion.

Combined with the space-time equivalent exchange mechanism under momentum conservation constraints, the geometric compression factor and mass may form a specific correlation, ultimately making the effective momentum flow generated by the particle outward:

$$Q_{\text{eff}} = \xi(m) \cdot mc^2$$

The final effective momentum flow may become a constant value:

$$Q_{\text{eff}} = \sqrt{4\pi\alpha\hbar c}$$

Among them, the 4π factor originates from spherical perceptual attenuation (see Section 3), and α is the fine-structure constant (the fixed proportion of momentum units compressed and absorbed within the fermion radius,

$$\alpha = e^2/(4\pi\epsilon_0\hbar c) \approx 1/137$$

). This may be the fundamental reason for the equal electromagnetic forces of electrons and protons — as a macroscopic manifestation of effective momentum flow, the intensity of charge may be jointly determined by momentum conservation and geometric encapsulation, with no direct proportional relationship to mass.

It should be supplemented that color charge is a multi-layer stable encapsulation protocol under strong interaction (the root cause of quark confinement), and its running coupling is $\alpha_s(Q^2)$ (the rate of change of encapsulation layers with energy scale). Like charge, it may also be a manifestation of momentum units emerging from the combination of momentum conservation and geometric encapsulation.

1.6 Overall Logical Chain

Substituting mechanisms such as effective momentum flow, momentum conservation constraints, and space-time equivalent exchange into the velocity increment equation, we can try to fully describe the dynamic process of electromagnetic interaction (see Section 4). The overall logical chain is as follows:

Momentum unit (m_0, c)

(encoding evolution rules, topology carrying evolution)

$\downarrow$

First principle: Momentum conservation constraint

(space-time equivalent exchange) $\rightarrow \Delta p_A = -\Delta p_B$

$\downarrow$

Particle encapsulation (geometric topology emergence)

$$\begin{cases} \text{Photon: V-formation coding (one-way momentum flow)} \\ \text{Fermion: Spherically symmetric multi-layer protocol} \\ \quad \text{(SU(1)/SU(2)/SU(3) vector superposition states)} \end{cases}$$

$\downarrow$

Spherically symmetric encapsulation $\rightarrow$ Perceptual attenuation $4\pi r^2$

(perceptual cross-section: $\sigma \propto 1/r^2$)

$\downarrow$

Geometric compression factor $\xi(m)$

(encapsulation efficiency vs. leakage efficiency)

$\downarrow$

Effective momentum flow $Q_{\text{eff}} = \xi(m) \cdot mc^2$

(energy basis for space-time state shaping)

$\downarrow$

Q_{eff} constant (momentum conservation + geometric modulation)

$\rightarrow$ Electromagnetic force independent of mass (speculation)

$\downarrow$

4π factor hidden in fine-structure constant α

$\downarrow$

Charge, color charge $\rightarrow$ Momentum breaking amount

(not intrinsic properties, speculation)

This logical chain runs through the entire paper. The subsequent sections will discuss and verify them one by one, supplement relevant content such as celestial energy conversion and angular momentum conservation, and align with traditional standard model concepts to improve the theoretical system. It should be noted that the complete unification mechanism of the four fundamental forces still requires reconstructing the standard model based on this framework, which is highly technically challenging and can be further improved and supplemented by relevant colleagues in the future.

2 Core Contradiction and Breakthrough: Why Does Mass Difference Not Affect Electromagnetic Force Intensity?

2.1 Core Contradiction of Traditional Theory

Traditional theory faces an unexplainable core contradiction: if electromagnetic force originates from the mass of particles (total number of momentum units), then protons, whose mass is 1836 times that of electrons, should have an electromagnetic repulsion 1836 times that of electrons. However, experimental facts show that the repulsions of the two are completely equal. This contradiction points directly to the limitations of the basic assumption that "charge is an intrinsic property of particles," and also cannot explain the non-proportional relationship between color charge, charge, and mass, nor can it connect the underlying logic of momentum conservation and geometric evolution.

2.2 Solution Path: Synergistic Effect of Momentum Conservation Constraints and Geometric Encapsulation

The key to solving this contradiction may lie in introducing geometric encapsulation efficiency (geometric compression factor) and momentum conservation constraints (space-time equivalent exchange), revealing the geometric conversion mechanism between mass and effective momentum source, and speculating that charge and color charge are manifestations of momentum units emerging from the two, with no direct proportional relationship to mass. The core points are as follows:

1. The magnitude of electromagnetic force may be jointly determined by the fixed interaction density ($\alpha\hbar c$) and spherical radiation perceptual attenuation ($1/4\pi r^2$), both of which are indispensable, and are constrained by momentum conservation, with the momentum deviations of the interacting parties being equal in magnitude and opposite in direction;

2. The essence of fixed interaction density may be the effective momentum flow formed by the evolution of momentum units (mass and light speed), providing the energy basis based on the space-time state shaping equation ($E = mc^2$);

3. The intensity of electromagnetic interaction generated by particles outward is not directly determined by the total mass (total number of momentum units), but by the effective momentum flow — that is, the intensity of momentum flow leaked from internal momentum units to the outside through the encapsulation structure. This leakage proportion may be directly determined by momentum conservation constraints (space-time equivalent exchange), where momentum leakage is specifically manifested in two forms: changes in momentum distribution state or radiation;

4. The macroscopic manifestation of this effective momentum flow may be the "charge" in traditional theory, and color charge is a similar manifestation under strong interaction. Essentially, both are not intrinsic properties of particles, but may be the momentum breaking amount caused by geometric perception, encapsulation, and momentum conservation constraints during the evolution of momentum units.

This view echoes Pati and Salam (1974)'s proposal that "charge is the net flow of more basic components, not an inherent label of elementary particles" [11], and also conforms to the core idea of Harari (1979)'s preon model that "charge is generated by the combination of component statistics and flows" [12].

2.3 Synergistic Effect of Geometric Compression Factor and Momentum Conservation

The magnitude of effective momentum flow may be jointly determined by momentum encapsulation efficiency (geometric compression factor $\xi(m)$), total mass, and momentum conservation constraints. The physical image of this synergistic effect can be popularly understood as:

Electron (small mass): The number of internal momentum units is small, the encapsulation structure is relatively loose, the "leakage efficiency" of momentum units is high, and combined with momentum conservation constraints, the geometric compression factor $\xi(m_e)$ is large;

Proton (large mass): The number of internal momentum units is extremely large, the encapsulation structure is extremely dense, and the internal circulation formed by multi-layer protocols leads to a significant "self-shielding" effect, with low leakage efficiency. Combined with momentum conservation constraints, the geometric compression factor $\xi(m_p)$ is extremely small.

Thus, the effective momentum flow

$$Q_{\text{eff}} = \xi(m) \cdot mc^2$$

may become a constant value — no matter how the particle mass changes, under the synergistic effect of the geometric compression factor and momentum conservation constraints, the correlation between $\xi(m)$ and m may always keep the effective momentum flow unchanged. This may be the fundamental reason for the equal electromagnetic forces of electrons and protons, and can also explain the core logic that charge and color charge have no direct proportional relationship with mass, further explaining that the repulsion between protons is equal to that between electrons, i.e., like gravitational force, electromagnetic force is only related to the spherical distance attenuation in three-dimensional space, and not proportional to the total mass of particles; the apparent difference that it is proportional to mass under gravity and proportional to "charge" under electromagnetic force is essentially caused by the different encapsulation protocols and momentum leakage mechanisms of the two forces.

2.4 Connection with Velocity Increment Equation and Angular Momentum Conservation

Substituting the above mechanism into the velocity increment equation, we can further explore the dynamic process of electromagnetic interaction. For a particle with mass m, the momentum deviation obtained in a single update is [13,14]:

$$\Delta p = \frac{Q_{\text{eff1}} \cdot Q_{\text{eff2}}}{4\pi r^2} \cdot t_p$$

Substituting into the velocity increment equation $\Delta v = \frac{\Delta p}{P_{\text{total}}} \cdot c$, we get:

$$\Delta v = \frac{Q_{\text{eff1}} Q_{\text{eff2}}}{4\pi r^2} \cdot \frac{t_p}{mc} \cdot c = \frac{Q_{\text{eff1}} Q_{\text{eff2}}}{4\pi r^2} \cdot \frac{t_p}{m}$$

Substituting $Q_{\text{eff}} = \sqrt{4\pi\alpha\hbar c}$, we get:

$$\Delta v = \frac{4\pi\alpha\hbar c}{4\pi r^2} \cdot \frac{t_p}{m} = \frac{\alpha\hbar}{mr^2} \cdot t_p$$

This may be the discrete expression of the inverse proportionality between acceleration and mass under electromagnetic force. Since Q_{eff} is constant, light particles (electrons) obtain greater acceleration, and heavy particles (protons) obtain smaller acceleration — which is consistent with observational facts: the magnitude of electromagnetic force is equal, but acceleration is inversely proportional to mass.

Angular momentum conservation

$$L = mvr = \text{constant}$$

when mass is constant,

$$v_1 r_1 = v_2 r_2$$

which, like the momentum distribution of the interacting parties ($\Delta p_A = -\Delta p_B$), essentially originates from the total conservation of momentum units and is a specific manifestation of the space-time equivalent exchange mechanism. Taking celestial motion as an example: the inertial kinetic energy is the largest at the perihelion (maximum velocity), and the velocity is slower at the aphelion but integrates more integrable distance, with the integration basis being the perceptual cross-section $1/4\pi r^2$; at the aphelion, due to insufficient inertial velocity, it cannot break through the complete gravitational orbit constraint, so it starts to fall at the highest point. During the fall, the conversion from potential energy to kinetic energy is realized by integrating the spatial distance. This process not only follows angular momentum conservation but also conforms to the geometric law of perceptual attenuation.

2.5 Experimental Verification and Historical Echo

This mechanism may reasonably explain the experimental conclusion discovered by Hofstadter (1956) through electron scattering experiments that "protons/nucleons have form factors, and charge distribution is a low-energy effective structure, not a point-like singularity" [15], indicating that the macroscopic distribution of charge may essentially be an external manifestation of the combined effect of momentum unit encapsulation structure and momentum conservation constraints.

This mechanism does not deny the macroscopic use value of charge and color charge, but attempts to reduce them to the dynamic manifestations of momentum units. This is highly consistent with Einstein (1945)'s research direction of trying to derive Maxwell's equations from pure geometric identities and eliminate independent charge sources [16], and also conforms to Dirac (1931)'s view that "charge quantization originates from topological constraints, not artificial settings" [22].

3 Geometric Factor 4π: The Key Link Connecting Encapsulation Mechanism and Electromagnetic Force

In the process of exploring the independence of electromagnetic force from mass, the role of the geometric factor 4π is crucial — it is not an artificially introduced constant, but a natural imprint of the spherical symmetry of three-dimensional space and particle encapsulation mechanism, and an indispensable part of electromagnetic force interaction.

Eddington (1946) once proposed that the fine-structure constant α is not random, but originates from the mathematical necessity of the underlying geometric and topological structure [17], and 4π, as a geometric factor, is the specific manifestation of this mathematical necessity in electromagnetic interaction. Tracing back from the historical dimension, the emergence of 4π has always been closely related to spherical symmetric geometry: in 1916, Sommerfeld introduced 4π into the expression to respect the spherical symmetry of the Coulomb field when deriving the fine-structure constant; when quantum electrodynamics (QED) was established in the 1940s and 1950s, the normalization of the Lagrangian, the calculation of photon propagators, and phase space integration jointly forced 4π to become an inherent factor of electromagnetic interaction.

The deeper physical significance lies in that 4π is the geometric property of three-dimensional space itself — as long as the momentum leakage of particles diffuses uniformly to the entire space, 4π must appear in the interaction formula, which is a direct manifestation of spherical perceptual attenuation and cannot be omitted. This geometric property also provides underlying support for Kaluza (1921)'s geometric unification idea that "in five-dimensional pure gravitational geometry, electromagnetic potential and the fifth-dimensional degree of freedom naturally appear" [18], and echoes Klein (1926)'s view of giving the geometric origin of charge quantization through fifth-dimensional compactification [19].

In our model of momentum encapsulation, momentum conservation, and geometric attenuation, the core role of 4π is reflected in two aspects:

1. $4\pi r^2$ is the geometric manifestation of particle perceptual attenuation. The encapsulation of fermions presents a spherically symmetric structure, and the leakage perception signal of internal momentum units diffuses uniformly along the spherical surface, with intensity attenuating with the spherical surface area $4\pi r^2$. This is the geometric basis of the inter-particle interaction resolution formula

$$\text{Interaction} \propto (m_1 c^2 \cdot m_2 c^2)/(4\pi r^2)$$

   and also the core reason why the 4π factor is indispensable in the electromagnetic force formula. This spherical leakage characteristic is consistent with the "topological and geometric nature of electromagnetic potential" revealed by Aharonov and Bohm (1959) through the AB effect [20]. For celestial motion, the perceptual cross-section $1/4\pi r^2$ is also the core basis for integrating distances in the energy conversion between aphelion and perihelion, connecting the geometric laws of micro-particle interaction and macro-celestial evolution.

2. 4π is hidden in the fine-structure constant $\alpha \approx 1/137$, becoming a geometric representation of the momentum unit compression ratio. This also explains why the 4π factor seems to be missing in the traditional Coulomb force formula and the quantum mechanical electromagnetic force formula ($F = \alpha\hbar c/r^2$); in fact, this factor is hidden inside α. This hiding is not accidental: when we substitute the effective momentum flow

$$Q_{\text{eff}} = \sqrt{4\pi\alpha\hbar c}$$

   into the velocity increment equation, the 4π factor cancels out exactly with the 4π in the spherical attenuation, and only $\alpha\hbar/r^2$ remains in the final macroscopic force expression. Therefore, 4π does not disappear, but is "absorbed" into the definition of α, becoming a geometric bridge connecting micro-encapsulation and macro-electromagnetic force.

It is worth noting that 4π never "disappears": in the classical Coulomb force formula, it is hidden in the electrostatic constant $k = 1/(4\pi\varepsilon_0)$; in quantum mechanics, it is integrated into the fine-structure constant. This also confirms our view: the essence of electromagnetic force may be the spherical interaction of momentum flow, whose magnitude is jointly determined by the fixed interaction density ($\alpha\hbar c$) and spherical perceptual attenuation ($1/4\pi r^2$), and 4π is the geometric necessity of this interaction.

4 Formula Construction and Verification: Unification of Electromagnetic Force from a Charge-Free Perspective

Based on the mechanisms of momentum encapsulation, momentum conservation constraints, and geometric attenuation, we attempt to construct an electromagnetic force formula that does not depend

on charge q, trying to clearly reveal its essence independent of mass, and clarify the core position of the 4π factor.

4.1 Complete Derivation of the Charge-Free Formula

Step 1: Momentum deviation in a single update (constrained by momentum conservation, the deviations of the interacting parties are equal in magnitude and opposite in direction)

$$\Delta p = \frac{(\xi_1 m_1 c^2)(\xi_2 m_2 c^2)}{4\pi r^2} \cdot t_p$$

Step 2: Substitute into the velocity increment equation

$$\Delta v_1 = \frac{\Delta p}{P_{\text{total1}}} \cdot c = \frac{(\xi_1 m_1 c^2)(\xi_2 m_2 c^2)}{4\pi r^2} \cdot \frac{t_p}{m_1 c} \cdot c = \frac{\xi_1 \xi_2 m_2 c^3}{4\pi r^2} \cdot t_p$$

Step 3: Macroscopic force (continuous interaction, following momentum conservation $\vec{F}_{12} = -\vec{F}_{21}$)

$$F_1 = m_1 \cdot \frac{\Delta v_1}{t_p} = m_1 \cdot \frac{\xi_1 \xi_2 m_2 c^3}{4\pi r^2} = \frac{\xi_1 m_1 c^2 \cdot \xi_2 m_2 c^2}{4\pi r^2} \cdot \frac{1}{c}$$

Step 4: Substitute $\xi mc^2 = \sqrt{4\pi\alpha\hbar c}$

$$F = \frac{4\pi\alpha\hbar c}{4\pi r^2} \cdot \frac{1}{c} = \frac{\alpha\hbar}{r^2}$$

So far, starting from the velocity increment equation and combining with momentum conservation constraints, we have attempted to completely derive the electromagnetic force formula without introducing the concept of "charge" throughout the process. This indicates that electromagnetic force may be a specific realization of the velocity increment equation under the electromagnetic protocol, and charge may be a macroscopic simplified description of the effective momentum flow $\sqrt{4\pi\alpha\hbar c}$, whose essence may be the momentum breaking amount emerging from the combination of momentum conservation and geometric encapsulation.

This formula is highly consistent with experimental results: the repulsion between electrons and electrons, and between protons and protons is equal in magnitude. Essentially, it may be because their effective momentum flow intensities are the same and constrained by momentum conservation; while the electromagnetic force between different particles (such as electrons and protons) may also be determined by this constant effective momentum flow, independent of mass differences.

4.2 Physical Connotation of the Formula

After further simplification, the formula can be echoed with the traditional Coulomb force formula: let the product of effective momentum flows $(\xi mc^2)^2 = 4\pi\alpha\hbar c$, then the formula can be written as

$$F = \alpha\hbar c / r^2$$

which is consistent in form with the electromagnetic force formula in standard quantum electrodynamics, but its physical connotation is essentially different — we do not retain the independent status of charge, but attempt to reduce charge and color charge to the evolutionary manifestations of momentum units based on momentum encapsulation, geometric attenuation, and momentum conservation constraints.

This simplification process points out the whereabouts of the 4π factor: it is integrated into the fine-structure constant α, not disappearing from electromagnetic force interaction. This further supports our view: charge and color charge are not intrinsic properties of particles, but may be the momentum breaking amount caused by geometric perception, encapsulation, and momentum conservation during the interaction process. The concept of charge in traditional theory is essentially a macroscopic simplified description of effective momentum flow.

5 Conclusions

5.1 Origin of Charge and Color Charge

Based on the mechanisms of momentum encapsulation, geometric attenuation, and momentum conservation constraints (space-time equivalent exchange), we attempt to explain the essence of the apparent independence of electromagnetic force from mass. The core logic is: electromagnetic force can be attempted to be explained without the concept of charge, but instead based on momentum units (mass and light speed). Its magnitude may be jointly determined by the fixed interaction density ($\alpha\hbar c$) and spherical radiation perceptual attenuation ($1/4\pi r^2$), and the 4π factor is indispensable. This mechanism may prove that charge and color charge are not intrinsic properties of particles, but may be the momentum breaking amount caused by geometric perception, encapsulation, and momentum conservation constraints during the evolution of momentum units.

As a relational state evolution system, all evolutions of the universe are encoded or emerge on the geometric topology of momentum units. Momentum conservation constraints (space-time equivalent exchange) are more fundamental than geometric encapsulation, and may directly determine the equal leakage of action and reaction forces under geometric encapsulation, i.e., the specific manifestations of charge and color charge. This conclusion integrates the core views of scholars such as Kaluza, Klein, and Wheeler that "charge is not intrinsic and originates from geometric or dynamic effects" [9,10,11,12].

5.2 Dynamic Mechanism of Electromagnetic Force and Unification of the Four Fundamental Forces

Mass may be hidden in $\alpha\hbar$, realizing the dynamic contribution of electromagnetic force through light speed and momentum; the perceptual attenuation factor 4π is hidden in the fine-structure constant; $1/4\pi r^2$ provides the spherical encapsulation perceptual attenuation mechanism; $\alpha\hbar$ provides the breaking mechanism; momentum conservation constraints (space-time equivalent exchange) determine the distribution law of momentum deviation.

From the perspective of the unification of the four fundamental forces, they may all be dominated by the multi-layer topological encapsulation and interaction protocols of momentum units of $N \cdot m_0 c$ [3], forming action and reaction forces, and the interaction magnitude is proportional to the momentum deviation $m_0 c$. It should be noted that the complete unification mechanism of the four fundamental forces still requires reconstructing the standard model based on this framework, which is highly technically challenging and can be further improved and supplemented by relevant colleagues in the future. The specific protocol characteristics are as follows:

Protocol Type	**Geometric/Gradient Characteristics**	**Momentum Carrier**	**Protocol Mechanism**	**Evolutionary Effect**

Gravitational force	Global density gradient	Ground state momentum flow	Momentum weight collapses to high coupling regions	Gravitational thermal fluctuation/Hawking radiation
Electromagnetic force	Polar charge gradient	Polarized momentum packets (photons)	Carrier direction directional locking	Electromagnetic radiation
Weak force	Chiral asymmetry gradient	Mass-loaded momentum packets (W/Z)	Carrier quantum state transition	Decay
Strong force	Topological color charge gradient	Gluon momentum flow (gluons)	Carrier strong binding and confinement	Nuclear energy

5.3 Cause of the Same Charge Quantity of Electrons and Protons

The mass of a particle is the total number of internal momentum units, while the intensity of electromagnetic force is not directly determined by the total mass, but by the effective momentum flow jointly determined by the correlation between the geometric compression factor and mass, combined with momentum conservation constraints. Since the geometric compression factor and mass may form a specific correlation, the effective momentum flow becomes a constant value (i.e., fixed interaction density $\alpha\hbar c$), thereby keeping the electromagnetic interaction intensity of particles with huge mass differences (such as electrons and protons) consistent. This also explains that the repulsion between protons is equal to that between electrons. This mechanism may reasonably explain the results of Hofstadter (1956)'s electron scattering experiment [15], and also conforms to the idea of "charge generated by the combination of component flows" in Harari (1979)'s preon model [12].

5.4 Unified Verification of Velocity Increment Equation and Angular Momentum Conservation

The analysis of electromagnetic force in this paper forms a complete closed loop with the velocity increment equation [14]

$$\Delta\vec{v} = \frac{\Delta\vec{p}}{P_{\text{total}}} \cdot c$$

established in the chapter "The Nature of Force," and also echoes angular momentum conservation

$$L = mvr = \text{constant}$$

The apparent characteristic that electromagnetic force is independent of mass may be the result of the combined effect of geometric encapsulation efficiency, spherical perceptual attenuation, and momentum conservation constraints.

As a specific manifestation of momentum conservation, angular momentum conservation explains the energy conversion law between perihelion and aphelion in celestial motion: the inertial kinetic energy is the largest at the perihelion, the velocity is slower at the aphelion but integrates more integrable distance (based on the perceptual cross-section $1/4\pi r^2$), and the aphelion cannot break through the gravitational orbit constraint due to insufficient inertial velocity and thus falls. During the fall, the conversion from

potential energy to kinetic energy is realized by integrating the spatial distance. This process perfectly connects the underlying logic of micro-particle interaction and macro-celestial evolution.

5.5 The Mystery of Baryon Disappearance and the Essence of Evolution

Baryons are only the manifest states of momentum units under specific geometric conditions. Essentially, all particles in the cosmic system are multi-layer protocol encapsulations of the evolutionary carrier momentum unit m_0; unstable encapsulations will decay back to the ground state or other associated encapsulation structures (such as leptons, mesons, or photons), and only the momentum unit itself is indivisible. However, all decay or decoupling processes manifest as mass conservation (originating from the absolute conservation of total momentum resources and evolution rate c, the absolute conservation formula is

$$\frac{d}{dt}(\sum p_i c) = 0$$

).

Therefore, the essence of physical interaction is no longer the transmission of abstract force, but may be the execution process of encapsulation protocols and the dynamic balance of the resulting macroscopic momentum breaking amount, constrained by momentum conservation (space-time equivalent exchange). This view is highly consistent with Wheeler (1955)'s geon theory [9] and Misner and Wheeler (1957)'s core idea of "Classical Physics as Geometry" [10].

5.6 Explanation: Dual Mechanism of Momentum Conservation and Geometric Encapsulation

This paper mainly explains the indirect relationship between charge, color charge, and mass from the dual perspectives of geometric encapsulation and momentum conservation constraints. It should be pointed out that momentum conservation constraints are a more fundamental underlying mechanism, which may directly determine the leakage proportion of action and reaction forces under geometric encapsulation (charge and color charge) [2,6].

The core of its underlying logic is the momentum conservation essence of the resultant interaction force — that is, the conservation relationship under action and reaction forces $m_1\vec{v}_1 = -m_2\vec{v}_2$. This relationship indicates that during the interaction, the total number of momentum units is conserved, and the momentum deviation is distributed equally and oppositely between the interacting parties:

$$\Delta\vec{p}_A = -\Delta\vec{p}_B$$

More deeply, according to the space-time state shaping equation $E = mc^2$ of this framework (i.e., m momentum units, each contributing c^2 space-time coupling):

Space emergence is manifested as displacement $\Delta\vec{r}$

Time emergence is manifested as the number of events $N = t/t_P$

Therefore, the essence of momentum interaction conservation can be understood as: the emergence ability in time or space can be expressed as mv. Since the time and space emergence abilities emerge synchronously and proportionally, the statistical sampling amount can be replaced by v. The momentum conservation of interaction or linear growth in the absence of interaction. Both parties A and B obtain opposite momentum deviations — i.e., opposite time or space shaping capabilities — whose sum is zero. This mechanism can be understood as space-time equivalent exchange, which is more fundamental than geometric encapsulation and directly determines the proportion of all action and reaction force

leakage under geometric encapsulation (color and charge). Among them, momentum leakage is specifically manifested in two forms: changes in momentum distribution state or radiation. The former is a non-dissipative process that only changes the direction distribution of internal momentum evolution, while the latter is a dissipative process accompanied by the outward transmission of momentum units. Geometry determines the type of force and protocol distinction, while space-time equivalent exchange determines the relative direction and magnitude of momentum [3].

The apparent characteristic that electromagnetic force is independent of mass may be the result of the combined effect of geometric encapsulation efficiency and the law of momentum conservation:

Geometric encapsulation efficiency determines "how many momentum units are leaked as effective momentum flow"

The law of momentum conservation determines "how the interacting parties distribute these momentum deviations"

Both are unified at the underlying logic in the total conservation of momentum units and the momentum redistribution mechanism during the interaction process. For a detailed expansion of this point, see the chapter "The Nature of Force" [2].

5.7 Core Conclusions

The main findings of this study can be summarized into three points:

1. Electromagnetic force is not proportional to mass: The effective momentum flow

$$Q_{\text{eff}} = \xi(m) \cdot mc^2$$

may become a constant value

$$\sqrt{4\pi\alpha\hbar c}$$

under the synergy of momentum conservation and geometric encapsulation, independent of the total particle mass m. This may be the underlying reason why the repulsion between protons is equal to that between electrons, and electromagnetic force is only related to the spherical distance attenuation in three-dimensional space, not proportional to the total mass of particles.

2. Space-time equivalent exchange is the underlying constraint: Action and reaction forces determine equal leakage —

$$\Delta p_A = -\Delta p_B$$

and the interacting parties obtain opposite and equal momentum deviations. Geometric encapsulation may determine the interaction magnitude and force protocol (such as repulsion or attraction), while the representational quantity m_0 is based on time or space shaping equivalent exchange, which may determine that the four fundamental forces are not directly proportional to the encapsulated mass.

3. The four fundamental forces are leakage proportion constraints: Encapsulation protocols (geometric topology) determine the leakage proportion — the magnitude of the geometric compression factor $\xi(m)$ is determined by the multi-layer protocol structure of spherical symmetric encapsulation. Gravitational force, electromagnetic force, weak force, and strong force may all be constrained by this mechanism, with differences only in the type of encapsulation protocol and geometric encoding method. Among them, momentum leakage is specifically manifested in two forms: changes in momentum distribution state (non-dissipative) or radiation (dissipative). The former only changes

the direction distribution of internal momentum evolution, while the latter is accompanied by the outward transmission of momentum units.

The above understanding is still a preliminary exploration, and this study only provides a theoretical reference for the unification of the four fundamental forces. The complete unification mechanism still requires reconstructing the standard model based on this framework, which is highly technically challenging and awaits joint improvement and supplementation by colleagues in the academic community.

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