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[Haigiang Wu](#) \*

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Article

# Derivation of Hubble's Law: Unified Field-Theoretic Explanations for Dark Energy, Dark Matter and Huge Magnetic Toroids of the Galaxy

Haiqiang Wu

Yuyao Joywee Electrics Co., Ltd., No.27 Miaohengtou, Fengshan Street, Yuyao, 315400, Zhejiang, China; info@joywee.cn

## Abstract

This paper initiates a dual-route derivations of Hubble's Law within standard relativistic and Newtonian frameworks, grounded in the intrinsic perfect symmetry of the local inertial frame. This reveals that the fundamental aim of a local inertial frame's motion is to restore Poincaré symmetry, from which it follows that the flow velocity of a strong gravitational field equals its gravitational acceleration multiplied by one second. Thus the standard theories inherently contain the seed of dynamic field theory. Mass Complex Space Theory (MCST) is the guidance to push the standard theories toward full dynamization and higher-dimensionalization. MCST introduces the "Quadruple State of the Planck Quantum  $\odot(h, \Phi_{ih}, \Phi_h, ih)$ " as the elementary complex-space generating element, whose hyper-cycle dynamically unifies matter and spacetime. A key finding is that gravitational field space is constituted by diverging negative-energy "positron state ( $\Phi_{ih}$ )". Consequently, dark matter and dark energy are unified as field effects of hyper-cycling mass complex space. Emergent from this framework is a gravitational circulation field ( $\Phi_r$ ). This field makes the apparent Keplerian mass exhibits a counter-intuitive monotonic decrease (mass inversion) in the outer halo of the Milky Way (22.5–26.5 kpc). Moreover, owing to its intrinsic "negative-energy positron state" property,  $\Phi_r$  naturally generates huge magnetic field toroids, the structure of which aligns remarkably with the observed galactic magnetic field, thereby achieving a preliminary structural unification of gravitation and electromagnetism on galactic scales without additional assumptions, and further providing theoretical foundation for the quantization research on the unification at the subatomic scale.

**Keywords:** intrinsic perfect symmetry; dynamic field theory; mass complex space theory; quadruple state of the Planck quantum; elementary complex space; negative energy; mass inversion; magnetic field toriod; GUT

## 1. Introduction

### 1.1. The Paradigm Dilemma of Modern Cosmology

The Standard Cosmological Model ( $\Lambda$ CDM) successfully fits numerous astronomical observations but relies on unverified ad-hoc assumptions, leading to growing theoretical crises [1]. It depends on unconfirmed elements: a Big Bang singularity implying quantum gravity's necessity [2]; an inflationary field without empirical proof [3]; dark matter, undetected despite extensive searches [4]; and dark energy, which remains theoretically mysterious and suffers from a severe fine-tuning problem [5]. These issues are exacerbated by observational anomalies like the Hubble Tension [6] and JWST's discovery of unexpectedly mature early galaxies [7], challenging existing cosmic timelines. The  $\Lambda$ CDM model violates Occam's Razor through continual addition of unexplained components. Modern cosmology may thus require a paradigm shift toward a first-principles theory beyond current adding more isolated assumptions to explain novel observational findings.

## 1.2. A Fundamental Challenge to $\Lambda$ CDM Paradigm

High-precision astrometry from the Gaia mission enables detailed reconstruction of the Milky Way's rotation curve [8]. Applying the standard Keplerian mass estimator  $M(<r) = 2.325 \times 10^5 \times \left(\frac{v}{\text{km/s}}\right)^2 \times \left(\frac{r}{\text{kpc}}\right) M_{\odot}$  to the 18.5-26.5 kpc range yields the following mass distribution.

Table 1 shows an oscillatory profile in the 18.5-22.5 kpc transition interval, followed by a systematic mass inversion trend beyond 22.5 kpc. The enclosed mass declines by approximately 6% toward the outermost measured point, forming a coherent trend across four consecutive data points that cannot be explained by random scatter [9].

**Table 1.** Apparent Mass for the Observed Velocities.

R (kpc)	$V_{obs}$ (km/s)	$M(<r)(10^{10}M_{\odot})$
18.5	209.17	18.819
19.5	206.25	19.286
20.5	202.54	19.552
21.5	197.56	19.510
22.5	197.00	20.302
23.5	191.62	20.062
24.5	187.12	19.945
25.5	181.44	19.518
26.5	175.68	19.016

## 2. Motion and Symmetry

Although the primary aim of this paper is to study the unified origin of dark energy effect and dark matter effect, it is essential—for conceptual clarity and reader comprehension—to first undertake a thorough investigation of motion and symmetry. This exploration serves to establish that the gravitational field flow velocity,  $v_g$ , is a physical quantity emerging from a dynamic field framework consistent with both "general relativity (GR)" and quantum field theory.

### 2.1. Symmetry in Special Relativity

The relationship between motion and symmetry offers profound insight into the nature of physical law. Consider the energy measurements in different inertial frames, with the vacuum ground state (or the Cosmic Microwave Background frame) serving as a privileged global reference.

Suppose two photons are produced from electron-positron annihilation in a comoving inertial frame. In the vacuum rest frame, these photons travel in opposite directions along the axis of motion. If the total energy measured in the comoving frame is  $E_0$ , and that in the privileged frame is  $E$ , one finds:

$$\Delta E = 2h\nu_0(\gamma - 1) \quad (1)$$

This energy difference  $\Delta E$  can be interpreted as the absolute "energy state" of the moving frame, a quantity with tangible cosmological significance.

So "special relativity (SR)" permits any inertial frame to be treated as a local Minkowski spacetime with Poincaré symmetry and Lorentz invariance. However, while physics relies on Poincaré transformations, nature does not—suggesting a paradigm shift: rather than referring transformations to a background Minkowski spacetime, we may anchor them in a local Minkowski frame shaped by the interaction between an object's motion and the local energy-momentum structure of spacetime.

This approach transforms complicated Poincaré transformations into a hierarchical system of local symmetries, effectively reducing problems in GR to simpler analyses within special relativity or even Newtonian mechanics.

## 2.2. Return to Einstein's Concept of Gravitational Field-as-Space

Einstein's general relativity redefined space: not a static backdrop as in Newtonian mechanics, but a dynamic entity fused with matter—the gravitational field itself. Planetary orbits, lensing, and cosmic expansion all stem from the geometry of spacetime. And Einstein ever pointed out that “It is something like this: The body (e.g., the earth) produces a field in its immediate neighbourhood directly; the intensity and direction of the field at points farther removed from the body are hence determined by the law which governs the properties in space of the gravitational fields themselves. [10]”

In the seek of quantizing everything, modern physics has moved away from this geometric intuition. Reducing spacetime to quantum fluctuations has brought mathematical complexity without breakthrough, leading instead to circularity and ambiguity. Returning to Einstein's vision means recognizing spacetime as fundamental existing. Only then can we develop a self-consistent quantum gravity that reflects nature's elegance, rather than fragmenting into endless quantization.

## 2.3. Motion of Gravitational Field Space

We introduce three foundational postulates:

- Postulate I (Principle of Equivalent Interaction): All fundamental interactions are dynamically equivalent and can be universally described within a unified interaction framework.
- Postulate II (Principle of Reciprocal Action): For any two interacting entities A and B, the mechanical effects of A moving relative to B are indistinguishable from those of B moving relative to A.
- Postulate III (Scalar Superposition of Gravitational Fields): Spacetime is constituted by the superposition of scalar components of the gravitational fields. The metric properties of space emerge from gravitational potentials, whose linear or nonlinear superposition defines spacetime itself.

Consider electromagnetic acceleration in nearly flat spacetime. The electromagnetic force on an object aligns with its motion direction in space. By Postulate II, the scenario in which an object accelerates through static space is mechanically equivalent to one where space accelerates through a static object. Therefore, if space accelerates relative to an object, the force exerted on the object must oppose that acceleration—implying that space exhibits a negative-energy property under such motion.

Thus, we deduce that gravitational field space manifests as an outwardly divergent negative-energy state. This leads to a radical reinterpretation: the divergence of gravitational field space is the fundamental mechanism of gravitational action, suggesting that the key evidence for the Big Bang may have been misread.

This framework of gravitational flow not only allows derivation of Hubble's law without dark energy but also indicates that dark matter effect might arise from dynamic gravitational field with vortex structure due to gravitational field itself has the perfect properties of CDM.

## 2.4. The First Kinematic Principle

We propose the following foundational principle:

The First Kinematic Principle: The fundamental purpose of motion is to restore the Poincaré symmetry of a local inertial frame, broken by the gradient of the background gravitational field.

The success of special relativity lies in the equivalence of all inertial frames and the covariance of physical laws under Lorentz transformations. This requires Poincaré symmetry—Lorentz invariance plus translational symmetry—in every inertial frame.

Our principle extends this idea: motion itself serves to maintain or restore the local Poincaré symmetry of an object's intrinsic spacetime. Any force perturbing a body from geodesic motion violates this local symmetry, and the response—whether motion or field adjustment—acts to compensate and reestablish symmetric conditions. The gravitational field represents a universal interaction that breaks local symmetry, and motion (e.g., gravitational free-fall) is the mechanism through which symmetry is restored.

### 3. Derivation of Gravitational Field Flow Velocity $v_g$ : A Symmetry Compensation

#### 3.1. Symmetry Breaking and Compensatory Need

A test mass in a gravitational field  $g$  deviates from inertial motion, meaning the Poincaré symmetry of its intrinsic spacetime is broken. A compensatory mechanism is required to restore symmetry.

#### 3.2. Mathematical Implementation of Compensation

The compensation must counteract the gravitational influence. In a local inertial frame, gravity manifests as an acceleration  $g$ . Kinematically, acceleration is the time derivative of velocity ( $g = dv/dt$ ). Therefore, to instantaneously compensate for acceleration  $g$ , a compensatory velocity  $v_{comp}$  is required, satisfying:  $g = d(v_{comp})/dt$ . Integrating this yields:

$$v_g = v_{comp} = g \cdot \tau \quad (2)$$

#### 3.3. Introducing a Universal Constant and Defining $v_g$

To give this integral definite physical meaning and fix the proportionality, we introduce a universal constant  $\tau$  with the dimension of time. We define  $\tau = 1$  second. Consequently, we define the Gravitational Field Flow Velocity  $v_g$  as this compensatory velocity:  $v_g \equiv v_{comp} = g \cdot \tau$

**The physical meaning is:** At any point, the velocity increment that the gravitational field can impart to an object within 1 second defines the flow velocity of the gravitational field itself at that point. Critically, the gravitational field flow velocity is defined within the inner domain of local particles in a strong-field, high-velocity regime. This state is effectively decoupled from the background spacetime, yielding a high-purity intrinsic manifold.

## 4. Generalized Mathematical Link Between $v_g$ and the Spacetime Metric

To establish a universal connection between  $v_g$  and spacetime geometry, we must move beyond the Newtonian approximation to the metric language of GR.

#### 4.1. Metric Formulation

We adopt the FLRW metric describing the universe:  $ds^2 = -c^2 dt^2 + a^2(t)[dr^2 + r^2(d\theta^2 + \sin^2 \theta d\phi^2)]$  where  $a(t)$  is the scale factor governing cosmic expansion [11].

#### 4.2. Core Constitutive Relation

We propose a core constitutive relation connecting spacetime geometry to gravitational flow:

$$\nabla \cdot v_g = -\frac{1}{\sqrt{-g}} \frac{\partial \sqrt{-g}}{\partial t} \quad (3)$$

#### Physical Interpretation:

- RHS:  $\sqrt{(-g)}$  is the space volume element.  $\partial_t \sqrt{(-g)} / \sqrt{(-g)}$  represents the relative expansion rate of this volume element. For the FLRW metric,  $\sqrt{(-g)} \propto a^3(t)$ , so the RHS equals  $3(\dot{a}/a) = 3H(t)$  [12].

- LHS: The divergence of the  $v_g$  field, describing the "source" or "sink" of the gravitational flow.
- This equation states that the divergence of the gravitational field flow is sourced by the inherent expansion of the space volume element. This provides a coordinate-independent, geometric definition for  $v_g$ .

## 5. Derivation of Hubble's Law: Framework of Negative-Energy State Space

### 5.1. Gravitational Field as a Negative-Energy State

We introduce an ontological viewpoint: The essence of the gravitational field is a negative-energy state of space. This implies that regions where a gravitational field exists possess an energy density negative relative to the Minkowski vacuum ( $\rho_{grav} < 0$ ). This view is consistent with the traditional understanding of negative gravitational binding energy and provides it with a more fundamental physical basis [13].

### 5.2. Physical Picture of the Field Equations

In the Einstein field equations  $G_{\mu\nu} = (8\pi G/c^4)T_{\mu\nu}$  [10], the energy-momentum tensor of matter fields  $T_{\mu\nu}$  is the source of gravity. Introducing the negative-energy state of the gravitational field itself implies that it also contributes a negative energy-momentum tensor  $T_{\mu\nu}^{(grav)}$ . Therefore, the total source term becomes:  $T_{\mu\nu}^{(total)} = T_{\mu\nu}^{(matter)} + T_{\mu\nu}^{(grav)}$

Cosmic acceleration can thus be understood as a dynamic adjustment of space to balance this intrinsic negative energy density.

### 5.3. Derivation of Hubble's Law

Substituting the FLRW metric into the core constitutive relation in Equation (3):

$$\nabla \cdot v_g = -3H(t) \quad (4)$$

For a homogeneous and isotropic universe,  $v_g$  is radial. Calculating its divergence in spherical coordinates:

$$\nabla \cdot v_g = \frac{1}{r^2} \frac{\partial}{\partial r} (r^2 v_g) \quad (5)$$

Equating (4) and (5):

$$\frac{1}{r^2} \frac{\partial}{\partial r} (r^2 v_g) = -3H(t) \quad (6)$$

Integrating this and disregarding the integration constant yields:

$$v_g = -H(t)r \quad (7)$$

The expanding velocity  $v$  of space at distance  $r$  is numerically equal to the gravitational field flow velocity  $v_g$  at that point, and  $r$  is the comoving distance  $D$ . Therefore:

$$v = |v_g| = H(t) \cdot D \quad (8)$$

Q.E.D. Hubble's Law is derived.

## 6. Derivation of Hubble's Law from the Scalar Superposition of Gravitational Field Flow Velocity

### 6.1. Objective and Postulates

Objective: To prove that in a static, homogeneous, and isotropic universe with matter density  $\rho$ , the total expanding velocity  $V$  of gravitational space at a distance  $D$  from an observer  $O$ , resulting from the scalar superposition of the gravitational field flow velocity  $v_g$  generated by all matter in the

universe, satisfies Hubble's Law:  $V = H \cdot D$  where  $H$  is the Hubble constant, constructed from the fundamental constants in this framework.

Core Postulates:

1. Gravitational Field Flow Velocity: There exists a gravitational field flow velocity field,  $v_g$ . For an isolated point mass  $M$ , the magnitude of the flow velocity it generates at a distance  $r$  is given by:

$$v_g = kM/r^2 \quad (9)$$

where  $k$  is a universal constant with dimensions  $[L]^3[T]^{-1}[M]^{-1}$ . This equation defines the strength distribution of the gravitational field.

2. Cosmological Principle: The universe is homogeneous and isotropic on large scales, with a constant average matter density  $\rho$ .

## 6.2. Derivation

Step 1: Establish the "Spherical Shell Integration" Model

The observer  $O$  is placed at the origin of a spherical coordinate system. According to the Cosmological Principle, the mass distribution of the universe can be treated as a uniform sphere centered on  $O$ . The mass is divided into an infinite number of infinitesimally thin, concentric spherical shells. Consider one such shell of radius  $r$  and thickness  $dr$ .

Step 2: Calculate the Flow Contribution from a Single Shell to Point  $P$

Let point  $P$  be located at a distance  $D$  from the origin  $O$ . We aim to calculate the scalar superposition of the flow velocity contributions at  $P$  from every mass element on this spherical shell.

Due to the spherical symmetry of the shell, the direction of the net flow velocity contribution at  $P$  will be purely radial (along  $OP$ ). Therefore, we need only calculate the superposition of scalar magnitudes.

- The mass  $dm$  of the shell is:  $dm = \rho * (\text{volume of the shell}) = \rho * 4\pi r^2 dr$
- According to Postulate 1, a mass element  $\delta m$  on the shell contributes a flow velocity  $\delta v_g = k\delta m/s^2$  at  $P$ , where  $s$  is the distance from the mass element to  $P$ .
- Crucially, due to the symmetry of the shell, every mass element on it is at the same distance  $s$  from point  $P$ . Therefore, the total flow velocity contribution  $dV$  from the entire shell at  $P$  is the simple algebraic sum (scalar superposition) of all infinitesimal contributions:

$$dV = k * (\text{total mass of shell})/s^2 = k(\rho 4\pi r^2 dr)/s^2 \quad (10)$$

Step 3: Integral Expression

The total recession velocity  $V$  at point  $P$  is obtained by integrating the contributions from all spherical shells of radius  $r$  from 0 to  $D$ . This is because we now only consider the mass inside a sphere of radius  $D$  centered on the observer  $O$ .

$$V = \int dV = \int_0^D \frac{k\rho 4\pi r^2}{s^2} dr \quad (11)$$

Step 4: Geometric Relation

The distance  $s$  is related to  $r$ ,  $D$ , and the angle  $\theta$  by the law of cosines:

$$s^2 = r^2 + D^2 - 2rD \cos \theta \quad (12)$$

Step 5: Solving the Integral and Obtaining the Result

5.1. The Core Simplification and Symmetry

The postulate of scalar superposition is crucial. We are summing the magnitudes of the flow velocity contributions, not their vectors. Due to the spherical symmetry of each shell, the net effect at point  $P$  can be calculated by considering the average contribution over the entire shell.

For a thin spherical shell of radius  $r$  and a point  $P$  at a fixed distance  $D$  from the shell's center, the appropriate way to perform this scalar sum is to use the average value of  $1/s^2$  over the entire surface of the shell.

5.2. Finding the Average Value of  $1/s^2$

From Equation (12),  $s^2 = r^2 + D^2 - 2rD \cos \theta$ . The average value of  $1/s^2$  over the sphere is given by:

$$\langle \frac{1}{s^2} \rangle = \frac{1}{4\pi} \int \frac{d\Omega}{s^2} = \frac{1}{4\pi} \int_0^{2\pi} d\phi \int_0^\pi \frac{\sin \theta d\theta}{r^2 + D^2 - 2rD \cos \theta} \quad (13)$$

where  $d\Omega$  is the solid angle element. This integral is standard. The result depends on the relative sizes of  $r$  and  $D$ :

- For a point  $P$  outside the shell ( $D > r$ ): The average value is  $\langle 1/s^2 \rangle = 1/D^2$ .
- For a point  $P$  inside the shell ( $D < r$ ): The average value is  $\langle 1/s^2 \rangle = 1/r^2$ .

In our revised model, we are only integrating over shells where  $r < D$  (i.e.,  $P$  is outside all shells). Therefore, for every shell in our integral,  $\langle 1/s^2 \rangle = 1/D^2$ .

### 5.3. Executing the Integral

Substituting the average value into the revised integral (Equation (11) Revised):

$$V = \int_0^D k \rho 4\pi r^2 \cdot \langle \frac{1}{s^2} \rangle dr = \int_0^D k \rho 4\pi r^2 \cdot \frac{1}{D^2} dr \quad (14)$$

$$V = \frac{k\rho 4\pi}{D^2} \int_0^D r^2 dr \quad (15)$$

### 5.4. Final Calculation

$$V = \frac{k\rho 4\pi}{D^2} \cdot \left[ \frac{r^3}{3} \right]_0^D = \frac{k\rho 4\pi}{D^2} \cdot \frac{D^3}{3} \quad (16)$$

$$V = \frac{4}{3} \pi k \rho D \quad (17)$$

Q.E.D.

### 6.3. Discussion

1. As gravitational field processes negative-energy state, gravitational space can be deduced propagating outward from matter.

2. Origin of Hubble's Law: The linear velocity-distance relation is not a kinematic consequence of motion but a direct result of the scalar superposition of the gravitational flow velocity field  $v_g$  generated by a homogeneous mass distribution.

3. Physical Meaning of  $H$ : The Hubble constant  $H$  is no longer a free parameter or a kinematic rate. It is fundamentally a measure of the flow field's strength gradient, determined by the universal constant  $k$  and the matter density  $\rho$  of the universe ( $H = (4/3)\pi k \rho$ ).

4. Hubble Tension: Hubble Tension referred to the discrepancy between early- and late-universe measurements of  $H_0$ —ceases to be a problem within this framework and instead becomes a natural prediction. The key is the derived relation  $H = (4/3)\pi k \rho$ , which redefines  $H$  not as a constant but as a field whose value is determined by local matter density  $\rho$ .

5. To sustain such an operating mechanism for the cosmos, this framework requires support from a higher-dimensional anti-cosmos coupled with the cosmos for negative-energy state hypercycling. This necessity implies that matter and antimatter are two manifestations of a single underlying entity.

6. Newtonian gravitation is not merely the weak-field approximation of general relativity. Within the framework of dynamic field theory, Newtonian gravitational field is the fundamental form of space, while general relativity describes the interaction of the dynamic gravitational field spaces.

## 7. Foundations, Postulates and Theorems of MCST

The above derivation of Hubble's law originates from a fundamental insight of Mass Complex Space Theory (MCST) [14]: the local symmetry in classical physics is the inherent seed for dynamic field theory. Thus MCST naturally extends General Relativity into complex space whose fiber element

is the “Quadruple States of Planck Quantum  $\odot(h, \Phi_{ih}, \Phi_h, ih)$ ”, containing the full elements of electromagnetism interaction. Within this framework, the gravitational field space is fundamentally constituted by the negative-energy positron state ( $\Phi_{ih}$  phase). This state dynamically couples with its higher-dimensional, positive-energy electron-state ( $\Phi_h$  phase) counterpart to form a hyper-cycling complex space. From this primordial cycle, the matter (hphase) and antimatter (ihphase) emerge as the two critical holographic surfaces of the unified Mass Complex Space (MCS). Consequently, MCST achieves a foundational unification of matter and spacetime, while simultaneously attributing the phenomena of dark matter and dark energy to macroscopic field effects arising from the divergent nature of the gravitational field space within this hyper-cyclic dynamics. From this foundation, a key new physical field emerges—the gravitational circulation field  $\Phi_\Gamma$ . Analysis establishes that observed velocity  $v_{obs}$ , Keplerian velocity  $v_K$ , and circulation velocity  $v_\Gamma$  follow a fourth-power relation:  $v_{obs}^4 = v_K^4 + v_\Gamma^4$ , with the fit residual accuracy ranging from 4.9% to 0.6%. [9] The circulation velocity  $v_\Gamma$  was interpreted as “free orbital motion” in a dynamical field work first proposed in 2020 [15].

### 7.1. Foundations of MCST

The fundamental challenges facing modern physics—such as the contradiction between absolute and relative spacetime, the conflict between quantum locality and globality, the internal/external duality of the universe, the matter/antimatter asymmetry, and the “first cause” problem—are systemic and share a common origin. Viewing these problems as an interconnected whole opens new pathways for theoretical physics.

A complete MCST must therefore satisfy the following six requirements:

1. Extend the mathematical complex plane into a physical matter complex space.
2. Derive a four-dimensional spacetime curvature mechanism compatible with general relativity.
3. Incorporate a quantization mechanism compatible with quantum mechanics.
4. Possess a closed complementary structure resolving the internal/external duality of the universe.
5. Exhibit an antisymmetric complementary structure addressing the matter/antimatter paradox.
6. Contain an intrinsic dynamical mechanism eliminating the need for a “first cause.”

To simultaneously satisfy these conditions, the MCST model must have the following characteristics: real and imaginary spaces are orthogonal and fully closed; they are complementary and antisymmetric; and energy exchange occurs between them. Geometrically, this corresponds to a double-singularity antisymmetric dynamical structure where real and imaginary spaces are mutually embedded.

The physical and philosophical motivations for this model include:

1. Positive and negative energy fields should be equal and antisymmetric, requiring an antisymmetric real/imaginary space structure.
2. The gravitational field energy remains constant with radius, suggesting a superfluid-like character.
3. A persistent gravitational field requires an energy feedback mechanism, implying the necessity of an imaginary space.
4. The absence of antimatter astronomical objects suggests matter is better understood as a unity of positive and negative energy fields.
5. Positrons and electrons should be symmetric, each capable of existing in both particle-like and hole-like states.
6. The widespread use of complex space in mathematics and the phenomenon of quark confinement both support the physical reality of an imaginary space.

The geometry of mass complex space can be expressed in 1D, 2D, and 3D forms, with the Taiji (Yin-Yang) diagram offering the deepest philosophical and physical insight. Crucially:

1. Real and imaginary spaces are physically equivalent.

2. Real space corresponds to the virtual state of matter (divergent negative energy, forming the gravitational field).
3. Imaginary space corresponds to the real state of matter (convergent positive energy, forming the repulsive field).
4. Their conjugation generates quantum particles.
5. The attributes of real/imaginary and large/small are symmetric; the distinction between real and imaginary is a result of natural selection.

### 7.2. Postulates of MCST

First Postulate of MCST: Matter is generated through the interaction of opposing and complementary real and imaginary spaces ( $\Phi_h \rightarrow h * ih \leftarrow \Phi_{ih}$ ).

Second Postulate of MCST: Real space is divergent gravitational field ( $\Phi_{ih}$ ), while imaginary space is convergent anti-gravitational field ( $\Phi_h$ ). (the properties corrected)

Third Postulate of MCST: Matter is the manifestation of the local coupling and differentiation of hypercyclic matter-states.

Fourth Postulate of MCST: The motion of hypercyclic matter-states follows the natural law of "changing phase to its reversal at the extreme ( $h \rightarrow \Phi_{ih} \rightarrow \Phi_h \rightarrow ih \rightarrow$ )."

Fifth Postulate of MCST: Real space is the negative-energy state of matter ( $\Phi_{ih}$  | negative positron--state), while imaginary space is the positive-energy state of matter ( $\Phi_h$  | positive electron--state).

Sixth Postulate of MCST: The distribution of gravitational field flows in multi-mass systems obeys the principle of least action.

Seventh Postulate of MCST: The motion of a body is an effect of external imbalance in its gravitational field space and the aim of motion is to restore intrinsic perfect symmetry. (evolution to the Seventh Theorem in this paper)

Eighth Postulate of MCST: In the critical surface of mass complex space, the gravitational field flow velocity equals the gravitational field wave velocity.

Ninth Postulate of MCST: The distribution of field flows in mass complex space possesses mechanical inertia.

Tenth Postulate of MCST: The area of the critical surface of a body's intrinsic complex space is proportional to its intrinsic mass.

### 7.3. Theorems of MCST

First Theorem of MCST: The maximum size of the universe and its minimum scale are opposing and unified ( $IP * IU = 1$ ).

Second Theorem of MCST: When two particles approach each other, the critical domains of their respective complex spaces both expand.

Third Theorem of MCST: For two mass-bodies sufficiently distant from other masses, the gravitational mass each intercepts from the other is inversely proportional to their intrinsic masses.

Fourth Theorem of MCST: The gravitational mass a body intercepts from the background vacuum is proportional to its intrinsic mass.

Fifth Theorem of MCST: The gravitational mass of a body is always equal to its inertial mass.

Sixth Theorem of MCST: In a stable celestial system, the gravitational effective mass of the central body is always less than its intrinsic mass. (This theorem predicts the existence of a third category of redshift, and can explain both the origin of quasar and the low activity of black hole in the center of galaxy.)

### 7.4. Hierarchical Cosmos and the Essence of Motion

MCST reveals a hierarchically recursive picture of cosmic dynamics:

- Its foundation is the intrinsic antisymmetric “imperfection” of the spatial fields themselves, which drives the eternal pursuit of symmetry restoration. The principle of local symmetry can be derived from the principle of least action, it provides theoretical foundation for MCST, a dynamical field theory, to incorporate SR, which is formulated within ideal static, flat spacetime.
- Its core is the Symmetry Restoration Theorem, which governs the ultimate purpose of all free motion.
- Its manifestation is the hierarchical comoving inertial frames with same physical laws, which constitute the common root from which all classical kinematics—from Newtonian mechanics to General Relativity—derive their validity.

Ultimately, we perceive not a universe governed by several independent forces, but a single physical entity—space itself—undergoing a continuous, dynamic evolution from asymmetry toward states of local symmetry across multiple scales. Gravity, inertia, and even matter itself are manifestations of this grand dynamical process at different stages and in different dimensions. MCST provides a possible mathematical formulation and preliminary evidence for this perspective, opening a path toward a more unified and fundamental understanding of the nature of motion.

## 8. Physical Conditions and Core Predictions for the Formation of Huge Magnetic Toroids in the Milky Way

### 8.1. Physical Conditions

The Galactic magnetic field is traced by Faraday rotation measures of background radio sources and pulsars. The antisymmetry observed in the Faraday sky of the inner Galaxy suggests the presence of halo magnetic toroids with reversed field directions above and below the Galactic plane, a feature incorporated into most global models. However, key parameters such as field strength and scale remain poorly constrained, and there is ongoing debate regarding how much of this antisymmetry originates from the local interstellar medium versus the global structure. These structures are immense, extending from a Galactocentric radius of less than 2 kpc to at least 15 kpc, with no reversal in field direction. Such magnetic toroids in the Galactic halo should naturally constrain the physical processes within galaxies. [17]

The entity of gravitational field space is the outer extension of classical virtue positron, which is named “positron-state” and it’s the fundamental motive for the gravitational circulation field to generate huge magnetic toroids. The formation of such immense magnetic toroids structure still requires the following physical conditions, which also constitute testable core predictions:

#### 1. Polarity Alignment of the Gravitational Circulation Field with the Galactic Poles

As the rotation of the gravitational circulation field in negative-energy state is opposite to the orbital motion of mainstream celestial bodies, its magnetic north pole (N-pole) corresponds to the south Galactic pole of the Milky Way.—This is the first unique and falsifiable prediction.

#### 2. Peak Magnetic Field Near the Inner Edge of Gravitational Circulation Field

A research on “Magnetic Field of a Current-Carrying Disc” indicates that for an idealized current distribution confined to a planar disc of negligible thickness, the magnetic field strength is maximized near both the inner and outer radial edges of the disc [18]. This provides a useful theoretical reference and analogy for understanding the large magnetic toroids potentially formed by the gravitational circulation field. It is crucial to note that the specific details of the toroidal magnetic field distribution—such as the locations of maxima and the field gradients—are expected to differ fundamentally from those of the classical current model in quite small scale. Due to the gravitational circulation field is primarily excited by the galactic spiral arms and enters into the decay channel within a conservative potential at the outer edge of the arms, the magnetic field excited by this circulation field consequently exhibits only a single peak in magnetic field strength, located above the inner side of the circulation field.—This is the second unique and falsifiable prediction.

#### 4. Opposite Macro Magnetic Field Direction at the Galactic Center

To form such a center-suspending, high-intensity magnetic toroids [17], the direction of the macroscopic magnetic field at the Galactic center must be opposite to that of the gravitational circulation field. Consequently, their magnetic fields cancel each other in the vicinity of the Galactic disk, giving rise to the center-suspending, high-intensity toroids. It can therefore be predicted that the direction of the macroscopic magnetic field at the Galactic Center is consistent with the defined orientation of the Galactic disk. —This is the third unique and falsifiable prediction.

#### 5. Observable Effects on Cosmic Rays

Based on the aforementioned geometry, the theory predicts the existence at the Solar position (north of the Galactic plane) of a net S-pole (south pole) magnetic field pointing toward the Galactic center, generated by the gravitational circulation field. This will lead to an observable effect: positively charged cosmic rays—which dominate the flux and originate from or traverse this region—will exhibit systematic anisotropy or distortion in their energy spectrum or angular distribution, correlated with the direction of the Galactic center. This effect is expected to be particularly pronounced, potentially resulting in a detectable cutoff or enhancement of the signal around the ~20 kpc “magnetic watershed” boundary. —This is the fourth unique and falsifiable prediction.

This prediction provides a theoretical resolution to the empirical practice wherein the maximum Galactocentric radius of the diffusion volume was set to  $R_{\max} = 18$  kpc [18], as it identifies the likely boundary of the internally dominant magnetic structure.

#### 8.4. Unified Picture: Global Topology of Magnetic-Matter Coupling

The theory ultimately depicts a unified global picture of matter-magnetic field interaction on galactic scales: The magnetic field lines generated by the gravitational circulation field emanate from its N-pole located south of the equatorial plane, converge into the Galactic center (acting as an S-pole), then re-emerge from the Galactic center’s north pole (N-pole), and finally return to the circulation field’s S-pole located north of the equatorial plane. This forms a pair huge magnetic toroids that connects the Galactic center with the galactic outskirts. This implies that the Galactic disk magnetic field, the halo magnetic field, and central activity are unified within a single geometrodynamical framework.

## 9. Summary: From Dynamic Gravitational Field to the Preliminary Unification of Gravitation and Electromagnetism

Derivation of Hubble’s law not only bridges MCST and GR, but also definitely clarifies that gravitational field space is diverging negative-energy state. MCST introduces the “Quadruple State of the Planck Quantum  $\odot(h, \Phi_{ih}, \Phi_h, ih)$ ” as the elementary complex-space generating element, whose hyper-cycle dynamically unifies matter and spacetime and electric charges. Consequently, dark matter and dark energy are unified as field effects of hyper-cycling mass complex space. Emergent from this framework is a gravitational circulation field ( $\Phi_{\Gamma}$ ). This field makes the apparent Keplerian mass exhibits a counter-intuitive monotonic decrease (mass inversion) in the outer halo of the Milky Way (22.5–26.5 kpc). Moreover, owing to its intrinsic “negative-energy positron state” property,  $\Phi_{\Gamma}$  naturally generates huge magnetic toroids with typical structure, which aligns remarkably with the observed galactic magnetic field, thereby achieving a preliminary structural unification of gravitation and electromagnetism on galactic scales without additional assumptions. At the location of galactic spiral arms, the equivalent current density of the gravitational circulation field undergoes nonlinear variation. Theoretically, performing a quantitative calculation of the three-dimensional structure of such a circulation field is extremely challenging. Therefore, at this stage, we can only conduct qualitative research by drawing upon insights from analogous models.

The most profound extension of this work is to advance the core field of MCST—gravitational circulation field—to the subatomic scale. The central thesis is that a vastly intensified and localized gravitational circulation field at quantum scales may be the key to a quantitative unification of gravitation and electromagnetism achievable at subatomic scales far below the Planck energy. This

exploration is to discover the interaction between quantum and background gravitational field space and the magnetic moment manifestations of a composite particle's gravitational circulation field, with the goal of deriving intrinsic properties of elementary particles—such as mass, spin, and magnetic moment—from the same dynamical principles that successfully govern galactic-scale phenomena. A direct challenge of this goal is to formulate a “universal circulation gauge theory” grounded in the gravitational circulation field—the field that governs the strong through the weak is an ultimate energy-efficient gauge field. Thus success in this endeavor would represent a monumental step toward the ultimate unification.

I warmly invite theoretical and experimental physicists to join in this exploration. Collaborative efforts in model-building, rigorous mathematical derivation, and the design of decisive experimental tests will be crucial to mapping this uncharted territory.

**Conflicts of Interest:** The authors declares no conflicts of interest.

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