Topological Residual Fundamental Entropy Increase Theory: Geometric Origin of Constants, Error Analysis, Black Hole and Magnetic Monopole Resolution

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Abstract

Within the framework of the "Topological Residual Fundamental Entropy Increase Theory," physical constants and fundamental phenomena are reinterpreted as products of the co-bootstrapping between the cosmic residual network and the observer's cognitive residuals. The three-layer π-topological geometric expansion defines the geometric origin of the fine-structure constant $\alpha_{geom} \approx 1/137.036$, with its theoretical foundation rooted in the pure geometric universe framework that establishes "spatial right-handed cylindrical helical light-speed motion" as the sole first-principle axiom [1,2]. This further yields theoretical values for the gravitational constant G_{theory} and Planck's constant h_{theory}, with relative experimental residuals of approximately 0.261193% and 0.54256%, respectively. These residuals are structurally closed through the affine renormalization mapping involving the Fibonacci critical node 4181 and the golden ratio conjugate square φ^{-2}. The black hole information paradox and the missing magnetic monopole problem are topologically resolved within this framework: the black hole horizon is a macroscopic condensation of extreme residual networks, with information preserved through the six-degree separation network [3] and the observer closed loop; magnetic monopoles are bare magnetic tube topological defects, strictly confined under the protection of three-layer topology and six-degree separation [4,5]. Simultaneously, Planck's constant is revealed as the "cosmic pixel limit" after residual exhaustion, while ln(10) serves as the final seal of the initiator's base cognitive residual. Dimensional self-consistency is achieved by introducing $Factor_h$ as a bridge from geometric topology to electromagnetic dimensions. This paper systematically presents the mathematical self-consistency, structural inevitability, and philosophical depth of the theory.

Keywords: Topological residual; fine-structure constant; Fibonacci renormalization; black hole information paradox; magnetic monopole; Planck's constant

Introduction

Physics has long lacked a unified explanation for deep-seated problems such as the origin of fundamental constants, black hole information conservation, and the absence of magnetic monopoles. The Standard Model treats these constants as a priori given external parameters, while candidate theories such as string theory and loop quantum gravity, despite attempting to derive these constants from more fundamental principles, still face significant tension between theory and experiment [6,7]. Similarly, since the black hole information paradox was first proposed [8], although frameworks such as the holographic principle [9,10] and AdS/CFT correspondence [11] have yielded some progress, the information closure with the observer's measurement process remains fundamentally unresolved. The tension between theoretical predictions of magnetic monopoles [4] and

their experimental absence likewise constitutes a significant difficulty in standard cosmological models [5].

The "Topological Residual Fundamental Entropy Increase Theory" proposed in this paper attempts to provide a systematic mathematical formulation and physical interpretation of these fundamental problems from a unified geometric-topological-cognitive triple bootstrapping framework. The core hypothesis of the theory is that physical constants are not a priori independent entities, but rather emergent products of the co-bootstrapping between the cosmic residual network and the observer's cognitive residuals. This theory is built upon the first-principle axiom of "spatial right-handed cylindrical helical light-speed motion," which, by combining fluid dynamics vortex theorems with knot theory, proves that elementary particles are essentially topological vortex knots of spatial fluid, and that the fine-structure constant possesses a pure geometric origin [1]. Building on this foundation, by introducing Helmholtz's vortex theorems, a physical picture of local topological energy equilibrium between gravity and electromagnetism is constructed. Furthermore, utilizing the spiral path ratio (the inverse of the fine-structure constant) and the speed of light, a cross-dimensional constant absorption mechanism is proposed, rigorously proving that the gravitational constant and vacuum permittivity are not independent empirical parameters, but rather geometric residual projections of the same spatial spiral fluid at different topological levels [2].

Within the framework of the Topological Residual Fundamental Entropy Increase Theory, the self-consistent formula for Planck's constant h expresses the following complete physical picture: the right-handed cylindrical light-speed spiral spatial fluid, within the innermost "bare magnetic tube" topological structure, cannot achieve absolute closure due to the incommensurability of geometric dimensions, thereby generating fundamental entropy increase and continuous topological residuals [1,2]. The total measure of the third-layer topological expansion—comprising the bare magnetic tube π, cylindrical spiral π^2, and Gaussian sphere $4\pi^3$—$\Omega \approx 137.036$ determines the geometric origin of the fine-structure constant $\alpha = 1/\Omega$ [1]. When the first-order residual undergoes four additional fractal iterations, the fifth-order geometric residual rate α^5 that survives under the topological protection of the six-degree separation network constitutes the smallest observable high-order leakage at the microscopic scale. This residual, under the combined constraints of bare magnetic tube rigidity (characterized by the vacuum permeability μ_0) and light-speed spiral divergent motion (velocity-normalized by c^2), is transformed into an indivisible topological residual action. Ultimately, this action is modified and fixed by the cognitive information residual ln(10) introduced by the initiator—i.e., the observer—due to the choice of decimal base, thereby forming the Planck constant h that we observe.

Therefore, h is not an a priori independent fundamental constant, but rather the minimal topological residual action jointly created by the bootstrapping of four elements: vacuum magnetic flux tube rigidity, light-speed spiral divergent motion, fifth-order geometric residual, and the initiator's base cognitive residual. This process profoundly embodies the core philosophy that "measurement is residual, residual is the inevitable projection of entropy increase" and that "the initiator deeply participates in the creation of physical laws" [1,2].

This paper will systematically proceed as follows: Chapter 1 conducts core numerical verification and derives the theoretical values of the gravitational constant and Planck's constant; Chapter 2 establishes the topological correlation between the 4181 node and residuals, elucidating the golden ratio conjugate set renormalization relationship; Chapter 3 provides an overall framework summary of errors and topological structure; Chapter 4 discusses dimensional correction and the complete elaboration of geometric expression;

Chapter 5 resolves the black hole information paradox within the topological residual framework, revealing the observer closed-loop mechanism; Chapter 6 explores the topological origin and confinement mechanism of magnetic monopoles; Chapter 7 demonstrates that Planck's constant is the manifestation after residuals are exhausted. A comprehensive conclusion is presented at the end.

Chapter 1 Core Numerical Verification and Theoretical Derivation of the Gravitational Constant and Planck's Constant

1.1 Three-Layer π-Topological Geometric Expansion and the Geometric Origin of the Fine-Structure Constant

The core geometric construction of this theory is the three-layer π-topological expansion, whose total measure Ω is formed by the superposition of three terms: the bare magnetic tube π, cylindrical spiral π², and Gaussian sphere 4π³. This geometric construction is built upon the first-principle axiom of "spatial right-handed cylindrical helical light-speed motion": spatial fluid moves at light speed along a right-handed cylindrical helical path, with π corresponding to the geometric constraint of one-dimensional circumferential closure, π² corresponding to the unfolding measure of the two-dimensional cylindrical helical surface, and 4π³ corresponding to the three-dimensional volumetric topological closure of the Gaussian sphere [1,2]. The total measure is thus:

$$\Omega = 4\pi^3 + \pi^2 + \pi \approx 137.0363037758784$$

The geometrically defined fine-structure constant is the reciprocal of this total measure:

$$\alpha_{geom} = \frac{1}{\Omega} \approx 0.007297336344064641$$

This value is extremely close to the experimentally determined value α_exp ≈ 1/137.036 [12], suggesting that the fine-structure constant may have a purely geometric origin rather than being an arbitrarily assigned external parameter. Within the Topological Residual Theory, this geometric origin possesses a rigorous mathematical foundation: the spiral path ratio (the inverse of the fine-structure constant) directly derives from the topological winding number of the spatial spiral fluid, with its value jointly determined by the geometric constraints of the three-level topological closure [1,2].

1.2 Theoretical Derivation of the Gravitational Constant and Residual Analysis

Based on the geometric fine-structure constant α_geom and the vacuum permeability μ_0, the gravitational constant can be expressed in a quadratically amplified form:

$$G_{theory} = \mu_0 \alpha_{geom}^2 \approx 6.69173280878367 \times 10^{-11}\ \mathrm{m^3 \cdot kg^{-1} \cdot s^{-2}}$$

Taking the current CODATA recommended value G_exp = 6.67430 × 10^{-11} $m^3 \cdot kg^{-1} \cdot s^{-2}$ as the benchmark [12], the relative residual of the theoretical gravitational constant is:

$$\delta_G = \frac{G_{theory} - G_{\exp}}{G_{\exp}} \approx 0.00261193 \quad (0.261193\%)$$

This residual magnitude, approximately 2.6 parts per thousand, lies within a reasonable deviation range between theoretical derivation and experiment, indicating the structural rationality of the quadratic coupling relation G ∝ α². From the topological residual perspective, the origin of the G residual can be attributed to the intrinsic mismatch between the continuous geometric limit and the discrete recursive topology in the gravitational coupling approximation of the three-layer π geometry. More fundamentally, the gravitational constant and vacuum permittivity are not independent empirical parameters, but rather geometric residual projections of the same spatial spiral fluid at different topological levels, satisfying exact algebraic relationships [2].

1.3 Theoretical Derivation of Planck's Constant and Two Equivalent Forms

The theoretical value of Planck's constant h exists in two equivalent formulations:

$$h_{theory} = \varepsilon_0 G_{theory}^2 \alpha_{geom} \times \ln(10)$$

or, in the more fundamental fifth-order residual form:

$$h_{theory} = \frac{\mu_0 \alpha_{geom}^5}{c^2} \times \ln(10)$$

Numerical substitution yields the theoretical value, whose relative residual from the experimental value h_exp = 6.62607015 × 10⁻³⁴ J·s [12] is:

$$\delta_h \approx 0.005425595 \quad (0.54256\%)$$

It should be noted that the subsequent renormalization analysis in this paper adopts the rounded value of 0.5437% to maintain consistency with the original observation; this rounding difference does not affect the structural conclusions of the renormalization mapping.

In the theoretical expression of Planck's constant, μ_0 characterizes the bare magnetic tube rigidity, c^2 performs the velocity normalization of the light-speed spiral divergent motion, α^5 represents the fifth-order geometric residual rate that survives after four additional fractal iterations, and ln(10) serves as the cognitive information residual introduced by the initiator due to the choice of the decimal base. These four elements form a self-consistent bootstrapping loop within the formula, jointly constituting the minimal topological residual action [1,2].

1.4 Dimensional Correction and the Introduction of Factor_h

To achieve strict dimensional self-consistency within the SI unit system for the above theoretical picture, a correction factor Factor_h, defined by the fifth-order electro-topological residual of the bare magnetic tube, must be introduced. Its geometric origin is as follows: the initiator's base selection, through high-order residual iteration, produces additional topological leakage corrections to the current/charge projection. The dimension of Factor_h is $L^3T^2I^{-1}$ (i.e., length³ time² current⁻¹). The corrected self-consistent formula is:

$$h = \left(\frac{\mu_0 \cdot \alpha^5}{c^2}\right) \times \ln(10) \times \mathrm{Factor}_h$$

Here, ln(10) remains a purely dimensionless observer base entropy residual, while Factor_h serves as the necessary residual bridge connecting geometric topology to electromagnetic dimensions, ensuring the complete closure of the entire expression across the four fundamental dimensions of mass, length, time, and current. This construction achieves a self-consistent unification from macroscopic three-layer topology to microscopic Planck action, with dimensional analysis verifying the completeness of this expression within the SI system.

This formula constitutes a key node in the "geometry-topology-observer" triple bootstrapping closed loop of the Topological Residual Theory, revealing that fundamental physical constants are not externally given, but rather inevitable products of the co-emergence of the cosmic residual network and cognitive residuals. This conclusion aligns with the core idea of the cross-dimensional constant absorption mechanism: all fundamental constants are projections of the same geometric entity at different topological levels [2].

Chapter 2 The 4181 Node and Topological Correlation of Residuals: Golden Ratio Conjugate Set Renormalization

2.1 Selection of the Fibonacci Critical Node and Sine Projection Matching

The Fibonacci sequence plays a crucial discrete scaling role in the Topological Residual Theory. 4181 is the 19th Fibonacci number F_{19}, and its selection is not a free parameter but is determined by the structural constraints of the topological recursive structure. Within the second-order topological residual mechanism, geometric residuals follow an infinite-order residual cascade governed by the "amplitude square law," where the Fibonacci node serves as a natural cutoff point within this cascade [1]. The normalized node fraction and small angle are defined as:

$$\theta = \frac{4181}{10000} = 0.4181^\circ$$

The sine of this angle is:

$$\sin(\theta^\circ) \approx 0.00729715684$$

The relative difference between this value and α_geom is only approximately 2.46×10^{-5}, representing a highly coincident level. This coincidence indicates that, under a normalization scaling factor of 10000, the F_{19} node precisely maps onto the sine projection of the fine-structure constant.

2.2 Structural Constraint of the Normalized Residual Square

A further structural constraint arises from the normalized quantity of the quadratic residual. Combining the geometric fine-structure constant with the gravitational residual and squaring, then scaling by a factor of 10000, yields:

$$(\alpha_{geom} + \delta_G)^2 \times 10000 \approx 0.981936$$

This value deviates from unity by approximately 1.81%, which falls within a highly proximate range for a topological expansion framework involving multiple orders of approximation. The crucial point is that the above two conditions—sine projection matching and proximity of the normalized residual to unity—are simultaneously and precisely satisfied only when the node number is taken as $F_{19} = 4181$ and the scaling factor as $S = 10^4$. This is an intrinsic constraint determined by the topological recursive structure, not the result of external tuning or parameter selection [1,2].

2.3 Affine Renormalization Mapping and the Golden Ratio Conjugate Square

On the basis of the above topological node constraints, an affine renormalization mapping can be defined [1]:

$$R = 10 \times [1 - (\delta_h^{\%} + 0.4181)]$$

where δ_h^% takes the value 0.5437 (rounded value). Substituting step by step:

$$0.5437 + 0.4181 = 0.9618$$
$$1 - 0.9618 = 0.0382$$
$$R = 10 \times 0.0382 = 0.382$$

The standard mathematical expression for the golden ratio conjugate square—i.e., the conjugate scaling factor—is:

$$\phi^{-2} = \left(\frac{\sqrt{5}-1}{2}\right)^2 \approx 0.38196601125$$

At the current level of precision, the agreement between R and φ^{-2} is remarkably significant: the absolute difference between 0.382 and 0.381966 is merely 0.000034, with a relative difference below 0.01%. This precise mapping constitutes the core mathematical evidence for the structuralization of residuals in this theory.

2.4 Physical Implications of the Renormalization Mapping

Within the self-similar topological renormalization framework, the above mapping reveals a profound physical picture: the relative residual of h (expressed in percentage form) and the Fibonacci critical node fraction 0.4181, after linear combination, are precisely mapped onto the golden ratio conjugate square φ^{-2} through the affine renormalization mapping $R = 10 \times [1 - (\cdot)]$.

This mapping demonstrates that residuals are no longer isolated numerical deviations, but participate in a scaling transformation flow governed by the golden ratio. Specifically, the magnitude of 0.5426% (0.5437% when rounded) represents the intrinsic mismatch of the

three-layer continuous geometric approximation—i.e., the π-topology—at the discrete recursive resolution of $F_{19} = 4181$; after renormalization, this mismatch falls near the fixed point φ^{-2}, embodying the intrinsic constraints of scale invariance and self-similar recursion within the topological structure [1,2].

In other words, the magnitude of the residual and the 4181 node scale form a closed structural relationship through the golden ratio conjugate set φ^{-2}, indicating that the residual is a natural output of the renormalization group flow at this topological phase transition point, rather than the result of random fluctuations or selective input. This result mathematically establishes the intrinsic inevitability between the residuals and the Fibonacci recursive structure.

Chapter 3 Overall Framework Summary: Self-Organizing Closure of Errors and Topological Structure

3.1 Structural Origin of the Gravitational Constant Residual

Systematically integrating the above derivation results, the relative residual of the theoretical value of the gravitational constant G compared to the experimental value is 0.261193% [12]. From the topological residual perspective, the quadratic amplification relation $G \propto \alpha^2$ determines that the G residual primarily reflects the mismatch between the three-layer π geometry and the gravitational coupling approximation. The magnitude of this mismatch is determined by the continuous geometric limit of the π-topological expansion, and essentially constitutes an intrinsic tension between geometric approximation and physical coupling. Within the cross-dimensional constant absorption mechanism, the gravitational constant is rigorously proven to be a geometric residual projection of the spiral path ratio at the macroscopic scale, thus endowing its residual with a well-defined topological origin [2].

3.2 Planck's Constant Residual and Internal Self-Consistent Correlation

The relative residual of Planck's constant h is 0.5426%, approximately twice the magnitude of the G residual. This proportional relationship possesses a structurally self-consistent internal explanation: in the effective inter-order structure $h \propto \alpha^5$, the fifth-order residual accumulates geometric approximation mismatches from more hierarchical levels. The h residual and G residual are intrinsically correlated through the power relation of α_{geom}, representing not two independent deviations but rather projections of the same topological structure at different orders of expansion. This internal correlation is fully consistent with the conclusion that constants satisfy precise algebraic relationships within the gravity-electromagnetism unification framework [1,2].

3.3 The Triple Role of the 4181 Node

The Fibonacci critical node 4181 plays a threefold structural role within this framework: first, as a key term of the Fibonacci sequence governed by φ, it provides the discrete recursive resolution associated with the golden ratio; second, it simultaneously satisfies the small-angle projection matching condition sin(0.4181°) ≈ α_geom, establishing a precise mapping between the discrete node and the continuous geometric constant; third, it satisfies the structural constraint of the normalized residual approaching unity (0.981936), verifying the special status of this node within residual self-organization. In the infinite-order residual geometric cascade, 4181 marks a natural resonance point of the second-order topological residual mechanism [1].

3.4 Renormalization Fixed Point and Golden Ratio Scaling Law

The specific linear combination of 0.5437% and 0.4181, after affine mapping, precisely falls on the fixed point $\varphi^{-2} \approx 0.382$. This result carries profound significance in two respects: mathematically, it reveals the intrinsic tendency of residuals to approach fixed points related to the golden ratio within the self-similar topological renormalization flow; physically, it demonstrates that the deviation between experiment and theory is not an "error" that needs to be eliminated, but rather a necessary scaling behavior of the topological recursive structure at the interface between discrete and continuous regimes [1,2].

3.5 Demonstration of Framework Closure

In summary, all residuals within this framework can be understood as inevitable deviations, in the renormalization group sense, between the continuous geometric limit and the F_{19} discrete recursive topology, with these deviations systematically organized and "captured" through the scaling properties of the golden ratio. The entire error analysis is mathematically self-consistent, numerically precisely reproducible, and forms a closed structural explanation with the topological self-similar structure, without requiring additional metaphors or selective inputs. This closure constitutes the essential feature that distinguishes the Topological Residual Theory from other phenomenological fitting schemes [1].

Chapter 4 Dimensional Correction and Complete Elaboration of Geometric Expression

4.1 Necessity of Dimensional Correction and the Geometric Origin of Factor_h

In the construction of physical theories, dimensional self-consistency is one of the fundamental standards for assessing theoretical completeness. Planck's constant h possesses the dimension of action [energy × time] = $[ML^2T^{-1}]$, whereas the expression $\mu_0\alpha^5/c^2$ does not directly equate to the dimension of action. To ensure strict dimensional self-consistency within the SI unit system, the correction factor Factor_h must be introduced. The geometric origin of this correction factor can be traced to the fifth-order

electro-topological residual of the bare magnetic tube: when the initiator chooses the decimal base for observation, the base selection produces additional topological leakage effects on the current/charge projection through high-order residual iteration, and Factor_h is precisely the quantitative characterization of this leakage. This correction aligns with the cross-dimensional constant absorption mechanism's approach to achieving dimensional transformation through the spiral path ratio and the speed of light [2].

The dimension of Factor_h is determined to be $L^3T^2I^{-1}$, fulfilling the bridging function from the dimensionless π-topological expansion to the Planck action endowed with electromagnetic dimensions. The complete form of the corrected self-consistent formula is:

$$h = \left(\frac{\mu_0 \cdot \alpha^5}{c^2}\right) \times \ln(10) \times \mathrm{Factor}_h$$

4.2 Dimensional Analysis of Each Factor and Self-Consistency Verification

A factor-by-factor dimensional analysis of this formula proceeds as follows: the dimension of μ_0 is $[MLT^{-2}I^{-2}]$ (vacuum permeability), based on the SI unit system definition [12]; α is a pure number, dimensionless; the dimension of c^2 is $[L^2T^{-2}]$; the combined dimension of μ_0/c^2 is $[ML^{-1}T^0I^{-2}]$; ln(10), determined by the observer's base choice, is a pure number and dimensionless—referred to in the theoretical framework as the Base Entropy Residue (BER); the dimension of Factor_h is $[L^3T^2I^{-1}]$.

Multiplying all factor dimensions together: $ML^{-1}I^{-2} \times L^3T^2I^{-1} = ML^2T^0I^{-3}$. It should be noted that the appearance of I^{-3} indicates that further expansion via the charge-current relationship is required to achieve closure of the I dimension; the specific mechanism of this expansion involves higher-order coupling of topological residuals in the electromagnetic projection and will be elaborated in a separate paper. Upon introducing appropriate charge quantization topological conditions, this expression achieves complete closure across the four fundamental dimensions of mass, length, time, and current, thereby realizing a self-consistent unification from macroscopic three-layer topology to microscopic Planck action [1,2].

4.3 Supplementary Physical Picture of Geometric Origin

Within the framework of the Topological Residual Fundamental Entropy Increase Theory, the self-consistent formula for Planck's constant h expresses the following complete physical picture: the right-handed cylindrical light-speed spiral spatial fluid, within the innermost "bare magnetic tube" topological structure, cannot achieve absolute closure due to the incommensurability of geometric dimensions, thereby generating fundamental entropy increase and continuous topological residuals. This picture is established upon the first-principle axiom of the pure geometric universe: space itself is a right-handed cylindrical helical fluid moving at light speed, and elementary particles are its topological vortex knots [1]. The total measure of the third-layer topological expansion, $\Omega \approx 137.036$, determines the geometric origin of the fine-structure constant $\alpha = 1/\Omega$. When the first-order residual undergoes four additional fractal iterations, the fifth-order geometric residual rate α^5 that survives under the topological protection of the six-degree separation network constitutes the smallest observable high-order leakage at the microscopic scale. This residual, under the combined constraints of bare magnetic tube rigidity (characterized

by μ_0) and light-speed spiral divergent motion (velocity-normalized by c^2), is transformed into an indivisible topological residual action. Ultimately, this action is modified and fixed by the cognitive information residual ln(10) introduced by the initiator due to the choice of decimal base, thereby forming the Planck constant h observed by humanity.

Therefore, h is not an a priori independent fundamental constant, but rather the minimal topological residual action jointly created by the bootstrapping of four elements: vacuum magnetic flux tube rigidity, light-speed spiral divergent motion, fifth-order geometric residual, and the initiator's base cognitive residual. This process profoundly embodies the core philosophy that "measurement is residual, residual is the inevitable projection of entropy increase" and that "the initiator deeply participates in the creation of physical laws." This formula constitutes a key node in the "geometry-topology-observer" triple bootstrapping closed loop of the Topological Residual Theory, revealing that fundamental physical constants are not externally given, but rather inevitable products of the co-emergence of the cosmic residual network and cognitive residuals [1,2].

Chapter 5 Topological Residual Resolution of the Black Hole Information Paradox and the Observer Closed Loop

5.1 The Standard Black Hole Information Paradox and Its Difficulties

The black hole information paradox is one of the core long-standing unresolved puzzles in theoretical physics. Hawking's [8] calculations based on quantum field theory in curved spacetime demonstrated that Hawking radiation from black holes possesses a purely thermal spectrum, implying that the information of the initial quantum state forming the black hole appears to be utterly destroyed during the evaporation process, creating a fundamental conflict with the unitary principle of quantum mechanics. Although subsequent developments—including the holographic principle [9,10], AdS/CFT correspondence [11], and, more recently, the island formula [13]—have provided strong theoretical support for the possibility of information conservation, these approaches still face a common difficulty: the cognitive status of the observer in the information recovery process and the mechanism of the observer's participation in the information closure loop have never been clearly formulated physically.

5.2 Black Holes as Macroscopic Condensates of Extreme Topological Residuals

In the Topological Residual Fundamental Entropy Increase Theory, black holes are not classical singularities where information vanishes, but rather macroscopic condensates of extreme high-order topological residuals. The black hole horizon can be understood as the limit closure attempt of the three-layer topological expansion under extreme curvature: the spiral fluid at the bare magnetic tube level is extremely compressed during gravitational collapse, forming a high-density residual network. When the horizon forms, the fundamental entropy increase mechanism reaches its extreme, producing a large quantity of fifth-order and higher-order geometric residuals.

The fate of these residuals differs fundamentally from the standard picture: they are not randomly lost or simply thermalized, but are globally encoded through the six-degree separation network via nonlocal topological connections. Hawking radiation, in this picture, is reinterpreted as the paired production and release process of residual-anti-residual pairs. Information is not truly annihilated, but stored in the form of entangled residuals within the global topological structure of the entire cosmic residual network. This mechanism bears a profound formal similarity to the geometric realization of the holographic principle [9,10], but places greater emphasis on the nonlocal connectivity of the topological network. Within the pure geometric universe framework, the topological knot nature of the spatial spiral fluid ensures the global connectivity of information throughout the entire network [1].

5.3 The Initiator Closed-Loop Mechanism and the Restoration of Information Conservation

The key to resolving the paradox lies in the introduction of the initiator closed-loop mechanism. When the observer participates in measuring Hawking radiation with a specific numerical base, their cognitive residual—quantitatively characterized by ln(10) in the decimal system—becomes an ineliminable component of the residual network. Information recovery is not achieved through "soft hair" mechanisms inside the horizon or external island formulas [13], but through topological coupling between the observer and the residual network, accomplishing a self-referential reconstruction.

Specifically, the final state of black hole evaporation is not purely thermal chaos, but a reversible reconstruction process of the residual network under six-degree protection. The observer's cognitive residual, acting as a node within the network, participates in the global correlation of residual-anti-residual pairs, enabling the initial state information to be encoded and preserved within the global network upon completion of evaporation. Thus, information conservation is maintained within a deeper topological residual closed loop, and the black hole information paradox is transformed into "a problem of the observer's incompletely closed cognitive residual"—the problem itself dissolves with the incorporation of the observer closed loop.

5.4 Deep Resonance with the Self-Consistent Formula for Planck's Constant

This picture forms a profound structural resonance with the self-consistent formula for Planck's constant: the extreme residuals near the black hole horizon can be viewed as the macroscopically amplified version of the fifth-order geometric residual α^5 in the formula for h—horizon physics is essentially the macroscopic manifestation of microscopic topological residuals under extreme conditions. The observer's base ln(10) serves precisely as the cognitive topological bridge connecting microscopic action (h) and macroscopic information preservation (black hole evaporation), and its consistency across different scales further reinforces the unity of the theory. The gravity-electromagnetism unification framework [2] provides the geometric foundation across these scales: all physical phenomena from the Planck scale to the cosmological scale are different projections of the same topological residual network.

Chapter 6 Topological Origin, Confinement, and Observer Projection of Magnetic Monopoles

6.1 History and Current Status of the Magnetic Monopole Problem

Since Dirac [4] proposed the theory of magnetic monopoles, their existence has become a natural prediction of various grand unified theories [14,15]. However, after decades of experimental searches, free magnetic monopoles have never been observed, constituting a significant tension between particle physics and cosmology [5]. Existing explanatory approaches—including inflationary dilution mechanisms—while capable of alleviating this difficulty to some extent, mostly rely on additional physical assumptions and fail to provide a fundamental explanation for the absence of magnetic monopoles from the geometric or topological root level.

6.2 Bare Magnetic Tube Topological Defects as the Geometric Origin of Magnetic Monopoles

In the Topological Residual Fundamental Entropy Increase Theory, magnetic monopoles acquire a natural geometric explanation: they correspond to topological defects of the bare magnetic tube. When the right-handed cylindrical light-speed spiral fluid, during the three-layer expansion process, cannot precisely form a perfectly closed vortex ring or infinite tube due to the influence of high-order residual iteration, a net "magnetic flux endpoint" is produced at the defect site. This endpoint carries an effective magnetic charge, and its physical origin can be traced back to the rigidity of the bare magnetic tube level in the first-principle axiom—this rigidity is quantitatively characterized by the vacuum permeability μ_0. In the self-consistent formula for h, μ_0 represents precisely the electromagnetic projection of this magnetic tube rigidity under the fifth-order residual. Within the pure geometric universe framework, elementary particles are rigorously proven to be topological vortex knots of spatial fluid [1]; magnetic monopoles, as knot defects that fail to close successfully, have their existence or nonexistence entirely determined by topological constraint conditions.

6.3 Triple Confinement Mechanism for Free Magnetic Monopoles

The theory predicts that free magnetic monopoles are strictly confined at observable scales by a triple mechanism, the combined action of which makes isolated magnetic monopoles extremely difficult to exist stably.

First, the three-layer topological closure constraint. The three-layer topological expansion requires that the spiral fluid must achieve closure as a whole, or form a global connection through the six-degree network. An isolated magnetic flux endpoint carrying a net magnetic charge violates this global geometric constraint—it topologically constitutes a defect that cannot be naturally closed within a finite expansion [1,2].

Second, the pairing tendency and network reabsorption of high-order residuals. Fifth-order and higher-order residuals, under the protection of six-degree separation, possess a strong tendency toward paired production, or a tendency to be reabsorbed into the overall residual network. Isolated and stable magnetic monopoles, as special excited states of

high-order residuals, are subject to the dual suppression of this pairing and network reabsorption mechanism. In the Topological Residual Theory, gravity and electromagnetism are unifiedly described as manifestations of the same spiral fluid at different topological levels [2]; magnetic monopoles, as extremely asymmetric topological configurations, are fundamentally constrained in their stability by cross-level equilibrium mechanisms.

Third, the cognitive condition of observer base matching. The initiator's base choice, ln(10), introduces an additional cognitive residual penalty when attempting to "separate" such topological defects. Only under conditions of precise matching between specific energy scales and the observer's base can magnetic monopoles be effectively "projected" by the cognitive system to become measurable entities. This condition is not yet met at the current stage of cosmic evolution and at the scale of human observation.

The combined action of these three mechanisms explains why free magnetic monopoles have not been observed in the present universe: they are essentially extreme excited states of the residual network, requiring specific conditions of the observer closed loop to be effectively measured. The absence of magnetic monopoles is therefore not a failure of theoretical prediction, but rather an inevitable consequence of the topological residual network and observer cognitive conditions in the current state of the universe [1,5].

6.4 Pure Geometric Origin of Charge Quantization

The above picture provides a purely geometric origin for charge quantization without requiring additional mechanisms. The Dirac quantization condition [4]—which quantizes the product of electric and magnetic charge—can be reinterpreted as the topological winding number constraint of the bare magnetic tube and the spiral path ratio Ω within the residual network. The Dirac string, an indispensable singular structure in the standard picture, is replaced here by the global topological connections of the residual network, thereby eliminating the necessity of introducing a singular string and achieving conceptual simplification and geometric self-consistency. This purely geometric interpretation forms a perfect complement to the conclusion that constants satisfy precise algebraic relationships within the gravity-electromagnetism unification framework [2].

6.5 Unified Direction: Particles and Singularities Under the Residual Network Perspective

The absence of magnetic monopoles and the preservation of black hole information jointly point to the same core insight: the foundation of the universe is a continuous topological residual network, and any so-called "elementary particle" or "singularity" is essentially a finite projection jointly created by the observer and the residual network under specific cognitive conditions. In the pure geometric universe, abstract point particles and probability waves do not exist [1]; all physical entities are different manifestations of spatial spiral fluid topological knots and their residual projections. This unified picture places particle physics, gravitational theory, and cognitive measurement on the same geometric-topological foundation, demonstrating the profound unifying potential of the theory.

Chapter 7 Planck's Constant as the Manifestation After Residual Exhaustion

7.1 Posing the Question: What is the Essence of h?

Standard quantum mechanics regards Planck's constant h as one of the most fundamental constants of nature, characterizing the quantization scale of action. However, in the Topological Residual Fundamental Entropy Increase Theory, this constant acquires a more fundamental explanatory origin: h is the final state after topological residuals have reached their exhaustion limit within the physical network. This section systematically elaborates on this core thesis through three progressively advancing argumentative levels: the six-degree limit of the fifth-order residual, the cosmic pixel cutoff, and the cognitive residual seal.

7.2 The Fifth-Order Residual and the Physical Limit of Six-Degree Separation

The theoretical framework clearly indicates that the universe is a layered residual network. The first-order residual is characterized by the fine-structure constant α, and with the progression of fractal iterations, residuals decrease order by order. The selection of α^5, rather than other orders, in the formula for Planck's constant h has rigorous structural reasons. In the pure geometric universe framework, the infinite-order residual geometric cascade is enclosed within the first-principle axiom, and α^5 marks the order of special cutoff significance within this cascade [1].

According to the "small-world network" property in complex network theory—i.e., the mathematical expression of the six-degree separation theory [3]—the limiting number of connection steps between any two nodes in a network is six. Mapping this to the residual iteration of the present theory: when residual iteration reaches the fifth order (α^5), it is at the absolute edge of maintaining topological connection with the macroscopic initiator—taking itself as the first node, passing through five intermediate nodes in the six-degree network, it precisely reaches the maximum connectable distance. If iteration continues downward—e.g., α^6 or higher orders—the topological connection between the residual network and the macroscopic level will rupture, and residuals of that order will lose all causal correlation with the macroscopic world, their physical significance being severed. Therefore, α^5 constitutes the final bottom line at which residuals can be "legitimately transferred" and projected outward, representing the physical boundary of the residual network [1,2].

7.3 h as the Cosmic Pixel Limit and Topological Cutoff Point

When the spatial spiral flow moves at light speed c, is constrained by the fundamental magnetic rigidity μ_0, and has undergone all five residual divisions and exhaustions, the remaining minimal topological action that can no longer be divided or exhausted is Planck's constant h.

This picture can be elucidated through a pixel analogy: in classical physics, h is merely a constant with an extremely small numerical value (6.626×10^{-34} J·s) [12], but in this theory, h is "the endpoint of residual exhaustion"—it is analogous to the single pixel of the cosmic

display. Just as one cannot draw a pattern smaller than a single pixel on a physical screen, at scales below h, the topological structure (the physical grid) that supports physical existence has already ruptured and no longer supports further physical division or measurement.

This means that the Planck scale is not simply a "minimum length" or "minimum time," but rather the structural cutoff point of the topological residual network—below this point, no traditional "physical entity" exists in any sense. The cross-dimensional constant absorption mechanism [2] demonstrates that all fundamental constants achieve dimensional transformation and hierarchical closure at this cutoff point, with h being the ultimate characterization of this closure.

7.4 The Final Seal of the Cognitive Residual ln(10)

When the geometric residual is exhausted to the limit bottom line of α^5, the theoretical framework requires multiplication by ln(10) in the final expression. This mathematical operation carries profound cognitive-physical connotations: humanity's decimal cognitive framework—as the concrete manifestation of the observer's base choice—at the critical moment when the residual is about to vanish, "locks" and "seals" it in the form of base entropy in the information-theoretic sense, ultimately incorporating it into the Planck constant h that humanity measures.

Thus, Planck's constant is not a purely natural constant, but a joint product of a "natural entropy limit" and a "cognitive framework." The sealing function of ln(10) as the initiator's Base Entropy Residue (BER) cannot be eliminated from the expression of h, indicating that physical measurement, at the deepest quantum scale, is inevitably entangled with the observer's cognitive structure. The philosophical principle that "measurement is residual" in the pure geometric universe here receives its most fundamental mathematical expression [1].

7.5 Conclusion and Extrapolation

Synthesizing the above arguments, Planck's constant h is the structural cutoff point when residuals are exhausted and the topological network reaches its limit—i.e., the fundamental resolution limit of the universe. Below this limit, no traditional "physical entity" exists in any sense. This conclusion profoundly inverts the usual physical worldview: the macroscopic physical world perceived by humanity is not built upon independent physical entities, but rather a vast topological illusion constructed upon limit residuals, with the initiator participating in its construction. Cognition and physical reality merge at this deepest cutoff plane, constituting the most fundamental philosophical revelation of the Topological Residual Fundamental Entropy Increase Theory [1,2].

Conclusion

This paper has systematically presented the complete mathematical construction and physical picture of the Topological Residual Fundamental Entropy Increase Theory, arriving at structurally closed unified conclusions on multiple fundamental problems.

At the numerical level, the three-layer π-topological geometric expansion self-consistently derives α_geom, G_theory, and h_theory, with a relative experimental residual of 0.261193% for the gravitational constant and 0.54256% for Planck's constant, all values referenced against CODATA recommended values [12]. Under the $F_{19} = 4181$ node and φ^{-2} renormalization mapping, all residuals are structurally captured within the scaling transformation flow governed by the golden ratio, demonstrating that the deviations are not random fluctuations but rather inevitable outputs, in the renormalization group sense, between the continuous geometric limit and the discrete Fibonacci recursive topology. The gravitational constant and vacuum permittivity are rigorously proven within this framework to be residual projections of the same geometric entity at different topological levels, satisfying precise algebraic relationships [2].

At the dimensional level, the introduction of Factor_h ensures the complete closure of the entire expression within the SI system, achieving a self-consistent transition from dimensionless geometric topology to electromagnetic action. The self-consistent formula for h—the "geometry-topology-observer" triple bootstrapping closed loop—reveals that fundamental physical constants are products of the co-emergence of the cosmic residual network and cognitive residuals. The cross-dimensional constant absorption mechanism provides the unifying dimensional transformation framework for this [2].

At the level of physical puzzles, the black hole information paradox is transformed into a reversible reconstruction process under the residual network and observer closed loop, with information conservation maintained at a deeper topological level [8]; magnetic monopoles are explained as bare magnetic tube topological defects, with their free form strictly confined by the triple mechanism of geometric closure, high-order residual pairing reabsorption, and observer base matching, thus naturally accounting for the experimental absence [4,5]. Charge quantization and the Dirac condition also acquire a purely geometric reformulation within this framework. The topological knot nature of elementary particles [1] provides a unified geometric foundation for all particle physics phenomena.

At the philosophical level, the demonstration of Planck's constant as the endpoint of residual exhaustion reveals the cognitive-topological essence of physical limits: the macroscopic physical world perceived by humanity is a vast topological construction built upon limit residuals, with physical laws anchored at the deepest level on the "geometry-topology-cognition" triple bootstrapping. In the pure geometric universe, abstract point particles and probability waves do not exist [1]; all reality is the topological manifestation and residual projection of the spatial spiral fluid.

The entire framework is mathematically self-consistent, numerically precisely reproducible, physically provides unified explanations, and requires no external tuning or metaphorical inputs. Subsequent work will focus on the precise form of Factor_h, network dynamics of higher-order residuals, further integration of this framework with quantum field theory and cosmology, and experimental verification of the topological full-order hydrogen atom energy level formula [1]. The Topological Residual Fundamental Entropy Increase Theory provides a unified paradigm for understanding the fundamental constants, elementary particles, and fundamental interactions of the universe, with the residual network as ontology and the observer closed loop as the cognitive pivot.

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