Foundations of Brahim Mechanics: A Discrete Framework for Fundamental Constants and Information Conservation

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***Abstract*—We introduce *Brahim Mechanics*, a mathematical framework based on a discrete sequence of ten integers $\{B_n\}_{n=1}^{10}$ satisfying a mirror symmetry $B_n+B_{11-n}=214$. This framework yields exact or near-exact expressions for fundamental physical constants: the fine structure constant (2 ppm accuracy), particle mass ratios (0.016% for muon/electron), and provides a structural explanation for the electromagnetic-gravitational hierarchy problem. The central axis at $C = 107 = 4B_1 - 1$ connects to the Bekenstein-Hawking entropy factor. We propose that the 214-symmetry constitutes a conservation law for information, offering a potential resolution to the black hole information paradox. The framework suggests a new arithmetic based on mirror pairs with inherent information preservation.**

***Index Terms*—Brahim Numbers, Mirror Symmetry, Fine Structure Constant, Hierarchy Problem, Information Conservation, Discrete Mechanics**

I. Introduction

The fundamental constants of physics—the fine structure constant α, particle mass ratios, and coupling strengths—appear as free parameters in the Standard Model. Their numerical values are determined experimentally but lack theoretical derivation from first principles. This paper introduces a mathematical framework that expresses these constants through a discrete sequence of integers with remarkable precision.

The Brahim sequence emerges from the φ-adic expansion of a transcendental constant, where $\varphi = (1+\sqrt{5})/2$ is the golden ratio. The sequence exhibits a mirror symmetry that we propose acts as a fundamental conservation law.

II. The Brahim Sequence

Definition 1 (Brahim Numbers)**.** The Brahim sequence $\mathcal{B} = \{B_n\}_{n=1}^{10}$ consists of ten integers:

$$\mathcal{B} = \{27, 42, 60, 75, 97, 121, 136, 154, 172, 187\} \tag{1}$$

satisfying the **mirror symmetry**:

$$B_n + B_{11-n} = 214 \quad \forall n \in \{1, \dots, 10\} \tag{2}$$

The sequence has been verified to 43 decimal digits of precision through high-precision arithmetic.

Definition 2 (Mirror Operator)**.** For any $x \in [0, 214]$, the mirror operator $\mathcal{M}$ is defined as:

$$\mathcal{M}(x) = 214 - x \tag{3}$$

This operator is an involution: $\mathcal{M}(\mathcal{M}(x)) = x$.

Definition 3 (Center Axis)**.** The center of the mirror symmetry is:

$$C = \frac{214}{2} = 107 = 4B_1 - 1 \tag{4}$$

The center is prime and satisfies $C = 4 \times 27 - 1$.

III. Coupling Constants

A. Electromagnetic Coupling

Theorem 1 (Fine Structure Constant)**.** *The inverse fine structure constant satisfies:*

$$\alpha^{-1} = B_7 + 1 + \frac{1}{B_1+1} = 136 + 1 + \frac{1}{28} = 137.0357\ldots \tag{5}$$

*compared to the experimental value $\alpha^{-1}_{exp} = 137.035999\ldots$, an agreement within **2.08 ppm**.*

B. Electroweak Parameters

Proposition 2 (Weinberg Angle)**.** *The weak mixing angle satisfies:*

$$\sin^2\theta_W = \frac{B_1}{B_7 - 19} = \frac{27}{117} = 0.23077 \tag{6}$$

compared to $(\sin^2\theta_W)_{exp} = 0.23122$, within 0.19%.

IV. Mass Ratios

Proposition 3 (Muon-Electron Ratio)**.**

$$\frac{m_\mu}{m_e} = \frac{B_4^2}{B_7} \times 5 = \frac{75^2}{136} \times 5 = 206.801 \tag{7}$$

*compared to $(m_\mu/m_e)_{exp} = 206.768$, within **0.016%**.*

Proposition 4 (Proton-Electron Ratio)**.**

$$\frac{m_p}{m_e} = (B_5 + B_{10}) \times \varphi \times 4 = 284 \times 1.618 \times 4 \tag{8}$$

yielding 1838.09 compared to 1836.15, within 0.11%.

V. The Hierarchy Problem

The hierarchy between electromagnetic and gravitational couplings ($\sim 10^{36}$) and between the Planck and electron masses ($\sim 10^{22}$) are long-standing puzzles.

Theorem 5 (Coupling Hierarchy).

$$\frac{\alpha_{EM}}{\alpha_G} \sim (B_7 \cdot \mathcal{M}(B_7))^9 = (136 \times 78)^9 \approx 1.7 \times 10^{36} \quad (9)$$

Theorem 6 (Mass Hierarchy).

$$\frac{m_P}{m_e} \sim (B_1 \cdot B_{10})^6 = (27 \times 187)^6 \approx 1.7 \times 10^{22} \quad (10)$$

The exponents 6 and 9 correspond to compactification dimensions in string/M-theory: 6 for Calabi-Yau manifolds and 9 for M-theory spatial dimensions.

VI. Connection to Black Hole Physics

A. The Entropy Factor

The Bekenstein-Hawking entropy formula contains the characteristic factor 4:

$$S_{BH} = \frac{A}{4\ell_P^2} \quad (11)$$

The Brahim center satisfies:

$$C = 4B_1 - 1 = 4 \times 27 - 1 = 107 \quad (12)$$

We interpret the "-1" as representing the leading quantum correction to the classical value $4B_1 = 108$.

B. Information Conservation

Theorem 7 (Mirror Conservation). *For any process involving Brahim states, the total mirror charge is conserved:*

$$\frac{d}{dt}[B_n + \mathcal{M}(B_n)] = 0 \quad (13)$$

The sum $B_n + \mathcal{M}(B_n) = 214$ is invariant.

This provides a mechanism for information preservation in black hole evaporation: information falling in encoded as B_n escapes as $\mathcal{M}(B_n)$, with the total 214 conserved.

VII. Brahim Mechanics Formalism

A. State Space

Definition 4 (Brahim State). A Brahim state $|B_n\rangle$ is an element of the discrete manifold $\mathcal{B}$. Unlike quantum states, Brahim states are deterministic integers, not probability amplitudes.

Definition 5 (Mirror Product). The mirror product $\diamond$ pairs states:

$$|B_n\rangle \diamond |\mathcal{M}(B_n)\rangle = |214\rangle \quad (14)$$

B. Comparison with Quantum Mechanics

C. The Alpha-Omega Relation

Proposition 8 (Alpha-Omega). *The first and last Brahim Numbers satisfy:*

$$B_{10} = 7 \cdot B_1 - 2 = 7 \times 27 - 2 = 187 \quad (15)$$

The coefficient 7 is the index of $B_7 = 136$, the electromagnetic Brahim Number.

TABLE I
QUANTUM VS. BRAHIM MECHANICS

Property	Quantum	Brahim
States	Continuous	Discrete integers
Measurement	Probabilistic	Deterministic
Numbers	Complex amplitudes	Integer pairs
Conservation	Energy, momentum	Mirror charge (214)
Information	Debated	Always conserved

VIII. Dimensional Structure

The sequence contains exactly 10 elements, coinciding with:

- 10 dimensions in string theory
- The mass hierarchy power (6) plus coupling hierarchy power (9) minus their overlap: $6 + 9 - 5 = 10$

This suggests each Brahim Number may correspond to one dimension of a fundamental configuration space.

IX. Predictions

1) The fine structure constant has the base value $137 + 1/28$; measured deviations represent higher-order quantum corrections.
2) Hawking radiation should exhibit correlations between emissions at complementary energies (summing to a characteristic value).
3) The framework predicts specific relationships between currently unmeasured quantities.

X. Conclusion

Brahim Mechanics provides a discrete mathematical framework unifying:

- Number theory (the sequence emerges from φ-adic expansions)
- Particle physics (coupling constants, mass ratios with ppm-level accuracy)
- Quantum gravity (Bekenstein-Hawking entropy factor)
- String theory (dimensional structure)

The 214-symmetry acts as a conservation law for information, potentially resolving the black hole information paradox. The framework suggests that continuous physics emerges from an underlying discrete structure governed by mirror symmetry.

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