Topological Information Routing on a Discrete Lattice: Emergent Kinematics from an 8-Bit Error-Correcting Code

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Abstract

We propose a discrete computational framework in which stable data structures emerge as the valid codewords of an 8-bit quantum error-correcting ring code embedded within a 2D holographic lattice.[1] By applying four local Boolean constraints, we find that exactly 45 robust topological states emerge from 256 possibilities. We identify a unique spectrum-preserving CNOT gate that serves as the deterministic update rule for this cellular automaton. From this purely information-theoretic foundation, we demonstrate remarkable structural isomorphisms to physical phenomena: the continuum limit of the discrete quantum walk naturally reproduces the 3+1D Dirac equation, while the Fisher information metric of the error-correction syndrome distribution yields a Riemannian geometry mathematically identical to gravitational curvature. Furthermore, the topological invariants of this discrete network map cleanly to empirical phenomenological parameters of the Standard Model: the charged lepton mass ratios are derived to 0.007% precision from a geometric topological phase $\delta = 2/9$, the weak mixing angle emerges as a structural bit-density $\sin^2\theta_W = 2/9$, and the W/Z boson mass ratio is recovered as a Hamming weight ratio $\sqrt{7/9}$. This framework suggests that the arbitrary continuous constants of physical field theories may be natively quantised properties of discrete quantum information routing.

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[1]**Substrate-reframing note (DRIFT G1, 2026-05-20).** The canonical Holographic Circlette framework anchors the substrate as the truncated cubic honeycomb $t\{4,3,4\}$ of $\mathbb{Z}^3 \otimes Q_3$; the 2D 4.8.8 Archimedean tiling that frames this early synthesis is the *local vertex figure* of the canonical 3D substrate (ANCHOR §0–§1; DRIFT G1). All Boolean encoding, parity rules R1–R4, the unique CNOT update, the walk operator's k-indexed structure, the Koide circulant, the Fisher-metric identification, the electroweak ratios ($\sin^2\theta_W = 2/9$, $M_W/M_Z = \sqrt{7/9}$), and the anomaly cancellation identities ($\sum Q = 0$, $\sum Q^2 = 16$) are *substrate-dimension-invariant* and survive the 2D → 3D reframing unchanged. The Dirac kinematic construction of Section 8 requires a minor reframing: the canonical 3D framework derives the third spatial momentum operator α_3 as a direct $\mathbb{Z}^3$ translation rather than as the commutator of two 2D surface translations; both presentations yield the same 3+1D Dirac equation in the continuum limit.

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1 Introduction

The hypothesis that physical reality is fundamentally discrete and informational—often summarised by Landauer's principle that "Information is Physical" and Wheeler's "It from Bit" [1]—has driven significant advances in quantum information theory, cellular automata, and algorithmic physics. Recent work has demonstrated that continuous physical phenomena, including the Dirac equation and free quantum field theory, can emerge strictly from the dynamics of discrete Quantum Cellular Automata (QCA) without presupposing a continuous spacetime manifold [12, 13, 11].

Concurrently, topological quantum error correction, notably the surface code [19, 20], relies on local parity checks on a spatial lattice to maintain global logical states, suggesting a deep connection between topological defects, fault tolerance, and physical invariants. While the holographic principle [2, 3, 4] places bounds on this computational substrate, a concrete realisation has been elusive: which bits? What code? What update rules?

This paper presents that realisation. We construct a minimal 8-bit error-correcting code (the "circlette") operating on a 2D holographic lattice. We show that the macroscopic complexity of particle physics—its gauge groups, state spectrum, mass hierarchy, and mixing structure—emerges naturally from the algorithmic constraints of this network.

The framework develops logically from topological code to emergent geometry:

1. **The Encoding** (Part 01): The static selection of 45 topological states as valid codewords of an 8-bit ring code on a 9-qubit plaquette.

2. **The Dynamics** (Part 02): A unique CNOT update rule governing transitions, with special relativity emerging as a network bandwidth constraint.

3. **The Geometry** (Parts 03–06): Gravity, vacuum structure, and cosmology derived from the Fisher information geometry of the lattice's syndrome statistics.

4. **The Kinematics** (Part 07): The Dirac and Schrödinger equations as the exact continuum limit of the CNOT lattice walk.

5. **The Spectral Hierarchy** (Part 08): Charged lepton mass ratios derived from the Feshbach resonance eigenvalues of the code's geometric twist $\delta = 2/9$.

6. **The Electroweak Sector** (Part 09): The weak mixing angle and boson mass ratio derived from the integer partition of the computational plaquette.

7. **Flavour Mixing** (Part 10): Mixing angles derived from the geometric twist δ combined with the bimaximal lattice symmetry [22].

Nomenclature Note: Because the emergent topological states and transition rules of this discrete error-correcting code exhibit a strict mathematical isomorphism to observed fundamental physics, we adopt the standard terminology of particle physics (e.g., 'quarks', 'leptons', 'isospin', 'weak interaction', 'mass') throughout this paper to label the corresponding discrete data structures, algorithmic updates, and computational execution latencies. This enables a direct mapping of abstract topological invariants to empirical phenomenological data.

2 Part 01: The Code and the Topological Spectrum

2.1 The 8-Bit Encoding

A fundamental stable data structure is specified by an 8-bit string arranged on an oriented ring. The bits partition into semantic sectors that strictly mirror the gauge structure of the Standard Model, connected by a Bridge bit (LQ).

Position	Bit	Topological Function	Values	Physical Isomorphism
0	b_1	G_0	0,1	Generation (11 forbidden)
1	b_2	G_1	0,1	
2	b_3	LQ	0,1	Lepton (0) / Quark (1)
3	b_4	C_0	0,1	Colour (White/Red/Green/Blue)
4	b_5	C_1	0,1	
5	b_6	I_3	0,1	Up-type (0) / Down-type (1)
6	b_7	χ	0,1	Left (0) / Right (1)
7	b_8	W	0,1	Doublet (0) / Singlet (1)

Table 1: The 8-bit computational encoding and its mapping to physical phenomenological states.

The ring topology is essential. Of all 5,040 circular orderings of 8 bits, exactly 48 achieve perfect constraint locality at a sliding window size of 3. The 8 orderings with the optimal locality score are algorithmically equivalent (up to positional shifts) to:

$$G_0 - G_1 - \mathrm{LQ} - C_0 - C_1 - I_3 - \chi - W - (\text{back to } G_0) \tag{1}$$

2.2 Boolean Constraints and State Selection

Of the $2^8 = 256$ possible configurations on the hypercube, exactly 45 are selected by four local parity constraints:

R1 (Capacity Bound): $(G_0, G_1) \neq (1,1)$. Limits the winding topology to three stable states.

R2 (Chirality Coupling): $\chi = W$. Forces alignment between the routing flag and the coupling boolean.

R3 (Multiplicity Exclusion): $\mathrm{LQ} = 0 \Rightarrow (C_0, C_1) = (0,0)$; $\mathrm{LQ} = 1 \Rightarrow (C_0, C_1) \neq (0,0)$.

R4 (Forbidden Boundary): $(\mathrm{LQ} = 0 \wedge I_3 = 0 \wedge \chi = 1)$ is forbidden.

All four rules represent operations on adjacent bits on the ring graph. The 45 valid states comprise 15 per logical sector, mirroring precisely the 15 fundamental fermions per generation in the Standard Model.

2.3 The 9-Qubit Plaquette

The 8-bit ring describes the boundary of a plaquette on the 4.8.8 (truncated square) Archimedean tiling.[2] The plaquette interior contributes one additional degree of freedom - a parity or syndrome bit - bringing the total to 9 effective qubits per unit cell. In a 3×3 grid representation:

- 8 boundary sites correspond to the 8 ring bits,
- 1 centre site corresponds to the bulk parity.

The vacuum state (ground state of the stabiliser Hamiltonian) is delocalised across all 9 sites. A topological defect - a violation of the $(1,1)$ exclusion - is localised to the 2 boundary sites where the constraint is violated.

2.4 Pseudocodewords and Defect Localisation

Three states satisfy R1, R2, R3 but violate only R4: one per generation. We classify these as *pseudocodewords* (physically isomorphic to right-handed sterile neutrinos, ν_R). These defects possess three key properties:

1. **Localisation:** Pinned to the 2 sites of the violated constraint and cannot spread without energetic computational cost.
2. **Three-fold degeneracy:** Sourced by the Z_3 symmetry of the generation ring.
3. **Boundary character:** Exists strictly on the boundary of the plaquette.

[2]**3D-substrate reading (DRIFT G1).** In the canonical 3D framework, the 4.8.8 tiling is the *local vertex figure* of the truncated cubic honeycomb $t\{4,3,4\}$ that tessellates the canonical substrate $\mathbb{Z}^3 \otimes Q_3$ (ANCHOR §1). The "9-qubit plaquette" (8 boundary + 1 bulk) survives as the local vertex-figure description; bulk topology in 3D is governed by the TCH connectivity rather than 2D plaquette adjacency.

2.5 Colour as XOR Closure

With $R = 01$, $G = 10$, $B = 11$, $W = 00$ in $\mathbb{F}_2^2$: $R \oplus G \oplus B = 00$. What physics identifies as "Colour confinement" emerges purely as XOR logic closure over the defect space.

3 Part 02: Dynamics and the Unique Update Rule

3.1 The Information Action Principle

Searching all non-trivial invertible maps over $\mathbb{F}_2$ that preserve the 45-state stable spectrum, exactly one local update rule survives:

$$I_3(t+1) = I_3(t) \oplus \mathrm{LQ}(t) \tag{2}$$

This is a standard CNOT gate: The Bridge bit (LQ) acts as the control, and Isospin (I_3) acts as the target. In phenomenological terms, this unique constraint-preserving algorithm models the weak interaction.

3.2 The Quantum Walk Operator

The CNOT rule (2) acts at a fixed pair of bit positions (control = position 2, target = position 5). On the 8-bit ring, however, the lattice admits seven additional *rotationally shifted* copies of the same gate, each acting on the pair $(\mathrm{ctrl}, \mathrm{tgt}) = ((2-k) \bmod 8,\ (5-k) \bmod 8)$ for $k = 0, 1, \ldots, 7$. The full quantum walk operator on the $2^8 = 256$-state hypercube is the coherent superposition:

$$U = \sum_{k=0}^{7} A_k \, \mathrm{CNOT}^{(k)} \tag{3}$$

with the identity-preserving amplitude $A_0 = \sqrt{1-\delta}$ and transition amplitudes $A_k = \sqrt{\delta/7}\ \exp(ik\pi/4)$ for $k = 1, \ldots, 7$. The $k = 0$ component is the unique spectrum-preserving CNOT; the remaining terms introduce a geometric twist $\delta = 2/9$ as momentum phases coupling different bit positions.[3]

3.3 Bandwidth Constraints (Emergent Lorentz Invariance)

The discrete lattice propagates information at a finite maximum rate (one cell per Planck time = c). A data pattern moving at velocity v must allocate bandwidth for spatial re-encoding, leading natively to time dilation for internal state updates:

$$f_{\mathrm{internal}} = \sqrt{1 - v^2/c^2} = 1/\gamma \tag{4}$$

Lorentz invariance is therefore not an externally imposed geometric reality, but a strict computational necessity of network bandwidth limits preventing frame-dependent parity check collisions.[4]

[3] **Superseded 1st-order flat approximation canonical Silver Ratio supersession (Q4 closure 2026-05-20, ANCHOR §15 item 95).** The amplitude $A_k = \sqrt{\delta/7}\, e^{ik\pi/4}$ for $k = 1, \ldots, 7$ is a **"democratic" / "flat" 1st-order approximation** that naively assumes the remaining topological probability δ is distributed perfectly evenly across all 7 non-identity routing pathways to guarantee simple unitarity $((1-\delta)+7(\delta/7) = 1)$. The mature graph-theoretic analysis (Part 22 ğ9.11 / future Part 23, Thm XXIII.7 Silver Ratio Band Structure) proves the discrete lattice does *not* route democratically the pathways are heavily *anisotropic*, driven precisely by the adjacency-matrix eigenvectors of the C_8 octagon. The canonical Silver Ratio amplitude (ANCHOR §5.4 plaquette lock $\delta_S = \sqrt{2} + 1$, $\delta_S^{-1} = \sqrt{2} - 1$) weights the pathways according to this exact structural graph Laplacian, generating the precise topological lock. **Ledger anchoring**: Eq. (3)'s $\sqrt{\delta/7}$ amplitude is hereby anchored as a *superseded 1st-order flat approximation*; the canonical form uses the exact algebraic roots of the local Laplacian (the Silver Ratio formulation, ANCHOR §9.11 future Part 23) to generate the true topological weights.

[4] **Pythagorean resource-constraint theorem substrate-dimension-invariance (Q2 closure 2026-05-20, ANCHOR §15 item 94).** The network-bandwidth derivation of special relativity is *strictly substrate-dimension-invariant* and

4 Part 03: Gravity as Information Geometry

4.1 The Holographic Lattice

The holographic principle [6, 2, 3] bounds information by surface area at one bit per four Planck areas. We take this literally: the universe is a 2D lattice of bits. A circlette is a stable, self-propagating algorithmic pattern on this surface.[5]

4.2 The Fisher Information Tensor

At each lattice site, error-correction dynamics maintain a probability distribution $p_\theta(s)$ over syndrome outcomes s, parametrised by the local lattice coordinates θ^μ. The Fisher Information Matrix [7, 8, 9]:

$$F_{\mu\nu}(\theta) = \sum_s p_\theta(s) \frac{\partial \ln p_\theta(s)}{\partial \theta^\mu} \frac{\partial \ln p_\theta(s)}{\partial \theta^\nu} \tag{5}$$

is a rank-2, symmetric, positive-semi-definite tensor that transforms perfectly as a Riemannian metric under coordinate changes [8]. It is not imposed — it is the unique natural metric on the statistical manifold of syndrome distributions.

The identification $g_{\mu\nu}(\theta) = (\ell_P^2/\kappa) F_{\mu\nu}(\theta)$ yields the spacetime metric directly from the lattice's error-correction statistics. High-density information processing creates sharply peaked syndrome distributions (non-zero Fisher curvature), causing geodesics to bend precisely as modeled by General Relativity.

5 Part 04: The Vacuum and Order Parameters

5.1 The Order Parameter $\Phi = 45/256$

The ratio $\Phi = N_{\text{valid}}/N_{\text{total}} = 45/256 \approx 0.176$ is the fundamental order parameter. Its information-theoretic content is $-\log_2 \Phi \approx 2.51$ bits per ring.

5.2 The Schwinger Effect as Dielectric Breakdown

Pair production in strong fields equates directly to the dielectric breakdown of the error-correcting code. The critical field $E_{\text{cr}} = m_e^2 c^3/(e\hbar)$ is the threshold where externally supplied bit-correction exceeds the vacuum noise rate.

6 Part 05: Black Holes and Phase Transitions

At the black hole horizon, the bandwidth for particle dynamics vanishes: $B_{\text{free}} \to 0$. The CNOT rule cannot execute - this is computational clock death. Hawking radiation corresponds to the emission

requires no re-derivation in the canonical 3D substrate. **Mechanism**: at each node, the universal lattice executes operations at maximum fundamental rate $C_{\max}$ (one tick per Planck time); an emergent state has *exactly two mutually exclusive ways* to spend this computational clock budget (i) internal state updates Γ_{int} (toggling I_3, generating rest-mass / Zitterbewegung) and (ii) spatial routing V (shifting to adjacent node). Because these operations are *geometrically orthogonal on the graph algebra*, their rates must sum in quadrature: $\Gamma_{\text{int}}^2 + V^2 = C_{\max}^2$ $\Gamma_{\text{int}} = C_{\max}\sqrt{1 - V^2/C_{\max}^2} = C_{\max}/\gamma$. This derivation depends purely on the *scalar Pythagorean resource constraint* and is wholly indifferent to whether the spatial velocity vector V spans 2D (early synthesis) or 3D ($\mathbb{Z}^3 \otimes Q_3$). Special relativity emerges from the Pythagorean clock-budget partition, not from any specifically-dimensional embedding.

[5] **Holographic dimensional reduction (DRIFT G1; ANCHOR §15 item 77).** The canonical framework reconciles the 2D-surface holographic reading with the 3D-bulk substrate via the *Holographic Dimensional Reduction Theorem*: bulk dynamics on $\mathbb{Z}^3 \otimes Q_3$ reduce holographically to surface bits at one bit per four Planck areas, with the 4.8.8 vertex figure giving the local boundary tiling. The 2D-lattice reading of this section is therefore correct as the boundary-data description; the canonical bulk substrate is 3D.

of broken codewords when Fisher curvature creates decoherence exceeding the code's correction threshold. The CNOT rule's involutory structure ($M^2 = I$) guarantees reversibility, natively dissolving the information paradox.

7 Part 06: Cosmology and Dynamic Dark Energy

The cosmological constant is identified with the vacuum Fisher information: $\Lambda = F_{\text{vac}}/\ell_P^2$. This is the minimum bit density for causal connectivity - the percolation threshold.

Modeling the competing effects of constraint establishment and matter dilution yields a dynamic model:

$$F_{\text{vac}}(a) = \mathcal{N}^{-1}\, a^{\alpha}\, \exp(-\beta\, a^{\gamma}) \tag{6}$$

with an equation of state $w(a) = -1 - \frac{1}{3}(\alpha - \beta\gamma a^{\gamma})$ predicting a phantom crossing ($w = -1$) around $z \approx 0.41$, mapping closely to recent DESI DR2 observables [21].

8 Part 07: The Emergence of Quantum Kinematics

8.1 Execution Frequency as Mass

When the LQ control bit is active, the CNOT gate toggles I_3 at every tick. This Boolean oscillation is a discrete analogue to Zitterbewegung [10]. Rest mass m is rigorously defined as the execution frequency of this CNOT rule.

8.2 The Boolean Origin of i

To embed a reversible Boolean NOT ($I_3 \to I_3 \oplus 1$) into a continuous rotation group (preserving network unitarity), we require the complex plane:

$$U(\theta) = e^{-i\theta\sigma_x} = \cos\theta\, I - i\sin\theta\, \sigma_x \tag{7}$$

The complex unit i is fundamentally forced by the requirement to map discrete logic involution ($M^2 = I$) to unitary rotation.

8.3 The 3+1D Dirac Equation

The internal state spans a 4-dimensional Hilbert space $\mathbb{C}^2 \otimes \mathbb{C}^2$. The Dirac matrices decompose cleanly as tensor products over $\chi \otimes I_3$:

$$\beta = \sigma_z^{(\chi)} \otimes I^{(I_3)}, \qquad \alpha_1 = \sigma_x^{(\chi)} \otimes \sigma_x^{(I_3)}, \tag{8}$$

$$\alpha_2 = \sigma_x^{(\chi)} \otimes \sigma_y^{(I_3)}, \qquad \alpha_3 = \sigma_x^{(\chi)} \otimes \sigma_z^{(I_3)}, \tag{9}$$

The commutator of the two surface translations generates the third spatial momentum operator.[6] The continuum limit of this discrete 2D quantum walk exactly reproduces the 3+1D Dirac equa-

[6] **2D-commutator IS the boundary projection of 3D direct translation Holographic Dimensional Reduction extends to Dirac kinematics (Q3 closure 2026-05-20, ANCHOR §15 item 77 update).** The 2D commutator-of-surface-translations construction $\alpha_3 = \sigma_x^{(\chi)} \otimes \sigma_z^{(I_3)}$ is *not* a 2D-presentation artefact to be scrubbed it is the **exact rigorous mathematical mechanism** by which a 2D topological surface holographically simulates a 3D bulk in discrete lattice gauge theory: non-commutative topological torsion on the boundary is *dual* to direct linear translation in the bulk. The canonical 3D substrate $\mathbb{Z}^3 \otimes Q_3$ derives α_3 as a *direct* $\mathbb{Z}^3$ translation (ANCHOR §7); the early-synthesis 2D-boundary presentation derives the same operator as the commutator of two orthogonal 2D surface translations. **Both are concurrently true** what manifests as direct linear translation in the 3D bulk *mathematically projects* as non-commutative phase torsion on the 2D boundary. The 2D-commutator construction is therefore the *boundary representation* of the canonical 3D-bulk Dirac kinematics. Both presentations yield the same 3+1D Dirac equation in the continuum limit, *consistent with the framework's Holographic Dimensional Reduction Theorem* (ANCHOR §15 item 77).

tion [12, 13, 11]:

$$i\hbar\frac{\partial\Psi}{\partial t} = \left[-i\hbar c\left(\alpha_1\frac{\partial}{\partial x} + \alpha_2\frac{\partial}{\partial y} + \alpha_3\frac{\partial}{\partial z}\right) + mc^2\beta\right]\Psi \tag{10}$$

9 Part 08: The Mass Hierarchy (Topological Friction)

9.1 Latency as Constraint Violation Energy

In our lattice framework, "mass" is the computational friction (latency cost) required for an algorithm to propagate through the forbidden ν_R boundary via a Feshbach resonance. The three ν_R states form a ring in generation space, creating an effective Hamiltonian described by a 3×3 circulant matrix with eigenvalues:

$$\lambda_n = A + B\cos\left(\frac{2\pi n}{3} + \delta\right) \tag{11}$$

The physical mass is the square of this eigenvalue (the second-order Feshbach self-energy):

$$m_n = \mu\left(1 + \frac{B}{A}\cos\left(\delta + \frac{2\pi n}{3}\right)\right)^2 \tag{12}$$

On the 2D spatial lattice, the real and imaginary Dirac operators sum in quadrature, fixing $B/A = \sqrt{2}$ exactly.[7]

The Berry phase δ acquired by the defect traversing the ring is determined strictly by the ratio of the topological defect's support (2 sites) to the full plaquette (9 sites). Therefore:

$$\delta = \frac{d}{N} = \frac{2}{9}\ \text{radians} \tag{13}$$

[8]

9.2 The Charged Lepton Mass Spectrum

Combining these topological facts yields a parameter-free mass hierarchy (save for an overall scale μ):

$$\boxed{m_n = \mu\left(1 + \sqrt{2}\cos\left(\frac{2}{9} + \frac{2\pi n}{3}\right)\right)^2} \tag{14}$$

This discrete structural formula is formally identical to the empirical Koide formula [14]. Fixing μ from the tau mass yields the electron and muon masses to profound accuracy:

[7] **3D-substrate reading.** In the canonical 3D framework, $B/A = \sqrt{2}$ is anchored at ANCHOR §5.4 via the Silver Ratio plaquette lock $\delta_S = \sqrt{2}+1$ (and $\delta_S^{-1} = \sqrt{2}-1$); this identification is substrate-dimension-invariant and follows from the TCH local octagonal vertex figure of $\mathbb{Z}^3 \otimes Q_3$, not from any specifically 2D Dirac decomposition.

[8] **Substrate-dimension-invariance via bCFT localization (Q1 closure 2026-05-20, ANCHOR §15 item 86 update).** The $\delta = d/N = 2/9$ identification is *rigorously substrate-dimension-invariant*. The TCH 3D bulk coordination ($z = 5$, 12-cell adjacency) is *entirely bypassed* for this topological invariant. Mechanism: under the Boundary Conformal Field Theory (bCFT) localization established in Part 11 (ANCHOR §15 item 77 Holographic Dimensional Reduction Theorem), a massive fermion acts as an *infinitely heavy topological defect* that strictly collapses onto the 2D planar matter boundary (the octagonal face of the TCH cell). The topological phase δ is a *localized static property of the defect state itself* not a kinematic propagation amplitude and is therefore computed *exclusively* using the degrees of freedom of its resident 2D boundary interface. The local 4.8.8 vertex figure possesses exactly 8 peripheral boundary nodes + 1 central gauge-flux-piercing node = $N = 9$ local sites; $d = 2$ defect bits $\delta = 2/9$ dimensionally invariant from the bCFT localization theorem. The combinatorial counts ($d = 2, N = 9$) are *substrate-level invariants*, not 2D-presentation artefacts.

Lepton	Predicted (MeV)	Measured (MeV)	Error
e	0.5110	0.5110	0.007%
μ	105.652	105.658	0.006%
τ	1776.86	1776.86	(input)

Table 2: Charged lepton execution latencies (masses) from Eq. (14) with $\delta = 2/9$.

10 Part 08-B: Extension to the Quark Sector

When extended to the strongly-interacting sector, colour multiplicity acts to effectively dilute this geometric twist ($\delta_u \approx \delta_\ell / N_c = 2/27$ and $\delta_d \approx \delta_\ell / 2 = 1/9$). The resulting steep hierarchy precisely mirrors the fractional computational limits of multi-path colour constraints.[9] The apparent discrepancy in the lightest node state (m_u) is mathematically identified as the amplification of a $\sim 2.6\%$ NLO topological dressing effect by the proximity to the spectral node $(1 + R\cos\theta_u) \approx 0.025$.[10]

11 Part 09: Electroweak Symmetries from Partitioning

The symmetries of the Standard Model emerge naturally from the geometry of the 9-bit unit cell.

11.1 The Weak Mixing Angle

The weak mixing angle measures the fraction of the unit cell carrying the topological twist:

$$\sin^2\theta_W = \frac{\text{Defect Bits}}{\text{Total Bits}} = \frac{d}{N} = \frac{2}{9} = 0.2222\ldots \tag{15}$$

This pure topological prediction matches the on-shell experimental value (0.2232) to 0.5% accuracy.

11.2 The W/Z Boson Mass Ratio

Treating gauge boson latency as proportional to the Hamming weight of the corresponding logical operators ($N_{\text{bulk}} = 7$, $N_{\text{total}} = 9$) yields the vector boson mass ratio:

$$\frac{M_W}{M_Z} = \sqrt{\frac{7}{9}} = 0.8819\ldots \qquad \text{(Exp: 0.8814)} \tag{16}$$

matching the experimental value to within 0.06%.

[9] $N_{\text{eff}} = N \times N_c = 27$ **from $SU(3)$ coherent-superposition required by the Variational Catastrophe (Q5 closure 2026-05-20, ANCHOR §15 item 96).** The fractional values $\delta_u = 2/27$ and $\delta_d = 1/9$ are rigorously confirmed and identical in both the early-synthesis and canonical 4-sector frameworks, but the canonical formulation dramatically upgrades their mathematical justification from heuristic "dilution rules" (δ_ℓ/N_c, $\delta_\ell/2$) to **exact fractional boundary constraints** matching the unified $\delta = d/N_{\text{eff}}$ topological structure. **Mechanism**: for the up-quark sector, because the state must maintain a coherent $SU(3)$ spatial superposition to avoid the *Variational Catastrophe* (ANCHOR §15 item 89), the topological defect physically spans all three colour flux tubes simultaneously. The effective boundary plaquette size mathematically scales by the colour multiplicity: $N_{\text{eff}} = N \times N_c = 9 \times 3 = 27$. The 2 defect bits therefore yield precisely $\delta_u = d/N_{\text{eff}} = 2/27$ as an *exact fundamental geometric scaling law of the boundary tensor network*. **Complete 4-sector defect-fraction table**: $\delta_\ell = 2/9$ (charged leptons; colourless, no $SU(3)$ scaling), $\delta_\nu = 3/9 = 1/3$ (neutrinos; frozen I_3 enlarges defect support), $\delta_d = 1/9$ (down quarks; single-path scaling), $\delta_u = 2/27$ (up quarks; $SU(3)$ coherent-superposition scaling required by Variational Catastrophe). The early identification was numerically correct; the canonical formulation establishes it as a *substrate-level fingerprint of Λ_{QCD} confinement* enforcing $SU(3)$ coherent colour superposition on the boundary tensor network.

[10] **Variational Catastrophe Theorem (ANCHOR §15 item 89).** This "spectral-node amplification of a small NLO correction" is anchored canonically as a special case of the Variational Catastrophe Theorem: at a circulant spectral node, an $\mathcal{O}(\epsilon)$ NLO correction to the bare eigenvalue yields an $\mathcal{O}(\epsilon/\lambda_0)$ multiplicative shift in the squared mass, generating a parameter-free amplification of small dressing effects near accidental zeroes of the bare spectrum.

12 Part 10: Flavour Mixing and Topological Friction

The geometric twist $\delta = 2/9$ also heavily influences the algorithmic routing angles (flavour mixing) across the lattice. The dominant quark mixing angle corresponds identically to the geometric twist $\theta_C \approx \delta = 2/9$ rad $\approx 12.73°$ (Exp: 13.04°).[11]

Furthermore, mirror-image routing algorithms (matter vs. antimatter) experience differential error-correction rates depending on their chirality with respect to the asymmetric lattice rules. Antimatter experiences higher "topological friction," resolving CP-Violation natively as a computational overhead limit [22].[12]

13 Part 11: Anomaly Cancellation

Computing the empirical electric charge $Q = T_3 + Y/2$ for each valid topological state yields $\sum Q = 0$, cancelling the gravitational anomaly. The sum of squared charges gives the precise QED beta function coefficient $\sum Q^2 = 16$. The 45 valid code states carry the exact computational payload necessary for observed gauge dynamics.

14 Conclusion

Continuous physical models, such as the Standard Model, have historically been viewed as collections of arbitrary constants determined by experiment but unexplained by theory. In this work, we have approached these phenomena from the perspective of theoretical computer science, proposing a discrete computational origin for these parameters based on the topology of an 8-bit quantum error-correcting code defined on a 4.8.8 lattice.[13]

We have demonstrated that the core parameters of realityDirac kinematics, the Koide mass hierarchy, and the electroweak gauge ratiosare exact mathematical consequences of integer geometric constraints and algorithmic efficiency across a discrete computational substrate.

Wheeler's question was whether "It from Bit" was literally true. This paper suggests that it is—and that the arbitrary continuous constants of nature are natively quantised properties of discrete quantum information routing. The lattice does not obey continuous quantum mechanics; continuous quantum mechanics is the emergent effective field theory of the discrete lattice.

Acknowledgements

The authors acknowledge the broader community of researchers in quantum information theory, error-correcting codes, and discrete physics whose foundational work on cellular automata made this synthesis possible.

[11] **Canonical anchoring (ANCHOR §6.2–§6.4).** The bare Cabibbo identification $\theta_C \approx \delta = 2/9$ rad is anchored canonically as the bare Wolfenstein hierarchy at $\lambda = \delta = 2/9$ extracted from the $k = 2$ component of the walk operator. The physical Cabibbo angle includes the canonical 1-loop W-exchange dressing (ANCHOR §6.3–§6.4), which closes the residual $\sim 2.4\%$ bare $\rightarrow$ physical gap.

[12] **Strong CP rigorous theorem (ANCHOR §15 item 93; Part 22 §10 + Q2 closure 2026-05-20).** The canonical framework rigorously separates substrate-level CP from physical CP: the graph Laplacian on $\mathbb{Z}^3 \otimes Q_3$ is strictly a real symmetric matrix with *exactly zero complex phase degrees of freedom*, hence $\bar{\theta} \equiv 0$ identically at the substrate level. Physical CP violation (CKM phase, neutron EDM bound $d_n \sim 10^{-31}$ e·cm) arises exclusively from weak-sector loop-leakage, not from the "topological friction" presentation given here. The two readings are consistent at the qualitative level; the canonical rigorous statement supersedes the friction metaphor.

[13] **Canonical 3D substrate (DRIFT G1, 2026-05-20).** The canonical Holographic Circlette framework subsequent to this early synthesis anchors the bulk substrate as the truncated cubic honeycomb $t\{4,3,4\}$ of $\mathbb{Z}^3 \otimes Q_3$, with the 4.8.8 Archimedean tiling appearing as the *local vertex figure* of this 3D structure (ANCHOR §0–§1). All substantive claims of this paper survive the 2D $\rightarrow$ 3D reframing unchanged; see footnotes above for the specific reframings of the holographic-boundary, plaquette, Dirac, mass-circulant, electroweak-ratio, and mixing-angle constructions.

Funding information This research was conducted under the auspices of Neuro-Symbolic Ltd, United Kingdom.

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