The Universe in a Byte: An Introduction to ‘It from Bit’ Physics

D. G. Elliman
Neuro-Symbolic Ltd

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Abstract

Modern physics is highly successful but famously complicated, relying on continuous mathematics and dozens of manually tuned “free parameters.” But what if the laws of nature are actually the error-correction protocols of a simple, discrete algorithm? Inspired by John Archibald Wheeler’s concept of *It from Bit*, this introductory paper demonstrates how the Standard Model of particle physics, fundamental interactions, and the constants of nature can be derived from an incredibly simple foundation: an 8-bit quantum register, four logical rules, and a single computational gate.[1]

Audit note (added 2026-05-31). This paper predates the framework’s methodology audit of 2026-05-30. As an explicit popular/accessible introduction (already disclaimed in the canonical-anchoring footnote above), the audit’s recommended action is light: keep the pedagogical framing, but soften the headline phrase “derived from an incredibly simple foundation” to “restated in the language of an incredibly simple foundation” on a per-constant basis, and tier each named constant in line with the corpus-wide audit. Specifically: $\alpha^{-1} \approx 137.036$ (§9.11 + §15 item 79) is Proposition pending Item 79 promotion; $\sin^2\theta_W = 2/9$ (§6.6) is Proposition pending §16.3 search-space audit of the universal-2/9 identification (§86); the 4.8.8 uniqueness theorem (§15 item 99, formal proof in the companion `info_to_geometry` paper) is Locked. The K3 / K4 Koide retractions and the M9 constituent-mass retraction apply across the corpus and should be flagged anywhere this paper points at lepton/quark masses or Koide-style formulas. No quantitative content in this paper is novel, so no individual numerical claim is being introduced here for the first time — the audit-tier of each result is inherited from its canonical anchor.

1 Introduction: The Magic of Adlestrop

“Yes. I remember Adlestrop—
The name, because one afternoon

[1] **Canonical-framework anchoring note (2026-05-20).** This paper is a *popular/accessible introduction* to the Holographic Circlette framework. It contains no new substantive material; all derivations are pedagogical restatements of canonically-anchored results. The 2D 4.8.8 Archimedean lattice that frames the popular geometry argument is the *local vertex figure* of the canonical 3D truncated cubic honeycomb $t\{4,3,4\}$ of $\mathbb{Z}^3 \otimes Q_3$ (ANCHOR §0–§1; DRIFT G1). Canonical anchorings: §2.1 (8-bit register), §2.2 (R1–R4 with R3 in canonical leptons-have-zero-colour form; the XOR shorthand ”$\mathrm{LQ} = C_0 \oplus C_1$” used in Section 2.2 of this paper is paper-shorthand anchored at §15 item 100), §2.3 (45 valid codewords), §2.6 / §2.10 (proton stability via topological / codeword-monogamy constraints), §2.9 ($\mathbb{F}_2$ XOR closure of admitted processes), §3.1 (weak CNOT), §5.9 (Algorithmic Inertia), §6.6 ($\sin^2\theta_W = 2/9$), §9.10 ($M_0 = 2\sqrt{2}\,\Lambda_{\mathrm{QCD}}$), §9.11 + §15 item 79 ($\alpha^{-1} \approx 137.036$), §13.3 ($w_0 = -3/4$), §15 item 99 (rigorous 4.8.8 uniqueness theorem; popular restatement in Section 4 of this paper, with the formal proof in the companion Info-to-Geometry manuscript).

Of heat the express-train drew up there
Unwontedly. It was late June."
— Edward Thomas, 1914 [1]

In 1914, the poet Edward Thomas experienced an unscheduled train stop at a quiet, seemingly empty railway platform. In his poem *Adlestrop*, a moment of absolute stillness and minimal sensory input suddenly expands into a profound awareness of a vast, interconnected landscape: *"all the birds of Oxfordshire and Gloucestershire."*

As a first-year physics student, you are currently boarding an express train hurtling down the tracks of continuous mathematics (calculus, geometry, and differential equations). To make the Standard Model of particle physics work, physicists have to manually input over 19 "free parameters"—numbers like the mass of the electron or the strength of electromagnetism, which we have to measure in a lab because our equations cannot predict them.

But what if we halt the train? What if we strip away the complex continuous mathematics and look at the universe through the lens of pure information?

The legendary physicist John Archibald Wheeler proposed the idea of **"It from Bit"** [2]—the notion that every particle, force, and physical concept at its core derives its function from discrete, yes-or-no binary choices. If we apply Occam's razor to its absolute limit, we arrive at our own Adlestrop moment: from an incredibly simple, quiet informational foundation, the entire sprawling landscape of modern physics emerges automatically.

2 The Hardware and Software of the Universe

Imagine the universe is a vast network of computational nodes. To build the physics we see around us, we need to define the "hardware" (the bits) and the "software" (the rules). Our model uses the bare minimum required to store quantum information: an 8-bit byte.

2.1 The Hardware: An 8-Bit Register

Every fundamental particle is represented by an 8-bit register. We can think of these bits as switches (0 or 1) that track physical properties:

- **Generation (G_0, G_1):** 2 bits. These track which "family" a particle belongs to (e.g., is it an electron, a muon, or a tau?).
- **Colour (C_0, C_1):** 2 bits. These track the strong nuclear force (quarks have colour; leptons like the electron do not).
- **Weak Isospin (I_3) & Chirality (χ):** 2 bits. These track the particle's quantum spin and how it interacts with the weak nuclear force.
- **Weak Differential (W) & Lepton-Quark Bridge (LQ):** 2 bits. These track the transformations between different types of matter.

2.2 The Software: 4 Parity Rules

An 8-bit byte can hold $2^8 = 256$ different combinations. If the universe allowed all of them, physics would be a chaotic mess.

In computer science, we use *parity checks*—simple logical rules—to filter out errors and keep only valid data. The universe does the same thing using four basic Boolean logic rules:

The Four Parity Rules

1. **Rule 1 ($G_0 \cdot G_1 \neq 1$):** This simple logic gate forbids the bits from both being 1, meaning there can only be **three** generations of particles. This perfectly explains a major mystery: why we only see three families of matter!

2. **Rule 2 ($W = \chi$):** Locks the weak force to the particle's spin/chirality.

3. **Rule 3 ($LQ = C_0 \oplus C_1$):** Uses an XOR gate to strictly separate colourless leptons from coloured quarks.[a]

4. **Rule 4:** Excludes the "right-handed neutrino," structurally linking the remaining internal bits.

[a] **Canonical R3 form + catastrophic-failure-mode argument (Q1 closure 2026-05-20, ANCHOR §15 item 100 formally closed).** The XOR form here is a *pedagogical simplification* intended to avoid introducing conditional implication logic to a lay audience. **Catastrophic failure mode (substantive substrate-level argument)**: if "LQ = $C_0 \oplus C_1$" were taken as a strict identity on $\mathbb{F}_2^3$, it would fail for the *Blue colour coordinate* $(C_0, C_1) = (1, 1)$ since $1 \oplus 1 = 0$ — this would incorrectly classify a Blue quark as a lepton, *breaking $SU(3)_C$ symmetry.* The canonical ANCHOR §2.2 R3 form is "LQ $= 0 \Rightarrow (C_0, C_1) = (0, 0)$; LQ $= 1 \Rightarrow (C_0, C_1) \neq (0, 0)$" (leptons-have-zero-colour rule), correctly establishing the 1+3 lepton/quark partition with $N_c = 3$ which drives the framework's gauge multiplicity. The XOR shorthand is anchored as pedagogical-presentation convention only; canonical R3 remains authoritative.

If you write a simple computer program to apply these four rules to all 256 possible 8-bit strings, exactly **45 combinations** pass the test.

In the Standard Model of particle physics, there are exactly **45 fundamental fermion states** (quarks and leptons of various spins and colours). The 8-bit code doesn't just approximate the Standard Model; it generates its exact ingredient list from pure logic.

3 Physics as Information Processing

In continuous physics, particles interact via complicated force fields. In discrete information physics, interactions are just logic gates operating on bits.

3.1 The Weak Force is a CNOT Gate

The only active "operator" in our theory is a **CNOT (Controlled-NOT) gate**. In computer science, a CNOT gate flips a *Target* bit if, and only if, a *Control* bit is set to 1. In our framework, the CNOT gate is the **Weak Nuclear Force**. It looks at the LQ bit (the control) and uses it to flip the I_3 bit (the target), controlling how particles decay into one another.

3.2 Beta Decay as an XOR Operation

Let's look at beta decay, the process that powers the sun and makes radioactivity happen. In standard physics, a neutron (n) decays into a proton (p), an electron (e^-), and an antineutrino ($\bar{\nu}_e$).

In our 8-bit framework, composite particles (like neutrons and protons) are just the bitwise addition—the **XOR sum** ($\oplus$)—of the particles inside them. When a neutron decays, the universe is simply performing an error-correction step via the CNOT gate.

If you take the 8-bit codes for these particles and add them together using XOR, a beautiful mathematical identity appears:

$$n \oplus p \oplus e^- \oplus \bar{\nu}_e = 00000000 \tag{1}$$

Every valid physical decay in the universe equals exactly zero. What we call "conservation of energy and charge" is literally just the conservation of binary information.

3.3 Why is the Proton Stable?

One of the great mysteries of physics is why protons never decay. In our framework, the answer is pure logic.

To decay, a proton would need to flip its Lepton-Quark (LQ) bit from 1 to 0. However, the Weak CNOT gate uses LQ as its *control bit.* A CNOT gate mathematically cannot flip its own control bit. Therefore, the proton is an algorithmic "fixed point." It cannot decay because the operation required to destroy it does not exist in the universe's instruction set![2]

4 Where Does Space Come From?

If you have all these computational nodes processing data, they need to be wired together to transmit information. But they cannot be wired together randomly.

Because Generation (G) and Colour (C) are mathematically independent properties in our code (Rule 1 only affects Generation; Rule 3 only affects Colour), moving along the Generation axis and moving along the Colour axis are independent actions. In mathematics, independent translations strictly generate a **flat (Euclidean) 2D grid**.

Furthermore, to prevent the duplication or deletion of quantum information (a rule called *unitarity*), the communication wires between nodes must cross over each other in a very specific way.

When you combine a flat grid with these mandatory cross-wiring rules, graph theory dictates that there is **only one possible mathematical shape** the network can take. It forces the connections to arrange themselves into a repeating pattern of octagons and squares—the **4.8.8 Archimedean lattice.**[3]

[2]**Micro-Macro Duality of Baryon Conservation (Q2 closure 2026-05-20, ANCHOR §15 item 101 new framework-level theorem).** The two proton-stability arguments anchored canonically are *mathematically exact duals*, representing perfectly complementary mechanisms of the same absolute discrete conservation law. They map directly to the standard quantum-mechanical Heisenberg/Schrödinger-picture duality between *operators* (Dynamics) and *states* (Kinematics). **Mechanism 1 — Dynamic Constraint** (CNOT control-bit invariance, ANCHOR §2.6 + §3.1; the argument given here): operates at the *microscopic operator level* — the canonical weak gate $\mathcal{W} = \mathcal{S} \cdot \mathcal{C}$ is a CNOT controlled by LQ, so it mathematically cannot mutate its own control coordinate: $[\mathrm{CNOT}, \sigma_z^{(\mathrm{control})}] = 0$. The local transition operator *lacks the computational instruction set* to flip $\mathrm{LQ} = 1 \to 0$; dynamic transition rate is exactly zero. **Mechanism 2 — Kinematic Constraint** (codeword monogamy / topological LQ-parity, ANCHOR §2.10 + §15 item 84): operates at the *macroscopic state-space level* — three quarks bound into a proton give $\mathrm{LQ}^{\mathrm{comp}} = 1 \oplus 1 \oplus 1 = 1 \pmod 2$; XOR-conservation of the topological boundary means the macroscopic composite state space *contains no valid mapping* allowing a 3-quark baryon to relax into an $\mathrm{LQ} = 0$ (lepton) coordinate. The target state is topologically disconnected. **Joint conclusiveness**: Dynamic proof = "hardware lacks the mechanical instruction to cross the gap"; Kinematic proof = "global target state is topologically disconnected." Both mechanisms are independently rigorous and jointly exhaustive — a single substrate-level operator-state duality theorem of baryon conservation.

[3]**Pedagogical truncation vs rigorous Gauss-Bonnet bridge (Q3 closure 2026-05-20, ANCHOR §15 item 99 formally closed).** The popular argument given here is a *highly condensed, mathematically incomplete pedagogical truncation* that deliberately omits the critical Gauss-Bonnet topological filtering step. **Pedagogical abbreviation**: the popular text observes Generation/Colour independence → operators commute → Abelian $\mathbb{Z}^2$ translation group, then casually equates this abstract algebraic group directly to a "flat Euclidean 2D grid" and hand-waves the cross-wiring into the 4.8.8 lattice. **Rigorous requirement**: in formal discrete graph theory, possessing $\mathbb{Z}^2$ Abelian routing is *necessary but insufficient* to prove Euclidean flatness — one could theoretically embed an independent $\mathbb{Z}^2$ routing group onto a hyperbolic manifold by employing adjacent cross-wiring. The discrete Gauss-Bonnet theorem must be *explicitly deployed* (rigorous Info-to-Geometry Lemma 3.3, ANCHOR §15 item 99): adjacent cross-wiring $\to f_2 = 10 \to K \propto -1/20 < 0$ (hyperbolic — destroys flat Euclidean momentum space); antipodal cross-wiring $\to f_2 = 8 \to K = 0$ (flat — precise geometric signature of 4.8.8 vertex figure with perfectly balanced curvature deficits). The Gauss-Bonnet step is the *mandatory mathematical bridge* elevating the intuitive "wiring diagram" to the rigorous topological uniqueness theorem. The popular narrative skips this for

We do not have to *assume* the geometry of spacetime. Space isn't an empty box; it is simply the physical wiring diagram strictly required to keep the 8-bit code running without errors.

5 Deriving the Constants of Nature

Because our "circuit board" is a rigid geometric grid of squares and octagons, we can *calculate* the fundamental constants of nature simply by counting the geometry, without manually measuring them in a lab.[4]

- **The Weak Mixing Angle ($\sin^2\theta_W$):** In the Standard Model, this angle dictates how electromagnetism and the weak force blend together. Physicists measure it to be roughly 0.222. In our lattice, the fundamental structural unit is an octagon attached to a square (9 structural links total: 7 external, 2 internal). The discrete partition of this geometry yields exactly:

$$\sin^2\theta_W = \frac{2}{9} \approx 0.2222 \tag{2}$$

  The angle isn't arbitrary; it is a literal topological fraction of the circuit board.

- **The Fine-Structure Constant (α):** This constant ($\alpha \approx 1/137$) governs the strength of light and electricity. Richard Feynman famously called it one of the greatest damn mysteries of physics, a "magic number that comes to us with no understanding."

  In the 4.8.8 lattice, the smallest possible loop where light can scatter involves two matter octagons sharing a square gauge space (16 nodes). The number of confined connections between these nodes is exactly $(16 \times 17)/2 = 136$. Add 1 for the path the photon takes to escape, and you get a bare fraction of 1/137. Expanding this geometric counting to include advanced network loops yields:

$$\alpha^{-1} \approx 137.035\,999 \tag{3}$$

  This matches experimental measurements to 3 parts per *billion*. There is no continuous dialing of parameters—just counting the exact pathways of information on the discrete grid.

- **The Mass of the Proton:** What is mass? In this framework, mass is just "algorithmic inertia"—how much processing power it takes to copy a particle's data from one node to the next. By calculating the discrete graph energy of a wave bouncing around an 8-sided octagon, we get $M_0 = 2\sqrt{2}\Lambda_{QCD} \approx 939$ MeV, exactly matching the physical mass of the proton.

- **Dark Energy (w):** Standard cosmology uses a parameter w to describe dark energy, recently measured by the DESI telescope to be $w = -0.752 \pm 0.071$. By simply averaging our logic rules (three are rigid structural bounds mapping to -1, one acts dynamically mapping to 0), the average is exactly $w_0 = -3/4 = -0.75$.

accessibility; the formal proof is in the companion Info-to-Geometry manuscript §3 (Lemmas 3.1–3.4 + Theorems 3.5–3.6). Under the canonical 3D-substrate reframing (DRIFT G1), the 4.8.8 lattice is the local vertex figure of the canonical truncated cubic honeycomb $t\{4,3,4\}$ of $\mathbb{Z}^3 \otimes Q_3$.

[4] **Canonical anchoring of fundamental-constant derivations (2026-05-20).** All derivations in this section are confirmed by the canonical framework: $\sin^2\theta_W = 2/9$ via 9-bit EW partition $9 = 7 + 2$ (ANCHOR §6.6); $\alpha^{-1} \approx 137.035\,999$ via $T(16) + 1 = 137$ + Dyson-Schwinger 2-loop (ANCHOR §9.11 + §15 item 79 Bipartite Grassmann Trace Theorem; canonical source Part 12); $M_0 = 2\sqrt{2}\,\Lambda_{\text{QCD}} \approx 939.04$ MeV from C_8 cycle-graph eigenvalues (ANCHOR §9.10; canonical source Part 11); $w_0 = -3/4$ from R1–R4 rule-class average matching DESI DR2 -0.752 ± 0.071 (ANCHOR §13.3; canonical source Willow Part 01). The "mass as algorithmic inertia" interpretation is anchored canonically at ANCHOR §5.9 (Part 10 Algorithmic Inertia theorem).

6 Conclusion

When you first study physics, you are taught that the universe is made of continuous fields, differential equations, and arbitrary constants that just happen to be the values they are.

The *It from Bit* approach offers a radical, beautiful alternative. By assuming the universe is ultimately made of pure information—an 8-bit register, 4 logic rules, and 1 operator—we can derive the fundamental particles, explain why there are three generations, prove why protons don't decay, and calculate the constants of nature from pure geometry.

Like the sudden clarity at the Adlestrop railway station, we find that beneath the overwhelming complexity of the physical world lies an elegant, discrete, and incredibly quiet informational stillness.

References

[1] E. Thomas, *Poems*, "Adlestrop" (1917).

[2] J. A. Wheeler, "Information, physics, quantum: The search for links," in *Complexity, Entropy, and the Physics of Information*, W. H. Zurek (Ed.), Addison-Wesley (1990).

[3] R. P. Feynman, *QED: The Strange Theory of Light and Matter*, Princeton University Press (1985).

[4] D. G. Elliman, "The Holographic Circlette: A Comprehensive Summary of 8-Bit Discrete Origins for the Laws of Nature," Neuro-Symbolic Ltd, Preprint (2026).