

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

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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 Introduction: The Magic of Adlestrop

*“Yes. I remember Adlestrop—  
The name, because one afternoon  
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 ( $\chi$ ):** 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.
4. **Rule 4:** Excludes the “right-handed neutrino,” structurally linking the remaining internal bits.

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:

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

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!

## 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**.

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.

- **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:

$$\sin^2 \theta_W = \frac{2}{9} \approx 0.2222 \quad (2)$$

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

- **The Fine-Structure Constant** ( $\alpha$ ): 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:

$$\alpha^{-1} \approx 137.035\,999 \quad (3)$$

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  $w_0 = -3/4 = -0.75$ .

## 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).