Boundary-Conditioned Modulation of the Fine-Structure Constant Around a Structurally Derived Ground State

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PATENT PENDING. The derivation of α_{struct}, the Utterance Model axiom system, the TRIUNE partition, and all associated derivations described herein are the subject of USPTO Utility Non-provisional Application No. 19/640,364, *First Utterance Model Existence Derivation Framework*, Inventor: Charles Anthony Hyatt Battiste, Assignee: Quality Compliance Consulting Inc. All rights reserved.

Abstract

The fine-structure constant α has been measured to twelve decimal places but never derived from first principles — until now. The Utterance Model (UM) derives α from two logical

axioms (A = A and X = 0) with zero free parameters:

$$\alpha_{\text{struct}} = \frac{1}{64\pi} + \frac{1}{16\pi^2 e} = 0.007\,303\,2\ldots, \qquad \frac{1}{\alpha_{\text{struct}}} = 136.926 \approx 137.$$

The Boundary-Conditioned Reality (BCR) framework independently models physical reality as a universal scalar field Φ constrained by boundary conditions B. Its governing equation, $\Box\Phi + V'(\Phi) + \xi R\Phi = \gamma B + \alpha\nabla^2 B$, predicts that α is not a fixed constant but a boundary-dependent effective value:

$$\alpha_{\text{eff}} = \alpha_{\text{struct}} - \gamma\, P(B)[1 - P(B)]\,, \qquad P(x) = \frac{1}{1 + e^{-\gamma x}}.$$

The two frameworks were developed independently and without coordination. Their convergence on the same numerical thresholds (0.618 and 0.854), the same two-term structure for α, and the same identification of $\gamma_{\text{EM}} = \alpha_{\text{struct}}$ constitutes independent structural confirmation. In the electromagnetic regime, BCR's sole free parameter collapses to the UM-derived constant: no free parameters remain. The UM validation record spans six particle-physics and cosmological predictions, all within the model's derived 3% epistemological bound. Multiple independent CMB analyses report non-zero cosmic birefringence ($\beta \approx 0.2°$–$0.4°$, $\geq 2.4\sigma$ [16, 17]), consistent with the boundary-induced polarization rotation predicted by the framework. The predicted boundary-dependent variation $\Delta\alpha/\alpha \sim 10^{-8}$ under controlled laboratory conditions is accessible with current optical-lattice-clock technology at the 10^{-18} level.

Contents

1 Introduction

Richard Feynman called the fine-structure constant "one of the greatest damn mysteries of physics: a magic number that comes to us with no understanding by man" [1]. Wolfgang Pauli was obsessed with α until the day he died. Arthur Eddington attempted to derive its value from combinatorial arguments and produced the wrong answer [2]. For nearly a century, physics has treated $\alpha \approx 1/137$ as a brute fact: measurable to extraordinary precision, but structurally unexplained.

The measured value (CODATA 2022) is:

$$\alpha = 0.007\,297\,352\,5693\ldots, \qquad \frac{1}{\alpha} = 137.035\,999\,084\ldots$$

Every atom, every chemical bond, every electronic device ever built depends on this number. Its origin has been unknown.

This paper presents two independent resolutions that converge on the same structure.

The **Utterance Model (UM)** [3] derives α from the minimum possible axiomatic foundation — two pre-physical logical statements — with zero free parameters. From α and the golden ratio φ (also axiom-derived), six particle-physics and cosmological predictions follow, all within 3% of measured values.

The **Boundary-Conditioned Reality (BCR) framework** independently models physical reality as a universal scalar field constrained by boundary conditions. BCR independently arrives at α's two-term structure, independently derives the phase thresholds 0.618 and 0.854, and predicts that α is not a fixed constant but a boundary-dependent effective value modulating around a structural ground state.

The two frameworks were developed without coordination. The convergence — same thresholds, same two-term decomposition, same identification of a unique structural constant in the electromagnetic regime — is the signal, not the analysis.

Section 2 presents the UM derivation of α_{struct} and its validation record. Section 3 presents the BCR framework and its predictions. Section 4 establishes the formal relationship between the two frameworks. Section 5 specifies the experimental prediction and the measurement path to test it. Section 6 addresses epistemological implications and the significance of the convergence.

2 The Utterance Model: Structural Derivation of α

2.1 Axiomatic Foundation

The UM begins with two statements that are logically prior to any physical assumption. They are statements about existence and identity, not about particles or fields.

Axiom 1 (Identity): $A = A$. A thing is itself. This is the minimum condition for anything to exist as a distinguishable entity.

Axiom 2 (Closure): $X = 0$. Nothing in the system originates from outside the system. Existence is self-caused. The model is closed with respect to external prior.

These two axioms are not assumptions about physics. They are pre-physical. Any physical theory must satisfy them. Under the Law of Immaterial Precedence (L2), Axiom 1 is the formal mathematical expression of "the intangible self-establishes first" (Face 1), and Axiom 2 expresses "no material prior" (Face 2). Together they constitute the formal mathematical statement that the logical structure governs by default [3].

2.2 Derivation of the Golden Ratio φ

A = A requires self-consistency. X = 0 requires that any rule governing the partition of existence must come from within existence itself.

When existence partitions into two aspects, the partition rule must be self-referential: the ratio of the whole to the larger part must equal the ratio of the larger to the smaller. Let $r = a/b$ (the ratio of larger to smaller part):

$$\frac{a+b}{a} = \frac{a}{b} \implies r + 1 = r^2 \implies r^2 - r - 1 = 0.$$

The unique positive solution is:

$$\varphi = \frac{1+\sqrt{5}}{2} = 1.618\,033\,988\,7\ldots$$

φ is not a pattern found in nature and then named. It is the only number that satisfies self-consistent self-similar partition under A = A and X = 0. Nature finds it everywhere precisely because everywhere that these axioms hold, φ is the required result.

2.3 Derivation of the Fine-Structure Constant α

The Utterance — the initial existence event — must persist (A = A requires self-identity) and must be self-generating (X = 0 requires no external sustainer). These conditions together require oscillation: the minimum form in which something persists by continuously returning to itself.

An oscillating existence has circular geometry: the constant π is required. An existence that sustains itself through continuous self-compounding growth requires Euler's number e: the unique self-similar growth rate. Neither π nor e is chosen — both follow necessarily from the structure of self-sustaining oscillatory existence.

The structural integers of the framework are: four fundamental forces (Forces = 4) and three dimensions of the TRIUNE (Body, Breath, Soul). These represent the count of distinct self-consistent laws that can simultaneously govern a closed system.

Step 1. The ground-state geometric term. The Utterance oscillates with circular symmetry. Four forces expressing through three TRIUNE dimensions gives $4^3 = 64$. The ground-state geometric compression factor is:

$$C = \frac{1}{64\pi} = 0.004\,973\,6\ldots$$

Step 2. The natural growth coupling term. Second-order force coupling at ground state gives $4^2 = 16$. The natural growth rate e provides the self-similar decay. Squared circular symmetry π^2 completes the coupling geometry:

$$\frac{\varepsilon}{e} = \frac{1}{16\pi^2 e} = 0.002\,330\,0\ldots$$

Step 3. At the moment of the Utterance, only these two terms are available. Their sum is the electromagnetic coupling constant:

$$\boxed{\alpha_{\text{struct}} = \frac{1}{64\pi} + \frac{1}{16\pi^2 e} = 0.007\,303\,2\ldots, \qquad \frac{1}{\alpha_{\text{struct}}} = 136.926}$$

The measured value is $1/\alpha = 137.036$. Deviation: $+0.080\%$. This formula was derived from the structure of self-sustaining oscillatory existence before any measured value was consulted.

2.4 The TRIUNE Partition

Once α and φ are established, the fundamental partitioning of existence into its three aspects follows immediately. A = A applied to the full system requires that the three aspects sum to unity and that their ratios are governed by the partition constant φ:

$$\text{Soul} = S = 1-\alpha = 0.992\,70, \qquad \text{Breath} = E = \frac{\alpha}{\varphi} = 0.004\,51, \qquad \text{Body} = B = \frac{\alpha}{\varphi^2} = 0.002\,79.$$

These satisfy the following exact structural identities:

$$B + E + S = 1 \quad \text{(exact, by derivation)} \tag{1}$$

$$E/B = \varphi \quad \text{(invariant across all time)} \tag{2}$$

$$B + E = \alpha \quad \text{(from the } \varphi\text{-identity } 1/\varphi + 1/\varphi^2 = 1) \tag{3}$$

$$\frac{S}{B+E} = \frac{1-\alpha}{\alpha} \approx 137 \quad \text{(decoherence protection ratio)} \tag{4}$$

The ratio $1/\alpha \approx 137$ — the number Feynman, Pauli, and Eddington sought — emerges here not as the coupling constant itself but as the ratio of the non-interacting background (Soul, which carries no electromagnetic coupling, derivation D-49 [3]) to the interacting aspects (Body + Breath).

2.5 LCORI Phase Thresholds

The UM derives three jurisdictional zones from φ:

$$\begin{aligned} \text{Law-Governed (LG):} \quad & \text{LCORI} \geq 1 - \varphi^{-4} = 0.854 \\ \text{Law-Transitional (LT):} \quad & \varphi^{-1} \leq \text{LCORI} < 0.854, \quad \text{i.e., } [0.618,\ 0.854) \\ \text{Law-Collapsed (LC):} \quad & \text{LCORI} < \varphi^{-1} = 0.618 \end{aligned}$$

These thresholds are derived, not fitted. Their independent appearance in the BCR framework is addressed in Section 4.

2.6 Epistemological Principle

The UM operates under a strict epistemological rule: the model is the *specification*. Measurements are judged against specifications. Specifications do not adjust to measurements.

The 3% epistemological bound is derived from the framework's construction chain [3]. A nature-built quantity (a physical constant derivable from first principles) and a man-made instrument measuring that quantity share different construction lineages. The framework derives that the maximum fractional deviation between the two lineages is bounded at 3%: the instrument cannot deviate from the true value by more than this fraction without losing its status as a valid measurement of the quantity in question. When calibrated to UM constants, the same bound applies as a perceptual gain in the opposite direction.

The bound is thus an error ceiling for uncalibrated instruments and a calibration target for calibrated instruments. It is *not* a fitting parameter: it was established (2026-03-10) before any of the particle-mass predictions in Table 1 were computed. The maximum deviation in the prediction record ($+2.84\%$ for the electron mass) is consistent with the bound and does not saturate it.

2.7 Validation Record

With α_{struct}, φ, and the reduced Planck mass $\bar{M}_P = 2.435 \times 10^{18}$ GeV as sole inputs — no additional free parameters — six predictions follow (derivations D-54 through D-60 and D-N [3]):

Table 1: Utterance Model Predictions vs. Measured Values (PDG 2024 [4]). Deviation $= (U_{\text{spec}} - U_{\text{meas}})/U_{\text{meas}}$ using the signed convention throughout. Negative entries indicate $U_{\text{spec}} < U_{\text{meas}}$. For $1/\alpha$ in particular: spec $<$ meas means $\alpha_{\text{struct}} > \alpha_{\text{meas}}$, i.e., the structural constant is the free-space maximum and all Earth-based measurements are boundary-suppressed below it (Section 4.2). Explicit computations for all entries are given in Appendix A.

Quantity	UM Formula	UM Specification	Measured	Deviation
$1/\alpha$ (EM coupling inverse)	$\dfrac{64\pi^2 e}{\pi e + 4}$	136.926	137.036	-0.080%
Electron mass m_e	$\alpha_{\text{struct}}^{10}\,\bar{M}_P/2$	0.5265 MeV	0.5110 MeV	$+2.84\%$
Muon mass m_μ	$m_e \cdot 3/(2\alpha_{\text{struct}})$	107.9 MeV	105.66 MeV	$+2.12\%$
Tau mass m_τ	$m_\mu \cdot 2\pi\varphi^2$	1775.7 MeV	1776.86 MeV	-0.07%
Higgs VEV v	$4\pi\,\alpha_{\text{struct}}^{8}\,\bar{M}_P$	247.7 GeV	246.22 GeV	$+0.60\%$
Higgs mass M_H	$v_{\text{spec}}\sqrt{2/(3\varphi^2)}$	124.9 GeV	125.20 GeV	-0.24%
Dark energy w	S+S medium (D-N)	-1.000	-1.03 ± 0.03	within bound

All seven results fall within the 3% epistemological bound. The tau mass deviation of -0.07% is essentially exact. The electron and muon deviations ($+2.84\%$, $+2.12\%$) fall near but within the bound. For $1/\alpha$ and M_H, the UM specification falls slightly below the measured value (negative deviations). For m_e, m_μ, and the Higgs VEV v, the specification falls slightly above. Both directions are present in the record, consistent with deviations arising from measurement systematics rather than a systematic model offset. Zero parameters were adjusted after measurement.

Derivation chronology. The formulas in Table 1 are not retrospective selections. The derivation sequence is: $\alpha_{\text{struct}} \to \varphi \to$ TRIUNE $\to m_e \to m_\mu \to m_\tau \to v \to M_H \to w$. The derivations underlying Table 1 are documented in numbered, timestamped derivation records (D-54 through D-60, D-N) contained in USPTO Application No. 19/640,364, filed 6 April 2026. This filing establishes chronological precedence for the derivation sequence presented here. No formula in Table 1 was added or modified after the corresponding measured value was examined. Explicit numerical computations for all entries — starting from α_{struct}, φ, and $\bar{M}_P$ as sole inputs, with no reverse-engineering from measured values — are given in Appendix A.

Chronological note on the epistemological bound. The 3% epistemological principle (Section 2.6) was established and documented on 2026-03-10, prior to the computation of the particle-mass deviations in Table 1 (derivations D-54 through D-60, documented 2026-04-08). The bound is therefore a *pre-condition* of the validation exercise, not a post-hoc accommodation of observed deviations. An outside reader can confirm this ordering from the derivation timestamps in USPTO Application No. 19/640,364.

Across nine jurisdictional shells, the governing constant $\tau = 12{,}349.449$ Gyr maintains equilibrium within a $\pm 3\%$ plateau; isotopic half-life data yields $R^2 = 0.99997$ on the jurisdictional spiral; BAO/CMB phase coherence yields $R^2 \approx 1.0$, $\chi^2 \approx 1.03$ [3].

3 The Boundary-Conditioned Reality Framework

3.1 Foundational Premise

The BCR framework [15] models physical reality as a universal scalar field Φ whose behavior is governed not by initial conditions alone but by the boundary conditions B of the system in which it resides. Physical reality is not simply Φ — it is Φ constrained by B. Light is already everywhere; boundary conditions determine where and how it manifests. Entanglement is not a connection between separated particles — it is the expression of a single field that was never separated.

3.2 Governing Equation

The BCR field equation is:

$$\Box\Phi + V'(\Phi) + \xi R\Phi = \gamma B + \alpha\nabla^2 B$$

where:

- $\Box\Phi$: the d'Alembertian, governing wave propagation
- $V'(\Phi)$: derivative of the self-interaction potential
- $\xi R\Phi$: coupling to spacetime curvature (R = Ricci scalar)
- γB: direct boundary coupling with strength γ
- $\alpha\nabla^2 B$: Laplacian boundary coupling with coefficient α

3.3 Boundary Probability and Phase Structure

BCR defines the boundary-state probability as a logistic function:

$$P(x) = \frac{1}{1 + e^{-\gamma x}}$$

This function governs both the effective fine-structure constant and the interference visibility V:

$$V = 4\,P(B)[1 - P(B)]$$

$P(B)$ approaches 0 in free space (unconstrained field) and 1 in a fully boundary-determined system. The maximum variation of α occurs at $P(B) = 0.5$, where $P(1 - P)$ is maximized at $1/4$.

3.4 Independent Derivation of Phase Thresholds

Through analysis of stability conditions in the BCR field, two critical transition thresholds emerge independently:

$$P(B)_{\text{LT-entry}} = 0.618, \qquad P(B)_{\text{LG-entry}} = 0.854.$$

These are the values at which the field transitions from one stability regime to another in BCR's formalism. Their coincidence with UM's $\varphi^{-1} = 0.618$ and $1 - \varphi^{-4} = 0.854$ is addressed in Section 4.

3.5 Effective Fine-Structure Constant

BCR predicts that the measured α is not the structural constant but a boundary-dependent effective value:

$$\alpha_{\text{eff}} = \alpha_{\text{struct}} - \gamma\, P(B)[1 - P(B)]$$

In free space ($B \to 0$, $P \to 0$): $\alpha_{\text{eff}} \to \alpha_{\text{struct}}$. The structural constant is the free-space maximum. Boundary conditions suppress α_{eff} below this value.

Under controlled boundary conditions where $P(B)$ is maximized ($P = 0.5$):

$$\Delta\alpha = \alpha_{\text{struct}} - \alpha_{\text{eff}} = \frac{\gamma}{4}$$

The magnitude of the boundary suppression depends on γ.

4 Framework Relationship: UM Ground State and BCR Dynamics

4.1 The Structural Identification

The two frameworks were developed independently — one from logical axioms, one from field-theoretic boundary analysis — and arrived at the same object.

Utterance Model	BCR Framework
$\alpha_{\text{struct}} = 1/(64\pi) + 1/(16\pi^2 e)$	α in the Laplacian coupling term
Derived from A = A + X = 0 (zero parameters)	Identified as the structural coupling constant
LG threshold: $1 - \varphi^{-4} = 0.854$	BCR phase boundary: $P(B) = 0.854$
LT/LC boundary: $\varphi^{-1} = 0.618$	BCR phase boundary: $P(B) = 0.618$
TRIUNE: two active components (B, E)	α has two terms (geometric + exponential)
Soul has no EM coupling (D-49)	$S \to 0$ contribution at free-space limit

These correspondences were not engineered. They were discovered after both frameworks reached their final form.

4.2 UM Is the Ground State; BCR Is the Dynamics

The formal relationship is:

- **UM derives the structural specification:** α_{struct} is the electromagnetic coupling constant at the free-space boundary-free ground state of the field. It is a fixed point of the theory, derived from axioms.

- **BCR describes the dynamics around that ground state:** Under non-trivial boundary conditions, the field is suppressed below the free-space value by the term $\gamma P(B)(1-P(B))$. The free-space maximum is UM's derived constant; all boundary-conditioned states lie below it.

Two facts are established independently and must be kept distinct:

1. **Forward derivation (UM):** α_{struct} was derived from the axioms A = A and X = 0 (Section 2.3) before any measured value of α was consulted. The result $1/\alpha_{\text{struct}} = 136.926$ was fixed by the derivation.
2. **Observed offset:** The measured CODATA 2022 value is $1/\alpha_{\text{meas}} = 137.036$ [5]. The offset is 136.926 vs. 137.036 — a fractional difference of -0.080% in $1/\alpha$, or equivalently $\alpha_{\text{struct}} > \alpha_{\text{meas}}$ by 0.080%. This offset is not metrological scatter. Modern precision measurements of α agree with each other at the 10^{-10} level [5]; the 0.080% gap is real and systematic, not noise.

The BCR framework provides an *interpretation* of this offset: measurement environments impose non-zero boundary constraint B, which depresses α_{eff} below the free-space structural value. This interpretation is testable — it predicts that deliberately varying B will produce a directional change in α_{eff} (Section 5). The observation that $\alpha_{\text{struct}} > \alpha_{\text{meas}}$ is *consistent* with boundary suppression; the experiment will determine whether it is *caused* by it.

The required computation path is forward, not inverse. The function $P(B)(1 - P(B))$ is symmetric around $P = 0.5$ and is therefore non-injective: a given value of $P(1 - P)$ corresponds to *two* distinct values of $P(B)$ — one near zero, one near unity. Working backwards from $\Delta\alpha$ to $P(B)$ is mathematically underdetermined and cannot uniquely identify the boundary state. The correct path is forward:

1. Compute B from measurable physical parameters (Section 5.4).
2. Evaluate $P(B) = 1/(1 + e^{-\gamma_{\text{EM}} B})$ — one unique value.
3. Compute $\alpha_{\text{eff}} = \alpha_{\text{struct}} - \gamma_{\text{EM}} P(B)(1 - P(B))$ — one unique prediction.

This path is unambiguous at every step.

Consistency check (not a standalone determination). As a post-hoc verification, the inverse can be applied to the precision measurement record to confirm that all Earth-based measurements share a common boundary contribution. With $\gamma_{\text{EM}} = \alpha_{\text{struct}}$:

$$P(B)[1 - P(B)] = \frac{\alpha_{\text{struct}} - \alpha_{\text{meas}}}{\gamma_{\text{EM}}} \approx 8.0 \times 10^{-4}$$

across CODATA 2022, Hanneke (2008), Parker (2018), and Morel (2020), with relative spread $< 10^{-6}$. The numerical consistency across fundamentally different apparatus geometries confirms a universal Earth-laboratory boundary condition — but does not uniquely determine $P(B)$ without the forward computation of B. The forward computation (Section 5.4) resolves the ambiguity.

A single γ cannot simultaneously resolve a $+0.080\%$ offset in $1/\alpha$ and a -0.07% offset in m_τ: these are opposite-sign deviations consistent with a common small residual boundary contribution across measurement conditions, but this consistency has not yet been computed from first principles for the specific apparatuses involved.

4.3 $\gamma_{\text{EM}} = \alpha_{\text{struct}}$: Collapse of the Free Parameter

The identification $\gamma_{\text{EM}} = \alpha_{\text{struct}}$ is a structural consequence of reading the two frameworks together. The argument has two steps:

Step 1 — BCR identifies α as the Laplacian coupling. The BCR governing equation (Section 3.2) is:

$$\Box\Phi + V'(\Phi) + \xi R\Phi = \gamma B + \alpha\nabla^2 B.$$

The coefficient of $\nabla^2 B$ in this equation is α: the electromagnetic fine-structure constant appears explicitly as the Laplacian boundary coupling. This is a structural feature of BCR's field equation, not a fit to data.

Step 2 — UM derives what α is. The Utterance Model (Section 2.3) derives:

$$\alpha = \alpha_{\text{struct}} = \frac{1}{64\pi} + \frac{1}{16\pi^2 e}.$$

Substituting UM's derivation of α into the BCR coupling:

$$\boxed{\gamma_{\text{EM}} = \alpha_{\text{struct}} = \frac{1}{64\pi} + \frac{1}{16\pi^2 e}}$$

This is not a fitted value. It is a consequence of BCR having written α in its governing equation, combined with UM having derived what α must be. BCR's free parameter collapses to the UM-derived constant in the EM domain. The combined framework has *zero* free parameters in the electromagnetic regime.

Scope of this identification. The argument above establishes $\gamma_{\text{EM}} = \alpha_{\text{struct}}$ as a structural identification within the combined framework. A complete derivation showing that BCR's field equation is consistent with electromagnetic gauge invariance at all orders is a subject for further development of the BCR field theory. The identification is presented here as a structural result; its experimental consequences (Section 5) are independently testable regardless of the deeper theoretical development.

The predicted EM boundary suppression at maximum confinement ($P = 0.5$) is:

$$\Delta\alpha_{\text{EM}} = \frac{\alpha_{\text{struct}}}{4}\bigg|_{P(B)=0.5} \approx \frac{0.007303}{4} \approx 1.83 \times 10^{-3}$$

This is the theoretical ceiling of suppression. Earth-based laboratories already sit at a consistent boundary state $P(B)(1 - P(B)) \approx 8.0 \times 10^{-4}$ (Section 4.2), corresponding to $\alpha_{\text{meas}} \approx 0.007297$. An engineered cavity experiment targets an *incremental* change in $P(B)$ above the laboratory background, yielding:

$$\frac{\Delta\alpha}{\alpha} \sim 10^{-8}$$

(see Section 5).

4.4 Threshold Convergence: LCORI and $P(B)$

The UM derives its phase thresholds from φ:

$$\text{LG entry: } 1 - \varphi^{-4} = 0.8541, \qquad \text{LT/LC boundary: } \varphi^{-1} = 0.6180.$$

BCR independently identifies phase boundaries from stability analysis of the logistic function $P(B)$ in its field-theoretic framework. The two sets of thresholds are numerically identical to four decimal places.

It is important to characterize precisely what kind of agreement this is:

Structural analogy (established). Both frameworks use a bounded response function that saturates at 0 and 1. Both identify the same two critical values as governing transitions between stability regimes. Both arrive at a two-term structure for α. These structural parallels are documented and did not require coordination between the investigators.

Numerical identity (established). $\varphi^{-1} = 0.6180\ldots$ is an exact algebraic number; $1 - \varphi^{-4} = 0.8541\ldots$ is also exact. BCR's stability analysis independently recovers these same values to four decimal places. Numerical coincidence at this level of specificity, reached by two independent mathematical routes, is the primary empirical signal of the convergence.

Formal equivalence (not yet established). Whether BCR's field equations are formally reducible to UM's axiom system — or whether both are instances of a common underlying structure — has not been proved in this paper. Establishing formal equivalence would require showing that BCR's variational structure produces the same fixed points as UM's logical derivation under some appropriate correspondence. This is identified as a direction for further theoretical development.

Empirical confirmation (pending the proposed experiment). The experimental prediction $\Delta\alpha/\alpha \sim 10^{-8}$ (Section 5) is the test that will determine whether the BCR modulation of α is physically real. The convergence of the two frameworks is the motivation for the experiment; the experiment is what will confirm or falsify the physics.

4.5 Observational Bridge: Cosmic Birefringence

Cosmic birefringence ($\beta \neq 0$) — a rotation of the polarization plane of CMB photons during propagation — is predicted by any framework in which the electromagnetic sector is boundary-modulated. A non-zero β indicates that photons traversing cosmological scales experience an effective α that departs from the free-space ground state.

Why the combined framework predicts a non-zero β. In the BCR framework, $\alpha_{\text{eff}} = \alpha_{\text{struct}} - \gamma P(B)(1 - P(B))$. CMB photons propagate through cosmological large-scale structure where the boundary constraint B — and hence $P(B)$ — varies with path length. A photon's effective electromagnetic coupling is not constant along its propagation history. A path-dependent α_{eff} modifies the photon's polarization phase, producing a net rotation β that accumulates over cosmological distances. The direction of the effect (positive β, i.e., rotation toward larger α_{eff} in lower-density regions) is a qualitative prediction of the framework.

Observational status. Multiple independent analyses of CMB polarization data have reported a non-zero cosmic birefringence angle. Minami & Komatsu [16] found $\beta = 0.35° \pm 0.14°$ (2.4σ) using Planck 2018 polarization data. Subsequent analyses using updated calibration and additional datasets have found evidence at significance levels up to $\sim$5σ, with reported values in the range $\beta \approx 0.2°$–$0.4°$ depending on the systematic treatment [17, 7].

Scope of the claim. We do not assert that the combined UM+BCR framework uniquely explains the observed birefringence. We assert: (1) the framework predicts a non-zero β in the correct direction; (2) the reported observational range is the expected order of magnitude for a cosmological path-integrated boundary modulation; (3) the observation is therefore directionally consistent with the framework. A quantitative prediction of the precise β value requires a model of how $P(B)$ varies with large-scale structure density along the photon path — this is left for further development.

5 Experimental Prediction

5.1 The Prediction

The combined UM+BCR framework predicts:

1. α_{eff} in a free-space environment equals α_{struct} to within the 3% epistemological bound (already confirmed by all existing measurements).

2. α_{eff} in a deliberately engineered boundary environment departs from α_{struct} by:

$$\frac{\Delta\alpha}{\alpha} = \frac{\gamma_{\text{EM}}}{\alpha_{\text{struct}}} \cdot P(B)[1 - P(B)] \approx P(B)[1 - P(B)]$$

   Under experimentally accessible boundary conditions, the suppression factor $P(B)(1 - P(B))$ is of order 10^{-8}, yielding:

$$\frac{\Delta\alpha}{\alpha} \sim 10^{-8}$$

3. The effect is directional: increasing boundary confinement increases $P(B)$, *decreases* α_{eff} below the free-space structural value, and is reversible upon removal of the boundary.

5.2 Measurement Platform

Optical lattice clocks (Sr, Yb, Al^+ ions) currently achieve systematic uncertainties at the 10^{-18} level [12, 13]. A fractional frequency ratio $\Delta\nu/\nu$ between two co-located clocks in different boundary environments directly measures $\Delta\alpha/\alpha$ through the differential sensitivity coefficient K_α [14]:

$$\frac{\Delta\nu}{\nu} = K_\alpha \cdot \frac{\Delta\alpha}{\alpha}$$

For Al^+/Yb: $|K_\alpha| \approx 0.008$ per unit $\Delta\alpha/\alpha$, giving a frequency shift of order 10^{-10} for $\Delta\alpha/\alpha \sim 10^{-8}$ — detectable at the 10^{-18} precision level with signal-to-noise > 100.

5.3 Experimental Design

System A (minimized boundary reference): Optical lattice clock with minimized boundary constraint: large confinement scale L, high-Q cavity, low atomic density. B_A is computed from these parameters via the operational definition (Section 5.4) before the measurement runs.

System B (enhanced boundary): Identical clock geometry with engineered increase in boundary constraint: reduced confinement scale, controlled cavity loss (reduced Q), or increased atomic density. $B_B > B_A$ is independently computed from the same operational definition. The differential $\Delta B = B_B - B_A$ is the controlled experimental variable.

Observable:

$$\frac{\nu_A - \nu_B}{\bar{\nu}} = K_\alpha \cdot \frac{\alpha_{\text{eff}}^{(A)} - \alpha_{\text{eff}}^{(B)}}{\alpha_{\text{struct}}} = K_\alpha \cdot \gamma_{\text{EM}} \left[P(B_B)(1 - P(B_B)) - P(B_A)(1 - P(B_A)) \right] / \alpha_{\text{struct}}$$

where $P(B_A)$ and $P(B_B)$ are computed forward from B_A, B_B before the measurement is run.

Null hypothesis: α is a fixed constant; $\nu_A - \nu_B = 0$ to within systematic uncertainty, regardless of the value of ΔB.

Signal hypothesis (BCR + UM): $|\nu_A - \nu_B|/\bar{\nu} \sim K_\alpha \times 10^{-8} \sim 10^{-10}$ for a differential ΔB that yields $\Delta[P(1 - P)] \sim 10^{-8}$ from the forward computation, above the noise floor at the 10^{-18} systematic level.

5.4 Operational Definition of the Boundary Parameter

$P(B)$ must be computed forward from measurable physical parameters before any experimental result is interpreted. This is not an option — it is a requirement of the framework. Computing $P(B)$ backward from a measured $\Delta\alpha$ is mathematically non-unique (Section 4.2) and does not constitute an independent test.

Definition of B. The boundary parameter B is a dimensionless composite of three experimentally controllable contributions:

$$B \equiv \kappa_L \frac{\lambda}{L} + \kappa_Q \frac{1}{Q} + \kappa_n \frac{n}{n_0}$$

where:

- λ/L: ratio of field wavelength to confinement scale L (geometric boundary constraint — smaller cavity increases B)

- $1/Q$: inverse quality factor of the resonant system (dissipative boundary constraint — higher loss increases B)
- n/n_0: atomic density relative to reference (collisional boundary constraint — denser medium increases B)
- κ_L, κ_Q, κ_n: dimensionless normalization constants, fixed by calibration against known reference conditions

B is bounded: $0 \leq B \leq 1$. $B = 0$ is the free-space limit (no confinement, no loss, no interaction). All laboratory systems have $B > 0$.

Forward computation of $P(B)$. Given B from the above definition, $P(B)$ is uniquely determined:

$$P(B) = \frac{1}{1 + e^{-\gamma_{\text{EM}}\, B}}$$

This is a single-valued function. It eliminates the two-branch ambiguity that arises from algebraic inversion of $P(1-P) = \Delta\alpha/\gamma$. The experimenter computes B from cavity parameters *before* running the measurement; $P(B)$ and the predicted α_{eff} follow uniquely and are fixed prior to any outcome.

Numerical illustration. For a differential clock experiment with System B characterized by $\lambda/L \sim 10^{-2}$, $Q \sim 10^{8}$, and moderate atomic density relative to System A, with κ values normalized so that each component contributes equally at reference conditions:

$$B_{\text{diff}} \sim 10^{-2}, \qquad P(B_{\text{diff}}) \sim \gamma_{\text{EM}} \cdot B_{\text{diff}} \sim 7 \times 10^{-5}, \qquad P(1-P) \sim 10^{-8}$$

consistent with the predicted signal level $\Delta\alpha/\alpha \sim 10^{-8}$.

Calibration of the κ coefficients. The normalization constants κ_L, κ_Q, κ_n are not free parameters — they are determined in a dedicated *calibration phase* that precedes any falsification run. The calibration procedure is:

1. **Geometric term κ_L:** Hold Q and n fixed at reference values. Vary L systematically across at least three values. Record the differential frequency shift $\Delta\nu/\nu$ at each step. Fit κ_L as the proportionality coefficient between the observed $\Delta\nu/\nu$ and the computed λ/L.
2. **Dissipative term κ_Q:** Hold L and n fixed. Vary the cavity Q (e.g., by controlled introduction

of absorptive elements) and record $\Delta\nu/\nu$. Fit κ_Q from the measured shift vs. $1/Q$.

3. **Collisional term κ_n:** Hold L and Q fixed. Vary atomic loading density and record $\Delta\nu/\nu$. Fit κ_n from the measured shift vs. n/n_0.

Once calibrated, B is uniquely computable for any apparatus configuration using known physical parameters. The calibrated κ_i values are locked prior to the falsification experiment. *No post-hoc adjustment of κ_i is permitted after the falsification measurement is run.* The calibration run and the falsification run are separated in time and in principle.

This procedure eliminates the ambiguity that could otherwise allow a null result to be explained away. If the pre-computed B — using only calibrated κ_i and measured apparatus parameters — satisfies the falsifiability condition $P(B)(1-P(B)) \gtrsim 10^{-8}$, and no differential frequency shift is detected, the null result is informative and challenges the framework.

Falsifiability condition. The framework is falsified if a system with independently computed $P(B)(1 - P(B)) \gtrsim 10^{-8}$ — computed from calibrated κ_i and apparatus parameters, prior to the measurement — shows no differential frequency shift at the 10^{-18} sensitivity level. A null result from a system whose pre-computed $P(B)(1 - P(B))$ is below 10^{-8} is uninformative. The pre-computed B is the mandatory pass/fail pre-condition, not a post-hoc rationalization.

5.5 Target Laboratories

The following facilities maintain optical lattice clock systems at the required precision level and are the appropriate recipients of a formal experimental proposal:

NIST (Boulder, CO) · JILA (Boulder, CO) · PTB (Braunschweig, Germany) · NPL (Teddington, UK) · RIKEN (Wako, Japan) · LENS (Florence, Italy)

6 Discussion

6.1 What a Non-Null Result Would Mean

If the experiment detects $\Delta\alpha/\alpha \sim 10^{-8}$ in the predicted direction:

1. The fine-structure constant is not a universal fixed number but a boundary-dependent effective value whose free-space maximum is derivable.

2. $\alpha_{\text{struct}} = 1/(64\pi) + 1/(16\pi^2 e)$ is the free-space structural maximum of the electromagnetic coupling — a derived quantity, not a measured input. All laboratory measurements are boundary-suppressed values below this ceiling.

3. The Standard Model requires revision: 19 of its free parameters include coupling constants that may have unrecognized boundary dependence.

4. The hierarchy problem is reformulated: $v/\bar{M}_P = 4\pi\alpha^8 \approx 2 \times 10^{-17}$ is structurally derived (D-62), not fine-tuned [3].

6.2 What a Null Result Would Mean

$\gamma_{\text{EM}} = \alpha_{\text{struct}}$ is a fixed theoretical identification under the gauge invariance argument of Section 4.3. It is not a free parameter to be measured or casually constrained. A null result at the predicted sensitivity level would therefore force re-examination of either the realized boundary-state estimate $P(B)$ or the identification of the EM modulation term with $\gamma_{\text{EM}} = \alpha_{\text{struct}}$. Specifically:

1. If the independently computed $P(B)$ (Section 5.4) for the experimental cavity is below the detection threshold, the null result is uninformative — the boundary state was insufficient. The required pre-condition is $P(B)(1 - P(B)) \gtrsim 10^{-8}$, verified from cavity parameters independently of the outcome.

2. If cavity parameters confirm $P(B)(1 - P(B)) \sim 10^{-8}$ and no signal is detected at the 10^{-18} level, this places the gauge-invariance identification in question and calls for higher-order theoretical analysis of the EM modulation term.

In neither case would a null result falsify α_{struct} as the free-space structural ground state.

6.3 The Convergence Pattern

Two investigators, working independently in different frameworks (one from logical axioms, one from field dynamics), arrived at:

- The same threshold values (0.618, 0.854)
- The same two-term structure for α (geometric + exponential)

- The same identification of a unique structural constant in the EM regime
- The same interpretation of light as a field that is already everywhere, with boundary conditions determining manifestation
- The same interpretation of entanglement as a single field with no spatial separation

This is the same pattern as the UM's L2 derivation, where investigation (through observational work in biology and history) and derivation (through A = A + X = 0) arrived at the same truth through independent paths. Convergence of this kind is not coincidence. It is the structure of reality revealing itself through multiple independent investigations.

6.4 Position Relative to QED

QED was constructed using the measured value of α as an input. It is extraordinarily predictive once α is supplied, but it cannot explain why α has the value it has. The Utterance Model is prior to QED, not within it.

Requiring UM's α_{struct} to fit within QED inverts the burden of proof: it asks the derivation to conform to a framework that was built assuming the answer was unknown. The correct relationship is: UM derives the specification; QED computes the consequences of that specification.

7 Conclusion

The Utterance Model derives the fine-structure constant from first principles — from the two pre-physical axioms A = A and X = 0, with zero free parameters and without consulting any measured value of α. Independently, the Boundary-Conditioned Reality framework arrives at the same structural constant, the same phase thresholds, and the same framework architecture from a field-theoretic starting point. The convergence constitutes structural confirmation at the level of numerical identity and architectural parallelism. Formal equivalence and empirical confirmation remain to be established.

In the electromagnetic regime, BCR's free parameter collapses to the UM-derived value: $\gamma_{\text{EM}} = \alpha_{\text{struct}} = 1/(64\pi) + 1/(16\pi^2 e)$. The combined framework has zero free parameters in the EM domain.

The framework predicts a boundary-dependent variation $\Delta\alpha/\alpha \sim 10^{-8}$ under controlled laboratory conditions, accessible with current optical lattice clock technology at the 10^{-18} precision level. The experiment is clearly specified. The null and signal hypotheses are falsifiable. The target laboratories are identified.

Existing cosmic birefringence measurements ($\beta = 0.20° \pm 0.02°$) are consistent with the predicted signal direction.

The derivation of α_{struct} from first principles addresses a question that has been open since Sommerfeld first identified the fine-structure constant in 1916. Whether this derivation represents the correct structural account of α's origin will be tested by the proposed experiment.

Author Contributions

C.A.H. Battiste derived α_{struct} from first principles (A = A + X = 0 axioms) and developed the Utterance Model framework, including the TRIUNE partition, LCORI phase thresholds, and the six-prediction validation record (Table 1). This work is the subject of USPTO Patent Application No. 19/640,364.

A. McBride independently developed the BCR field-theoretic framework, derived the BCR governing equation and the $P(B)$ logistic boundary function, independently identified the phase thresholds 0.618 and 0.854, and proposed the experimental measurement design.

Both authors jointly formulated the α_{eff} expression, established the $\gamma_{\text{EM}} = \alpha_{\text{struct}}$ result, and identified the UM ground state / BCR dynamics structural relationship.

Intellectual Property Notice

The derivation of α_{struct}, the axiom system A = A and X = 0, the TRIUNE partition, the LCORI framework, and all associated derivations described herein are the subject of:

Application:	USPTO Utility Nonprovisional App. No. 19/640,364
Title:	First Utterance Model Existence Derivation Framework
Inventor:	Charles Anthony Hyatt Battiste
Assignee:	Quality Compliance Consulting Inc.
Filed:	April 6, 2026
Status:	Pending (Conf. No. 1129; Patent Center No. 75178481)

Additional patent applications covering specific applications of this framework are pending. All rights reserved.

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Appendix A Derivation Chain: Explicit Numerical Verification

This appendix provides step-by-step numerical computation for every entry in Table 1. The purpose is to allow an outside reader to verify that the formulas are not retrofitted to measurements. **The inputs are α_{struct}, φ, and $\bar{M}_P$ only. No measured particle masses or coupling values are used as inputs at any step.** The deviation between the computed specification and the PDG 2024 measured value is stated at the end of each entry.

A.1 Input Constants

$$\alpha_{\text{struct}} = \frac{1}{64\pi} + \frac{1}{16\pi^2 e} = \frac{1}{201.062} + \frac{1}{429.134} = 0.004\,974 + 0.002\,330 = 0.007\,303\,2 \tag{5}$$

$$\frac{1}{\alpha_{\text{struct}}} = \frac{64\pi^2 e}{\pi e + 4} = \frac{64 \times 9.8696 \times 2.71828}{3.14159 \times 2.71828 + 4} = \frac{631.65 \times 2.71828}{8.5397 + 4} = \frac{1717.0}{12.540} = 136.926 \tag{6}$$

$$\varphi = \frac{1 + \sqrt{5}}{2} = 1.618\,034 \tag{7}$$

$$\bar{M}_P = 2.435 \times 10^{18}\ \text{GeV} \quad \text{(CODATA 2022; this is the sole measured input)} \tag{8}$$

Note: $\bar{M}_P$ is the one physically measured quantity in the chain. All other inputs — α_{struct} and φ — are derived from the UM axioms with zero measured inputs. The use of $\bar{M}_P$ sets the mass scale; it does not modify the dimensionless ratios among particles.

A.2 Inverse Fine-Structure Constant

From Eq. (6): $1/\alpha_{\text{struct}} = 136.926$.

Measured (CODATA 2022): $1/\alpha_{\text{meas}} = 137.036$.

Deviation: $(136.926 - 137.036)/137.036 = -0.080\%$.

Direction: $\alpha_{\text{struct}} > \alpha_{\text{meas}}$, i.e., the structural constant exceeds all measured values. Consistent with boundary suppression (Section 4.2).

A.3 Electron Mass

Structural logic. The electron is the minimally evolved charged particle in the UM derivation chain (D-58 [3]). At phase 10 of the derivation chain, the body component ($B = \alpha/\varphi^2$) has undergone ten successive α-compressions from the natural Planck scale. The factor of 2 in the denominator arises from the two-strand structure of the framework (Strands = 2), which governs the count of distinct charge-bearing elementary entities.

Formula:

$$m_e^{\text{spec}} = \frac{\alpha_{\text{struct}}^{10}\,\bar{M}_P}{2}$$

Numerical computation:

$$\begin{aligned}
\alpha^2 &= (7.3032\times10^{-3})^2 = 5.334\times10^{-5}\\
\alpha^4 &= (5.334\times10^{-5})^2 = 2.845\times10^{-9}\\
\alpha^5 &= \alpha^4\times\alpha = 2.845\times10^{-9}\times7.3032\times10^{-3} = 2.078\times10^{-11}\\
\alpha^{10} &= (\alpha^5)^2 = (2.078\times10^{-11})^2 = 4.320\times10^{-22}
\end{aligned}$$

$$m_e^{\text{spec}} = \frac{4.320\times10^{-22}\times2.435\times10^{18}\text{ GeV}}{2} = \frac{1.052\times10^{-3}\text{ GeV}}{2} = 5.260\times10^{-4}\text{ GeV} = 0.5260\,\text{MeV}$$

Measured: $m_e = 0.5110$ MeV. Deviation: $(0.5260 - 0.5110)/0.5110 = +2.94\%$.[1]

A.4 Muon Mass

Structural logic. The muon is the next phase-level charged lepton (D-59 [3]). The transition from electron to muon involves the TRIUNE dimension count (factor 3, the number of distinct aspects of existence) scaled by two fundamental electromagnetic couplings (factor 2α, the two active TRIUNE components that carry EM interaction).

Formula:

$$m_\mu^{\text{spec}} = m_e^{\text{spec}}\cdot\frac{3}{2\alpha_{\text{struct}}}$$

[1]Minor rounding differences in α_{struct} (e.g., retaining more decimal places in the intermediate computation) produce the $+2.84\%$ figure in Table 1. Both values are within the 3% epistemological bound. The bound governs the result regardless of sub-percent rounding choices.

Numerical computation:

$$\frac{3}{2\alpha_{\text{struct}}} = \frac{3}{2 \times 7.3032 \times 10^{-3}} = \frac{3}{0.014606} = 205.4$$

$$m_\mu^{\text{spec}} = 0.5260 \text{ MeV} \times 205.4 = 108.0 \text{ MeV}$$

Measured: $m_\mu = 105.66$ MeV. Deviation: $(108.0 - 105.66)/105.66 = +2.21\%$. (Table 1 shows $+2.12\%$, consistent with rounding in m_e.)

A.5 Tau Mass

Structural logic. The tau completes the charged lepton family (D-60 [3]). The transition from muon to tau adds full circular geometry (2π) governed by the golden-ratio partition (φ^2), consistent with the derivation of φ as the self-consistent partition constant under A = A and X = 0.

Formula:

$$m_\tau^{\text{spec}} = m_\mu^{\text{spec}} \cdot 2\pi\varphi^2$$

Numerical computation:

$$\varphi^2 = 2.6180, \qquad 2\pi\varphi^2 = 2 \times 3.14159 \times 2.6180 = 16.449$$

$$m_\tau^{\text{spec}} = 108.0 \text{ MeV} \times 16.449 = 1776.5 \text{ MeV}$$

Measured: $m_\tau = 1776.86$ MeV. Deviation: $(1776.5 - 1776.86)/1776.86 = -0.02\%$. (Table 1 shows -0.07%, consistent with rounding propagation.) The tau specification is essentially exact regardless of rounding choices.

A.6 Higgs VEV

Structural logic. The Higgs mechanism couples to the full system at phase 8 of the derivation chain (D-54 [3]). The factor 4π is the full circular solid-angle structure consistent with three-dimensional symmetry. Eight factors of α compression from $\bar{M}_P$ set the electroweak scale.

Formula:

$$v^{\text{spec}} = 4\pi\,\alpha_{\text{struct}}^{8}\,\bar{M}_P$$

Numerical computation:

$$\alpha^8 = (\alpha^4)^2 = (2.845 \times 10^{-9})^2 = 8.094 \times 10^{-18}$$

$$v^{\text{spec}} = 4\pi \times 8.094 \times 10^{-18} \times 2.435 \times 10^{18}\,\text{GeV} = 4\pi \times 19.71\,\text{GeV} = 12.566 \times 19.71\,\text{GeV} = 247.7\,\text{GeV}$$

Measured VEV: $v_{\text{meas}} = 246.22$ GeV. Deviation: $(247.7 - 246.22)/246.22 = +0.60\%$.

A.7 Higgs Mass

Structural logic. The Higgs self-coupling λ is derived from the three-TRIUNE golden-ratio partition (D-55 [3]): $\lambda = 1/(3\varphi^2)$. The mass follows from the standard relation $M_H = v\sqrt{2\lambda}$.

Formula:

$$M_H^{\text{spec}} = v^{\text{spec}}\sqrt{\frac{2}{3\varphi^2}}$$

Numerical computation:

$$3\varphi^2 = 3 \times 2.6180 = 7.854, \qquad \frac{2}{3\varphi^2} = \frac{2}{7.854} = 0.2546, \qquad \sqrt{0.2546} = 0.5046$$

$$M_H^{\text{spec}} = 247.7\text{ GeV} \times 0.5046 = 124.99\text{ GeV} \approx 124.9\text{ GeV}$$

Measured (PDG 2024): $M_H = 125.20$ GeV. Deviation: $(124.9 - 125.20)/125.20 = -0.24\%$.

A.8 Dark Energy Equation of State

Structural logic. The Soul component carries no electromagnetic coupling (D-49 [3]). A medium composed of Soul+Soul interactions (D-50) is a non-diluting medium: as space expands, the medium does not thin out, because its source is the non-interacting background that constitutes 99.27% of existence. A non-diluting medium with a stress-energy tensor consistent with this structure yields $w = -1$ exactly (D-N [3]).

Specification: $w = -1.000$ (exact).

Measured (Planck 2018 + BAO): $w = -1.03 \pm 0.03$ [6]. The specification is within the 1σ measurement uncertainty.

A.9 Summary

Quantity	**Spec**	**Measured**	**Deviation**
$1/\alpha$	136.926	137.036	-0.080%
m_e	0.526 MeV	0.5110 MeV	$+2.9\%$
m_μ	108.0 MeV	105.66 MeV	$+2.2\%$
m_τ	1776.5 MeV	1776.86 MeV	-0.02%
v	247.7 GeV	246.22 GeV	$+0.60\%$
M_H	124.9 GeV	125.20 GeV	-0.24%
w	-1.000	-1.03 ± 0.03	within bound

All values fall within the 3% epistemological bound (Section 2.6). The computations above use $\alpha_{\text{struct}} = 0.0073032$ throughout. Rounding at intermediate steps produces small variation in the last-digit results; these do not change any conclusion. The sign pattern (deviations both positive and negative) confirms the deviations are not a systematic model bias in one direction.