The Superlight Unified Theory of the Universe
Version 6.1 — Falsifiability Under Fire

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Abstract

This paper introduces the Superlight Unified Theory, a falsifiable framework proposing a Lorentz-invariant hidden U(1) gauge field—Superlight—as a foundational substrate of physical reality. The field obeys Maxwell-like dynamics and couples to a dimensionless observer current derived from measurable physiological coherence. A feeble portal coupling ϵ to electromagnetism enables indirect detection via precision instruments. We outline lock-in experimental protocols using interferometers, SQUIDs, and cryogenic cavities, with frequency-locked modulation, blinded controls, and replication thresholds. This framework offers a physically grounded route to explore correlations between cognitive coherence and field-level observables, extending testable physics into a novel regime.

1. Motivation Within EFT

Hidden U(1) sectors with kinetic mixing are the minimal, renormalizable extensions of the Standard Model. Loop-level mixing of order $\epsilon \sim 10^{-6}$–10^{-12} arises generically from heavy bi-charged states. No UV completion is required to justify laboratory-scale probes. We target a distinct regime: low-frequency boundary modulation in open systems, complementary to astrophysical and collider searches. Observable signatures arise from slow modulation of an effective susceptibility, not from accessing the field's carrier frequency.

2. Conceptual Foundations

Superlight is posited as a hidden abelian gauge field with portal coupling to electromagnetism. It is not a metaphor, but a field with definable dynamics, stress-energy contributions, and boundary modulation. Cognitive coherence is not equated with Superlight, but correlates with specific physiological states that modulate its boundary conditions.

3. Mathematical Framework

3.1. Field Dynamics

Let $A_{s\,\mu}$ be the Superlight gauge potential. The field strength tensor is:

$$F_{s\,\mu\nu} = \partial_\mu A_{s\,\nu} - \partial_\nu A_{s\,\mu}$$

3.2.   Effective Field Theory

We adopt the minimal extension:

$$\mathcal{L} = -\frac{1}{4}F_{s\,\mu\nu}F_s^{\mu\nu} - \frac{\epsilon}{2}F_{s\,\mu\nu}F_{\mathrm{EM}}^{\mu\nu} + \frac{1}{2}m_s^2 A_{s\,\mu}A_s^\mu + J_s^\mu A_{s\,\mu}$$

3.3.   Physiological Source Coupling

We define a preregistered physiological order parameter $\Upsilon(t, \mathbf{x})$ derived from phase-locking value (PLV) and cortical current source density (CSD). The source term is:

$$J_s^\mu(t, \mathbf{x}) = g\,\Pi^{\mu\nu}\partial_\nu\Upsilon(t, \mathbf{x})$$

and the boundary coupling is:

$$S_{\mathrm{int}} = \int_{\partial\mathcal{V}} g\,\Upsilon\,n_\mu A_s^\mu\,d\Sigma$$

This avoids circularity and grounds the coupling in measurable physiology.

4.   Three-Layer Architecture

We separate three layers:

- Physics: $(A_s^\mu, \epsilon, m_s, g)$

- Physiology: Υ (instrument-defined)

- Psychology: subjective reports (recorded but not used in coupling)

Predictions depend solely on (ϵ, m_s, g) and Υ. Subjective experience is decoupled from the source term.

5.   Experimental Protocols

5.1.   Interferometric Phase Modulation

A fiber delay interferometer with phase sensitivity $< 10^{-6}$ rad/$\sqrt{\mathrm{Hz}}$ is modulated by alternating cognitive tasks at 0.125 Hz. Predicted signal:

$$\mathrm{SNR} \approx \frac{\Delta\phi\,\sqrt{T\,\Delta f}}{S_\phi}$$

5.2. SQUID Flux Noise Differential

A gradiometric SQUID pair detects flux noise coherence at 0.2 Hz. Sham tasks and robot-playback isolate physiological effects.

5.3. Cryogenic Cavity Frequency Shift

Twin sapphire resonators at 4 K monitor differential frequency shifts during modulation. Allan deviation and comb injection validate detection.

5.4. Casimir Pressure Modulation

A microelectromechanical Casimir setup is modulated by task blocks. Pressure shifts are demodulated at the task frequency.

5.5. Optomechanical Force Noise

An optomechanical resonator monitors force noise coherence at 0.1 Hz. Blinded timing and reference channels isolate Superlight-induced effects.

5.6. State and Perturbation Tests

- Anesthesia contrast: signal drops under propofol-induced unresponsiveness.

- TMS causality: PLV disruption reduces signal amplitude proportionally.

- Spatial falloff: amplitude ratio across sensors matches near-field scaling.

- Frequency fingerprint: coherence confined to preregistered task bands.

- Cross-modality invariance: matched Υ yields matched amplitudes.

6. Power Thresholds and Replication

For $S_\phi = 10^{-6}$ rad/$\sqrt{\text{Hz}}$, $T = 3600$ s, $\Delta f = 0.01$ Hz:

$$\Delta\phi_{\min} \approx \frac{S_\phi}{\sqrt{T\Delta f}} \approx 1.7 \times 10^{-7} \text{ rad}$$

We preregister a 3σ threshold of 5×10^{-7} rad. Null results yield bounds on $g\epsilon$. Claims require replication in two external labs.

7. Exclusion Map and Prior Skepticism

We publish exclusion curves in $(\epsilon g, m_s)$ for each instrument. Null results expand the excluded region. Claims must exceed 3 and replicate externally. This addresses low prior probability concerns with pre-committed falsifiability.

8.   Scale Bridging Clarification

Observable effects arise from slow modulation of an effective susceptibility:

$$\delta\mathcal{O}(\omega_m) \propto \chi_{\text{eff}}(\omega_0; \epsilon, m_s) \cdot \widehat{\Upsilon}(\omega_m)$$

where ω_0 is the field's intrinsic scale and ω_m is the modulation band. This resolves the scale gap between neural coherence and field dynamics.

Appendix A — Comparative Framework

Criterion	Dark Matter	Quantum Consciousness	Superlight Unified Theory
Field-theoretic Lagrangian	Yes	No	Yes
Lab falsifiability	No	No	Yes (lock-in protocols)
Observer coupling	None	Vague	Explicit: $J_s^{\mu} = g\,\Pi^{\mu\nu}\partial_\nu\Upsilon$
Experimental controls	N/A	Rare	Blinded, differential, calibrated
Portal coupling to EM	None	None	$\mathcal{L}_{\mathrm{mix}} = \frac{\epsilon}{2}F_s F_{\mathrm{EM}}$
Philosophical clarity	Ontologically inert	Often circular	Correlational, not identity-based
Historical novelty	Established	Recycled	Discriminable, falsifiable, testable