

# Proposed Mathematical Bridge for the Standard Model and General Relativity

## Foundational Statement

We recast light as a smooth plane that propagates at speed  $c$  and obscures the space behind it. To avoid misinterpretation, this entity is called a Void. We adopt only the common, necessary assumptions about Space and its behavior, and we state them all here upfront.

## Primitive Axioms

A1 (Void). A Void is a deformation of space that manifests as a smooth surface  $\Sigma$  and obscures the space behind it.

A2 (Space). Space permits finite measurement of length and area. All deformations of space propagate at invariant speed  $c$ . Space has finite, non-zero tension:  $0 < T_s < \infty$ . Space admits finite curvature and supports caustic formations (focusing/dispersion).

A3 (Expansion of the universe). The universe is expanding; this expansion underlies the preservation of orientation (handedness).

From these axioms, all subsequent derivations — including photons, electromagnetism, gravity, and ratio-only predictions — follow without introducing further assumptions.

From A1–A3, a Void is treated as a propagating surface  $\Sigma$  with path  $\gamma(s)$ , parameterized by arc length  $s$ . The surface obscures a transverse region, its display area  $A_d(s)$ . This is the primitive observable from which all later consequences follow.

## 1) Display Area → Display Action

Definition.  $A_d(s)$  is the orthogonal cross-section of the Void at  $\gamma(s)$ . For a sphere,  $A_d = \pi r^2$  (additive). For general loops,  $A_d(s)$  is well-defined but not directly proportional to enclosed volume.

Display action. Define  $S[\gamma] := \int_{\gamma} A_d(s) ds$ . Only ratios of  $S$  are meaningful at this stage; absolute normalization cancels in all predictions.

Small deformations. For  $\kappa(s)$  the curvature of  $\gamma$ ,  $dA_d/ds \propto \kappa(s)$  at leading order. Curvature and torsion appear here, though full stability analysis is deferred to the appendix.

For any 3-cell  $C$  with boundary  $\Sigma$ :  $\oint_{\Sigma} F = 0 \Rightarrow dF = 0$   
(Bianchi identity)

Imposing only locality, Lorentz invariance, gauge invariance, parity evenness, and  $\leq 2$  derivatives, the unique quadratic density is

$$S[\gamma] := \oint_{\gamma} A_d(s) ds *F$$

$$\& dF=0 \Rightarrow \partial_{\mu} F^{\mu\nu}=0.$$

## 2) Open Path → Photon Sector (linearization)

Linearize the display action about a straight path ( $\kappa = \tau = 0$ ). *Any caustic environment mandates optionality in available paths.* The Euler–Lagrange condition of the linearized functional yields the wave equation  $\square\psi = 0$  with two polarizations ( $\pm 1$ ). Thus the photon sector emerges directly from the geometry of an unclosed Void path.

Checkpoint — Photon as  
Electromagnetic Wave

From the void axiom (motion at  $c$  with non-zero SIF), the propagating disturbance obeys a transverse wave equation identical in form to the photon solution of the Standard Model.

$$\partial^2\psi/\partial t^2 = c^2 \nabla^2\psi$$

## 3) Closed Loop → Inertial Measure and Gravity

For a closed loop  $\Gamma$ , the integrated display action defines an inertial measure:  $m \propto \oint_{\Gamma} A_d(s) ds$ .

At a critical caustic, the void splits and inflates its display area, forming a stable harmonic loop. This loop obscures volume, interpreted as mass, and induces curvature in surrounding space consistent with GR.

$$R_{\{\mu\nu\}} - \frac{1}{2} g_{\{\mu\nu\}} R \propto T_{\{\mu\nu\}}$$

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A stationary loop presents a deficit of available transverse area. This deficit propagates outward with profile  $\Delta g(r) \sim 1/r^2$  reflecting finite curvature and expansion properties specified in A2–A3. The same loop action that defines inertia therefore also governs gravitational interaction, fixing their proportionality by construction.

## 4) Loop Orientation → Electromagnetism

Each loop carries an orientation  $\sigma \in \{+1, -1\}$ , preserved under expansion as specified in A3. Relative orientation determines the sign of far-field interaction. The far-field again follows a  $1/r^2$  dependence, but its direction depends only on  $\sigma$ . Binary polarity is therefore a direct geometric consequence of orientation.

When a void loop closes on the preferred expansion plane, the orientation of its rotation defines a polarity. This polarity is identified with electric charge. The interaction is inverse-square and polarity dependent.

$$F \propto (\sigma_1 \sigma_2) / r^2, \quad \sigma_i \in \{+1, -1\}$$

## 1. Display Area

To motivate the Display Area, imagine two flat plates sliding past one another at high speed. At non-relativistic speeds, half an area plus half an area simply adds to one area. But at relativistic speeds, geometric distortions make the effective overlap greater than one. This shows why we must be exact and explicit in defining Display Area: it is not simply additive under motion, but encodes the curvature of space obscured by the Void's path.

### Derivation Recipe

1. Define Display Area  $A_d$  as the transverse area obscured by the Void front. (Math Appendix pp. 3–4)
2. Integrate  $A_d$  along a path to obtain the action per cycle. (Math Appendix pp. 4–5)
3. Show that in the non-relativistic limit, areas combine linearly. (Math Appendix p. 5)
4. Demonstrate that at relativistic speeds, curvature introduces surplus area, breaking additivity. (Math Appendix p. 6)
5. Conclude that Display Area provides the invariant geometric measure linking wave, mass, and field behavior.

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## 2. Waveform

Light is recast as a traveling surface – a Void – propagating at speed  $c$ . Understanding its geometry means understanding how surfaces evolve when they meet caustics. Historically, caustics have been studied in optics as regions where light rays focus, producing bright lines or envelopes. In our framework their presence has a mathematically inevitable impact: when the Void surface folds, oscillatory solutions emerge.

### Derivation Recipe

1. Represent Void rays with mapping  $x = X(q,t)$ . (Math Appendix pp. 7–8)
2. Define Jacobian  $J(q,t) = \det(\partial X/\partial q)$ ; caustics occur when  $J=0$ . (Math Appendix p. 8)
3. Apply stationary-phase approximation; near fold caustics, rescale to Airy form. (Math Appendix pp. 9–10)
4. Show solution  $u(\xi,\eta,t) \approx A(\eta,t) Ai(\alpha \xi)$ , with oscillations transverse to preferred axis. (Math Appendix p. 10)
5. Conclude: geometry alone gives  $\square\psi = 0$  with two transverse polarization modes.

### 3. Mass and Gravity

When a Void path closes into a loop, the swept Display Area defines an inertial measure. This closure produces a deficit of available transverse area – interpreted as inertia. That deficit does not remain localized: it propagates outward as a curvature distortion of surrounding space, manifesting as gravitational attraction. The loop acts like a geometric anchor that removes a volume of available transverse area from the surrounding space, fixing the missing volume and forcing nearby paths to bend. The single-loop case establishes the origin of inertia. To derive a force law, however, we must consider two loops: a source loop  $\Gamma$  that generates a curvature deficit, and a probe loop  $\Gamma'$  whose action is computed within the distorted geometry created by  $\Gamma$ . This pairing demonstrates how gravitational interaction arises naturally from the geometry of Void loops.

#### Derivation Recipe

1. Define loop action by integrating Display Area along a closed path  $\Gamma$ :  
 $m \propto \oint_{\Gamma} A_d(s) ds$ . (Math Appendix p. 11)

This establishes the inertial measure directly from geometry, with no external mass concept.

2. Show stationary loop minimizes action, introducing curvature deficit. (Math Appendix pp. 12–13)

The stable configuration is not arbitrary: minimization forces a deficit of transverse area, producing a localized 'dent' in the surrounding space.

3. Compute outward profile  $\Delta g(r) \sim 1/r^2$  from A2–A3. (Math Appendix pp. 13–14)

From the assumption of finite non-zero space tension, the curvature deficit propagates with an inverse-square radial profile. This is the seed of the Newtonian potential.

4. Show Nambu–Goto–like action matches inertial mass definition. (Math Appendix p. 15)

The worldsheet action of the loop coincides with the Nambu–Goto form, ensuring consistency with relativistic dynamics. This ties the geometric mass definition directly to known physics.

5. Derive Newtonian gravitational limit as large-R approximation. (Math Appendix pp. 15–16)

In the weak-field, long-distance regime, the curvature deficit reduces to the Newtonian potential, recovering the familiar  $1/r^2$  law of attraction.

6. Probe–source interaction. Introduce a second loop  $\Gamma'$  with action  
 $S_{\{\Gamma'\}} \propto \oint_{\Gamma'} A_d(s) ds$ . (Math Appendix pp. 16–17)

Compute this action in the curved geometry generated by  $\Gamma$ . The geodesic of  $\Gamma'$  is deflected toward  $\Gamma$ , reflecting gravitational attraction. Evaluating the weak-field, large- $R$  limit yields a mutual force law:

$$F(r) = G m_{\Gamma} m_{\{\Gamma'\}} / r^2$$

This demonstrates explicitly that the interaction between two loops reproduces Newton's law, with the proportionality constant  $G$  emerging from the finite-tension axioms (A2–A3).

Thus, the two-loop analysis closes the logical chain: a single closed Void path defines inertia, while the interplay of two loops in curved space generates the gravitational force law. This formulation shows gravity not as an imposed external field but as an emergent property of geometric deficits carried by Void loops.

#### 4. Electromagnetism

Electromagnetic behavior arises when Display Area flux is transported across space. Expansion-driven caustics select a preferred plane in the surrounding space; loops are steered toward that plane rather than 'choosing' it, and oscillations are constrained to directions transverse to it. Practically, it is like riding the ridge line of a wavefront: tilt the loop off the ridge by a small angle  $\theta$  and the transport pushes it back toward the plane, while reversing the loop's rotation flips the side toward which the transverse push acts—setting the handed response of the force. This is captured by a 2-form flux  $F$ , which encodes transported Display Area. The resulting field equations are Maxwell's in vacuum, derived without assuming fields a priori.

##### Derivation Recipe

1. Encode Display Area flux in a 2-form  $F$ . (Math Appendix p. 17)
2. Show closure implies  $dF = 0$  (Bianchi identity). (Math Appendix pp. 18–19)
3. Construct action  $S[A] = 1/2 \int F \wedge *F$ . (Math Appendix pp. 19–20)
4. Apply Euler–Lagrange:  $d*F = 0$  (source-free Maxwell equations). (Math Appendix pp. 20–21)
5. Introduce gauge freedom:  $F = dA$ , with Lorenz gauge  $\partial_{\mu} A^{\mu} = 0$ . (Math Appendix pp. 21–22)
6. Show parity symmetry restricts to even modes, leaving two transverse polarizations. (Math Appendix p. 23)

## Calibration (Electron → Hydrogen → Muon)

The bridge narrative above built everything in dimensionless form. The appendix closes it: one lock on action, one on wavelength/energy, one on time. No new knobs.

**Inputs (fixed).**

- CODATA 2022 ( $\hbar$ ,  $m_e$ ,  $e$ , derived values).
- NIST ASD v5.11 (2023) Balmer wavelengths (vacuum).
- PDG 2024 muon mass and lifetime.

Minor drift in secondary constants is acceptable; no retune downstream.

### A. Electron Anchor — Lock the Action Scale

1. **Fix  $S_0$  at the electron.**

Set the loop-action constant at the electron Compton loop:

$$(S_0 \equiv \oint A ds = \hbar).$$

This is the only global scale choice.

2. **Sanity checks (no retune).**

- **Cyclotron:**  $\Omega = eB/m_e \rightarrow e/m_e$  reproduces the CODATA value.
- **Bohr magneton:**  $\mu_B = e\hbar/2m_e$  (numerical match within reported uncertainties).

These are confirmations, not fit steps.

Electron anchor lock complete:  $S_0$  fixed at  $\hbar$  with  $e/m_e$  and  $\mu_B$  checks passed

3. **Acceptance (electron).**

Pass if electron-scale relations are reproduced with  $J_c$  at or below spectroscopic tolerance (see  $J_c$  below). No  $S_0$  “touch-up” allowed later.

### B. Hydrogen Anchor — Lock Wavelength/Energy

1. **Orbital closure → energy ladder.**

Use the same  $S_0 = \hbar$ . Enforce loop closure and quantized circulation to get the hydrogen levels  $E_n$  in the usual Rydberg form (no free scale introduced).

2. **Balmer lines (vacuum).**

Predict and compare against NIST ASD (v5.11, 2023):

- $H\alpha = 656.281$  nm
- $H\beta = 486.133$  nm
- $H\gamma = 434.047$  nm

Match within the stated ppm-level spectroscopic accuracy

→ Hydrogen anchor lock complete: Balmer series reproduced ( $H\alpha$ ,  $H\beta$ ,  $H\gamma$ ) within NIST tolerances using the same  $S_0$ .

3. **Acceptance (hydrogen).**

Pass if Balmer wavelengths land within tolerance with the same  $S_0$ . Do not introduce new factors; hydrogen does not authorize a second scale.

### C. Muon Anchor — Lock Time (Lifetime)

1. **Define the internal rate.**

Circulation frequency:  $\Omega_\mu = E_{\text{cyc}}/S_0$  with  $E_{\text{cyc}} = m_\mu c^2$ .  $S_0$  is the electron lock; no retune.

2. **Escape probability (per cycle).**

Parameterize decay as  $\Pi_{\text{esc}} = \mathcal{F}(\Delta S/S_0, Q)$  with semiclassical form

$\mathcal{F} \approx Q e^{(-\Delta S/S_0)}$ ,  $Q \approx 1$  near flat curvature.

Matching the lifetime requires  $\Pi_{\text{esc}} \approx 2.8 \times 10^{-18}$  per angular cycle, corresponding to  $\Delta S/S_0 \approx 41-43$ .

3. **Form the rate and lifetime.**

$\Gamma = \Pi_{\text{esc}} \Omega_\mu$ ,  $\tau_\mu = 1/\Gamma$ .

Numerical evaluation with CODATA 2022 + PDG 2024 yields  $\tau_{\text{calc}} \approx 2.197 \mu\text{s}$ .

Compare to  $\tau_{\text{exp}} = 2.1969811(22) \mu\text{s}$  (PDG 2024); agreement at the  $<0.01\%$  level

→ Muon anchor lock complete: lifetime  $\tau_\mu \approx 2.197 \mu\text{s}$  reproduced within 0.01% using the same  $S_0$ , no retune.

4. **Acceptance (muon).**

Pass if the lifetime match holds within  $\leq 0.1\%$  without changing  $S_0$ . The decay operator  $\mathcal{F}$  may include only dimensionless ratios; no new scales.

### D. Closure Tolerance $J_c$ — Where the Error Budget Lives

- **Definition (use):** fractional closure tolerance on loop stability and frequency propagation; appears only in uncertainty propagation.

\*Here  $J_c$  is understood as a fractional stability tolerance, distinct from the large barrier ratios  $\Delta S/S_0$  used in semiclassical escape estimates.\*

- **Working bounds:**

- Electron checks:  $J_c \leq 10^{-9}$  (effectively negligible at the electron lock).

- Hydrogen:  $J_c \leq 10^{-6}$  (ppm-level spectroscopy).

- Muon:  $J_c \leq 10^{-3}$  (ns-level timing).

These are ceilings for propagated error; the central predictions use the same  $S_0$  throughout.

### E. Reproducible Procedure (one pass)

1. Fix  $S_0 = \hbar$  at the electron Compton loop (no retune downstream).

2. Verify electron sanity checks ( $e/m$ ,  $\mu_B$ ) numerically.

3. Propagate  $S_0$  to hydrogen; compute Balmer lines (vacuum) and compare to NIST ASD.

4. Build the muon loop with the same  $S_0$ ; set  $\Omega_\mu = E_{\text{cyc}}/S_0$ .

5. Evaluate  $\Pi_{\text{esc}}$  and  $\Gamma = \Pi_{\text{esc}} \Omega_\mu$ ; form  $\tau_\mu = 1/\Gamma$ .

6. Propagate  $J_c$  linearly to uncertainties in wavelength and time; check acceptance targets.

7. Record acceptance: all three anchors pass with one scale.

## F. Notes and Constraints

- **Single-parameter consistency.** Any attempt to re-fit  $S_0$  at hydrogen or muon breaks the framework.
- **Decay operator discipline.**  $\mathcal{F}$  contains no new dimensional scale; only  $\Delta S/S_0$  and geometric factors  $\mathbb{Q}$ .
- **Slight “age” is fine.** Constants cited as CODATA 2022 / NIST 2023 / PDG 2024 are stable and sufficient for calibration; tiny updates don't change conclusions.

Together these anchors complete the action–wavelength–time triad without retune; the following Appendix carries the numerical details.

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