An Open Letter to CERN, DESY, and the Precision-Optics Community: Generalized 1-Form Flux Continuity, Bulk Topological Reductions, and Multi-Messenger Bounds on Extended Electrodynamics

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[*]Dimensional Electrodynamics Working Note: Resolution of Form-Degree Obstructions, Linear-Superposition Constraints, and Empirical Bounds Across Extended Maxwell Frameworks, (peterdeceuster5@gmail.com)

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Abstract

This document is written as an open letter to physicists at CERN, DESY, and associated precision-optics, high-energy, and astroparticle collaborations. Earlier working notes on cross-dimensional photonic continuity [1–13] proposed deforming four-dimensional Maxwell electrodynamics via bulk-induced currents, Higgs–photon portals, and axion-like couplings, while leaving open severe mathematical and physical ambiguities: inhomogeneous differential-form subtractions, vanishing five-dimensional actions on four-dimensional spacetime, singular decoupling limits, and the assumption that a fixed background current directly shifts the interference visibility of electrically neutral probe photons.

Here we resolve those obstructions into a mathematically consistent, gauge-invariant effective field theory. Separating four-dimensional deformations into *Class A* bilinear 2-form constitutive/axion portals and *Class B* conserved 3-form topological sources eliminates form-degree mismatches, restores exact variational and stress-energy accounting, and establishes the *Neutral-Photon Linear Superposition Theorem*: fixed external 3-form currents shift background fields without altering probe-photon dispersion or phase, whereas optical interferometers probe strictly Class A dynamical or bilinear operators. Confronting the resulting dimensionally homogeneous observables with LHAASO GRB 221009A, ALPS II, CAST, Planck+ACT, GW170817, and LHC Higgs-to-diphoton measurements demonstrates that laboratory optics achieves unique sensitivity not to static quadratic Lorentz-invariance violation, but to coherent ultralight axion/dark-photon backgrounds and resonant light-shining-through-a-wall cavities.

What follows is a technical formulation of the resolved cross-dimensional electrodynamic framework, together with quantitative multi-messenger bounds and a direct request that experimental and theoretical groups evaluate the resulting laboratory search windows. The discussion is organized in six points.

(1) Differential-form classification resolving the 2-form versus 3-form obstruction. Let X denote the four-dimensional Lorentzian spacetime manifold with metric signature $(-,+,+,+)$ and Hodge star $\star$, and let $\pi : Y \to X$ be a compactified $(4+k)$-dimensional ambient bundle with fiber K_k. In earlier formulations [1–4, 6, 9, 12], a bulk-induced 3-form current $J_s \in \Omega^3(X)$ was subtracted directly from the 2-form $\star F \in \Omega^2(X)$ in $d(\star F - J_s) = 0$, paired with a 5-form action density $A \wedge dJ_s \in \Omega^5(X) \equiv 0$ [1], an erroneous factor of $\frac{1}{4}$ in the differential-form kinetic term [10] (yielding $\frac{1}{2} d \star F = J_s$), or a bulk derived-pushforward 4-form $\mathcal{O}(\eta) = \mathrm{Tr}_K[R\pi_*(\eta^\dagger \wedge \star_Y \eta)] \in \Omega^4(X)$ whose wedge product with A again vanishes identically in four dimensions [8]. Similarly, cohomological extensions relying on $\mathrm{Ext}_Y^{k+3}(\mathcal{E}_P \otimes \mathcal{H}, \mathcal{O}_Y)$ vanish identically for locally free sheaves on complex manifolds of real dimension $4+k$ ($\dim_{\mathbb{C}} Y = 2 + k/2 < k+3$) [10], and contracting purely $(1,1)$ Atiyah classes cannot yield odd-degree $(k+3)$-forms.

To eliminate every degree, variational, and parity contradiction simultaneously, deformations of four-dimensional Maxwell theory descending from $Y \to X$ must be partitioned into two strictly distinct, degree-homogeneous classes:

- **Class A (2-form constitutive, axion, and kinetic-mixing portals):** Whenever higher-dimensional moduli, Kalb–Ramond 2-forms, or hidden Abelian sectors induce a gauge-invariant 2-form polarization $B_s(F, \Phi) \in \Omega^2(X)$, an axion-like pseudoscalar a with coupling $g_{a\gamma\gamma}$, or a kinetically mixed dark photon X with field strength $X_2 = dX$, the four-dimensional action takes the consistent form

$$S_A[A; a, X, B_s] = \int_X \left(-\frac{1}{2} F \wedge \star F - \frac{1}{2} \chi \, F \wedge \star X_2 - \frac{g_{a\gamma\gamma}}{4} a \, F \wedge F + \frac{1}{2} F \wedge B_s(F, \Phi) \right) + S_{\text{bulk}}, \tag{1}$$

  whose variation with respect to A yields the exact, degree-consistent generalized 1-form global continuity equation and conserved 2-surface flux charge $Q_{\text{flux}}(\Sigma_2)$:

$$d\left(\star F + \chi \star X_2 + \frac{1}{2} g_{a\gamma\gamma}\, aF - B_s\right) = 0, \qquad Q_{\mathrm{flux}}(\Sigma_2) = \int_{\Sigma_2} \left(\star F + \chi \star X_2 + \frac{1}{2} g_{a\gamma\gamma}\, aF - B_s\right), \tag{2}$$

for any closed 2-surface $\Sigma_2 \subset X$. Here every term in the integrand is strictly a 2-form, preserving $dF = 0$ and exact $U(1)$ gauge invariance without introducing spurious 3-surface integrals of 2-forms.

- **Class B (conserved 3-form topological currents):** Whenever fiber integration over K_k pushes down a closed $(k+3)$-form Θ_{k+3} on Y—using the relative roof genus $\hat{A}(T_\pi)$ in odd fiber dimension $k = 2m-1$ or an odd $K^{-1}(Y)$-theory Chern character in even fiber dimension $k = 2m$ [11]—the resulting object $J_s = \pi_* \Theta_{k+3} \in \Omega^3(X)$ couples linearly to A via

$$S_B[A; J_s] = \int_X \left(-\frac{1}{2} F \wedge \star F + A \wedge J_s\right), \qquad dF = 0, \qquad d \star F = J_s. \tag{3}$$

  Gauge invariance under $A \mapsto A + d\lambda$ holds if and only if $dJ_s = 0$. Crucially, Eq. (3) enforces global de Rham exactness $[J_s]_{\mathrm{dR}} = 0 \in H^3_{\mathrm{dR}}(X)$ [11], refuting earlier claims of a non-vanishing class $[J_s] \in H^3(X)$ coexisting with $d \star F = J_s$ [7, 10]; any non-trivial cohomology class requires either a compensating topological defect 1-cycle Γ ($d \star F = J_s - \delta_\Gamma$) or a Cheeger–Simons differential-cohomology 1-gerbe formulation in $\check{H}^3(X)$. Moreover, contrary to [7], current conservation $dJ_s = 0$ does not keep the electromagnetic stress-energy tensor covariantly conserved: $\nabla_\mu T^{\mu\nu}_{\mathrm{EM}} = -F^{\nu\alpha} j_{s,\alpha} \neq 0$ unless bulk momentum exchange is included dynamically.

(2) The Neutral-Photon Linear Superposition Theorem and experimental dichotomy. A central physical flaw in earlier drafts [1, 2, 7, 10, 11, 12] was the assumption that a fixed external background current J_s directly modifies the phase, dispersion, or interference visibility of optical probe photons, or induces an Aharonov–Bohm holonomy phase $\Delta\Phi = \oint_{\gamma_1 - \gamma_2} A$. Two elementary principles of quantum electrodynamics overturn that assumption:

Theorem 1 (Neutral-Photon Linear Superposition and Experimental Dichotomy). *Let $J_s \in \Omega^3(X)$ be an A-independent Class B source satisfying $dJ_s = 0$ and $[J_s]_{\mathrm{dR}} = 0$, and let F_{bg} be any background solution of $d \star F_{\mathrm{bg}} = J_s$. Then every linearized probe photon perturbation $\delta F = F - F_{\mathrm{bg}}$ satisfies the exact homogeneous vacuum Maxwell equations $d(\delta F) = 0$ and $d(\star \delta F) = 0$, experiencing zero dispersion shift and zero interferometric visibility floor from J_s. Furthermore, because the photon is an electrically neutral $U(1)$ gauge boson ($q_\gamma = 0$, correcting the statement in [1] that the photon carries $U(1)$ gauge charge), a neutral photon acquires no minimal-coupling Aharonov–Bohm phase $\oint A$.*

Proof. By linearity of the exterior derivative and Hodge star in Eq. (3), subtracting $d \star F_{\mathrm{bg}} = J_s$ from $d \star F = J_s$ yields $d \star (F - F_{\mathrm{bg}}) = 0$ identically. Minimal coupling $D_\mu = \partial_\mu - iqA_\mu$ vanishes for $q = 0$; hence Eq. (38) of [11] and Eq. (18) of [10] apply solely to charged-fermion (electron) interferometers, not to neutral photons. □

This dichotomy cleanly resolves five additional physical errors across the prior photonic notes: (i) in slow-light electromagnetically induced transparency (EIT) in Bose–Einstein condensates [12], storing a pulse as an atomic spin-wave polariton suppresses the electromagnetic field amplitude by the photonic Hopfield fraction $\cos^2\theta_{\mathrm{DM}} \approx v_g/c \ll 1$, which exactly cancels the c/v_g interaction-time enhancement for any local F-coupled portal; (ii) additive external currents $J_s(t) = J_0 \cos(\omega_s t)$ cannot generate Mathieu parametric amplification $e^{\Gamma t}$ [4, 7], which requires multiplicative modulation of the resonator permittivity powered by an external pump; (iii) if a linear current depends on A (e.g., $J_s \propto m_\gamma^2 \star A$ [6]), it becomes a gauge-breaking Proca photon mass bounded by $m_\gamma < 10^{-18}\,\mathrm{eV}$ [14]; (iv) in bulk Higgs–photon models [3, 9], the sign of $+M_Y^2|\Phi|^2$ in $\mathcal{L}_Y$ matched rather than inverted the 4D tachyonic mass, $+\Lambda_Y|\Phi|^4$ made the potential unbounded below, the AdS Breitenlohner–Freedman bound was misapplied to Ricci-flat Calabi–Yau manifolds, and mirror symmetry was misapplied across manifolds of unequal dimension; and (v) in lossless single-mode waveguides [13], unitary defects cannot yield $V < 1$, while any $V < 1$ induced by coupling to environmental or which-path modes is fully accounted for by standard QED Englert–Greenberger–Yasin duality $V^2 + D^2 \leq 1$, once the reversed extension arrow in $\mathrm{Ext}^1_{X'}(R\phi_* \mathrm{Cone}(\iota_F), R\phi_* S(F))$ and the difference $\Delta o = o(F, \phi_A) - o(F, \phi_B)$ are properly normalized.

(3) Dimensionally homogeneous visibility scaling, smooth decoupling, and SUSY consistency. Nearly every earlier work in the series [1–4, 6–10, 12] wrote the interferometric visibility floor as $1 - V \sim \|\omega(\eta)\|^2 \Lambda^{-2k}$ (or dropped the square and allowed $V < 0$ via $e^{2\Gamma T}$ [4, 7]). Whenever $\omega(\eta)$ is a dimensionless cohomological norm, Λ^{-2k} carries mass dimension $M^{-2k} \neq M^0$. Equally problematic, normalizing the Hodge dual of a background 3-form current into a unit timelike 4-vector $u^\mu = v^\mu/|v|$ in $P^{\mu\nu} = g^{\mu\nu} + u^\mu u^\nu$ [11] renders the Lorentz-violating operator $\frac{\alpha_s}{4\Lambda^{2n}} P^{\alpha\beta}(\nabla_\alpha F^\perp_{\mu\nu})^2$ singular $(0/0)$ as $J_s \to 0$ so that new physics never decouples in the zero-current limit; restoring unnormalized $v^\alpha v^\beta$ with $[v^\mu] = M^3$ elevates the operator to mass dimension

12 (Λ^{-8}). Furthermore, a timelike vector u^μ breaks Lorentz boosts $SO(1,3) \to SO(3)$, invalidating appeals to four-dimensional Poincaré $\mathcal{N}=1$ supersymmetric non-renormalization theorems [11].

To construct physically viable, dimensionally homogeneous Class A optical observables with smooth decoupling, one must express all phase variances in dimensionless combinations of the photon energy E_γ, arm length L, external magnetic field B_0, Higgs vacuum expectation value $v \approx 246\,\mathrm{GeV}$, and compactification scale Λ. Specifically, for a coherent ultralight axion or axion-like background $a(t) = a_0 \cos(m_a t)$ or magnetic birefringence cavity (Class A), the induced optical phase difference and interferometric visibility deficit are strictly dimensionless and bounded by $0 \le 1 - V \le 1$:

$$\Delta\phi_{\mathrm{axion}} \simeq \frac{1}{4}(g_{a\gamma\gamma} B_0 L)^2 \quad \left(\frac{m_a^2 L}{4E_\gamma} \ll 1\right), \qquad 1 - V = 1 - \exp\!\left(-\frac{1}{2}\,\mathrm{Var}(\Delta\phi)\right) \approx \frac{1}{2}(g_{a\gamma\gamma}\,\delta a)^2. \tag{4}$$

Similarly, gauge-invariant SMEFT portals descend from Kaluza–Klein towers of compactification volume $V_k \sim \Lambda^{-k}$ via well-defined dimension-6 and dimension-8 operators,

$$\mathcal{L}^{(6,8)}_{\mathrm{SMEFT}} = \frac{c_{\gamma\gamma}}{\Lambda^2}(H^\dagger H)F_{\mu\nu}F^{\mu\nu} + \frac{\tilde{c}_{\gamma\gamma}}{\Lambda^2}(H^\dagger H)F_{\mu\nu}\tilde{F}^{\mu\nu} + \frac{c_1}{\Lambda^4}(F_{\mu\nu}F^{\mu\nu})^2 + \frac{c_2}{\Lambda^4}(F_{\mu\nu}\tilde{F}^{\mu\nu})^2, \tag{5}$$

eliminating the uncontracted Lorentz index in [6] and replacing epistemic moduli-space averaging over $\mathcal{M}_g$ [5, 7]—which represents theoretical uncertainty over a single cosmic vacuum rather than independent stochastic draws across terrestrial laboratories—with concrete, local quantum field fluctuations δa or thermal/quantum photon-loop corrections (noting also that quadratic scalar stochastic quantization in $d=2$ [5] shifts $+m^2$ by a constant tadpole $-C_1(\epsilon)$, not a linear mass counterterm $-C_1(\epsilon)m$).

(4) Confrontation with multi-messenger astrophysical and collider bounds. When the dispersion relation $\omega^2 = q^2(1 - \beta q^2)$ derived in [11] is evaluated against high-energy gamma-ray time-of-flight observations rather than laboratory interferometry alone, a decisive scale separation emerges. Table 1 summarizes the 2024–2026 empirical constraints across every Class A and Lorentz-violating operator invoked in [1–13].

Table 1. Quantitative multi-messenger, collider, and laboratory bounds (95% CL) on extended-electrodynamic portals, contrasting static dispersion benchmarks from [11] with current astrophysical and precision-cavity limits.

Operator / Sector	Experiment / Observatory	Current Empirical Bound	Implication for [1–13]
Quadratic subluminal photon LIV, $\omega^2 = q^2(1 - q^2/\Lambda^2)$	LHAASO GRB 221009A [15]	$E_{\mathrm{QG},2} > 7.3 \times 10^{11}$ GeV (up to 1.2×10^{12} GeV)	Exceeds lab benchmarks of [11] (1.38 MeV–423 GeV) by 10^9–$10^{15}\times$
Axion–photon coupling $\lvert g_{a\gamma\gamma}\rvert$ (pure lab LSW)	ALPS II (DESY) [16]	$\lvert g_{a\gamma\gamma}\rvert < 1.5 \times 10^{-9}\,\mathrm{GeV}^{-1}$ ($m_a \lesssim 0.1$ meV)	Model-independent cavity benchmark for Class A $aF \wedge F$
Solar axion helioscope $g_{a\gamma\gamma}$	CAST / BabyIAXO–IAXO [17]	$g_{a\gamma\gamma} < 6.6 \times 10^{-11}\,\mathrm{GeV}^{-1}$ (IAXO target $\sim 10^{-12}$)	Constrains bulk-induced pseudoscalar portals [12]
Isotropic cosmic birefringence β	Planck DR4 + ACT DR6 [18]	$\beta = 0.277^\circ \pm 0.057^\circ$ (4.8σ; 3.5σ dust-mitigated)	Tightly bounds cosmological $\Delta\theta$ variations
Higgs–diphoton portal $(c_{\gamma\gamma}/\Lambda^2)(H^\dagger H)F^2$	ATLAS / CMS Run 2–3 [19]	$\mu_{\gamma\gamma} \approx 1.00 \pm 0.05 \Rightarrow \Lambda/\sqrt{\lvert c_{\gamma\gamma}\rvert} \gtrsim$ multi-TeV	Directly constrains Higgs–photon vertex [3, 12]
Vacuum speed shift $\Delta c/c$ & Proca mass m_γ	GW170817 [20] / PDG [14]	$\lvert\Delta c/c\rvert < 10^{-15}$; $m_\gamma < 10^{-18}$ eV	Rules out [6] $\varepsilon \sim 10^{-12}$ and $K^\mu \propto A^\mu$

Two decisive conclusions follow from Table 1. First, static quadratic dispersion deformations $\omega^2 = q^2(1 - q^2/\Lambda^2)$ at TeV or sub-TeV scales are already excluded by nine to fifteen orders of magnitude by LHAASO observations of multi-TeV photons from GRB 221009A [15]; moreover, generating order-unity visibility deficits in balanced meter-scale interferometers via Eq. (45) of [11] would require unphysical $\mathcal{O}(1)$ spatial fluctuations of a fundamental EFT Wilson coefficient over laboratory distances. Second, precision optical cavities retain a genuine, irreplaceable advantage over astrophysical time-of-flight bounds in two specific regimes: (a) resonant light-shining-through-a-wall (LSW) and magnetic vacuum-birefringence experiments targeting Class A pseudoscalar couplings $g_{a\gamma\gamma}$ in the sub-meV mass range (ALPS II, IAXO, PVLAS), and (b) phase-sensitive interferometric searches for coherent oscillating ultralight axion or dark-photon dark matter ($\delta a(t) = a_0 \cos m_a t$) where astrophysical line-of-sight integrals cancel between identical endpoints.

(5) Request to CERN, DESY, and Precision-Optics Groups. Building on the original request in [1] with these formal obstructions now resolved, we respectfully submit two focused technical requests:

- **Theoretical evaluation.** We request that field-theory and phenomenology groups evaluate the dual Class A / Class B action hierarchy (Eqs. 1–3) for anomaly inflow, unitarity, and UV embedding in

compactified string/KK models, specifically verifying whether any controlled compactification produces a macroscopic Class B 3-form J_s detectable via *electron* Aharonov–Bohm interferometry rather than optical paths, and refining SMEFT correlations between $h \to \gamma\gamma$ (Eq. 5) and low-energy Euler–Heisenberg photon scattering.

- **Experimental feasibility.** Rather than instrumenting for an A-independent Class B visibility floor (which vanishes identically by Theorem 1) or static quadratic LIV (already excluded by LHAASO to $7.3 \times 10^{11}\,\mathrm{GeV}$), we ask that experimental efforts at CERN (CAST/IAXO, LHC $H \to \gamma\gamma$ and $\gamma\gamma \to \gamma\gamma$ ultraperipheral collisions), DESY (ALPS II), and partner optical-cavity groups target coherent time-varying Class A phase/polarization modulations (Eq. 4) alongside electron-beam topological-flux interferometry for Class B currents.

(6) Conclusion and forward work. The resolution presented here establishes three firm results: (1) inhomogeneous 2-form/3-form Maxwell deformations and vanishing 5-form actions are cleanly replaced by Class A 2-form flux continuity (Eqs. 1–2) and Class B exact 3-form sources (Eq. 3); (2) Theorem 1 proves that neutral probe photons do not experience dispersion or Aharonov–Bohm phases from fixed Class B currents; and (3) multi-messenger LHAASO, Planck+ACT, GW170817, and LHC bounds redirect laboratory interferometry away from static LIV toward coherent Class A axion, dark-photon, and Higgs–diphoton portals. Detailed numerical re-parametrizations of cavity-birefringence sensitivity curves will accompany future joint experimental proposals.

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