The Selective Transient Field from First Principles — The Two-Clock Theory

The two-clock theory and its conditional gravitational completion — with the five-gate audit layer and the frozen-consolidation records: what is proved, what is derived, what is conditional, and what is open

Z. Paz · ORCID 0009-0003-1690-3669 V9.1 2026

ARCHIVE NOTICE — 2 September 2026. This is Version 9.1 (29 August 2026), retained in full as a record. It is superseded by the current edition of First Principles, whose version history lists all editions. Where this text conflicts with the current record, the current edition governs. V9.1 is the frozen-consolidation release: the v9.0 content carried in full plus §XI and the seven post-v9.0 stop-gate records (Appendices AB–AH), with the 44-item ledger. Two rendering defects of the original page are repaired here at the page layer (five missing backslashes before `\qquad` in Appendix AF; a missing display-math close before the Appendix AH boxed grade); the frozen source file is unchanged.

The Two-Clock Theory and Its Conditional Gravitational Completion

Version 9.1 — Frozen Consolidation Release — 29 August 2026

Z. Paz The Hague, Netherlands Email: zevpaz@gmail.com ORCID: https://orcid.org/0009-0003-1690-3669

Abstract

The Selective Transient Field (STF) is a scalar-response framework organized around two temporal objects: a universal ordering field and an internal cyclic phase. The distinction is forced by the gradient-clock obstruction. If an oscillatory scalar amplitude is used as a normalized-gradient clock, its gradient vanishes at every turning point; a periodic amplitude therefore cannot provide a continuous global ordering. STF consequently uses a universal scalar (T_U), with future-directed unit normal

$$N_\mu = -\frac{\nabla_\mu T_U}{\sqrt{-\nabla T_U \cdot \nabla T_U}}, \qquad D_U = N^\mu \nabla_\mu,$$

and a distinct internal phase $\Theta_I \in S^1$, with $\phi = A\cos\Theta_I$. Universal time orients causal response and the clock-relative curvature decomposition; the internal phase labels the field cycle.

The framework's prior ontology already kept these roles separate. *Theory of Time* V4.3 §10.3 states universal time as an ontologically real, globally coherent temporal background and local time as something each closed system creates while referencing that shared background. *The Structure of What Happens* (General Theory) V3.1 §§1.4 and 6.4 likewise distinguishes the universal history from the internal clocks by which a subsystem measures within it. Version 8.1's gradient-clock obstruction promotes that corpus distinction from ontology to theorem: the internal cyclic phase and the universal ordering cannot be the same object because an oscillatory amplitude cannot carry a global ordering through its normalized gradient. Conditional on a global phase lift and dynamical synchronization, universal time may be represented by an unwrapped phase and the internal phase by its cyclic projection, the covering map $\mathbb{R} \to S^1$; that is a completion, not the theorem. **[theorem/entailment]**

Version 8.2, which version 9.0 carries in full, is a frozen-baseline revision of version 8.1. It preserves the two-clock theorem, the positive clock-relative curvature state

$$q_N^2 = R^2 + 8\mathcal{W}_N, \qquad \mathcal{W}_N = E_{\mu\nu}E^{\mu\nu} + B_{\mu\nu}B^{\mu\nu},$$

the exact causal high-pass memory, the corrected Peters timing provenance, the flyby no-work and observation-map theorems, the empirical falsification program, and the regime-limited scalar–Gauss–Bonnet tensor calculation.

The numerical timing structure also retains its exact provenance. Observation supplied the 3.32-year and 71-day anchors. The STF Lagrangian's emission-window closure supplied the $53.88 \simeq 54$-year outer anchor, conditional on the named boundary $\tau_- = 0.1\,\mathrm{yr}$. The Peters a^4 law is the translator that maps those three times to 1466, 730, and $360\,R_S$, successive near-halvings of separation. The separations are GR images of the temporal anchors, not three independently predicted radii. The blind $n = 11/8$ likelihood, $\langle T\rangle = 3.31\,\mathrm{yr}$, and the direct timing, $3.32 \pm 0.89\,\mathrm{yr}$, converge on the same central value, with $m_s = h/(c^2T) = 3.94 \times 10^{-23}\,\mathrm{eV}/c^2$. **[calculation/conditional convergence]**

The flyby sector remains a measurement map rather than a force law. Pulled back to a worldline, the original interaction is the connection one-form $\mathcal{A} = \gamma\phi\,dq$, with curvature $\mathcal{F} = \gamma\,d\phi \wedge dq$. Its antisymmetry gives no work while a closed radio transaction can register the holonomy $\oint \mathcal{A}$. The factor of two is the vorticity identity $\nabla \times (\boldsymbol{\omega} \times \mathbf{r}) = 2\boldsymbol{\omega}$; the equatorial R and declination-only dependence are the operator norm of the rotational clock channel over the closed carrier. Earth flybys are source–observer degenerate because Earth is both the rotating gravitating source and the rotating clock carrier. The constitutive clock–link normalization and each tracking configuration's utilization coefficient remain open. **[derived/theorem/open]**

Version 8.2 supersedes the claim that the local reciprocal interaction $\int \sqrt{-g}\,\phi D_U q_N[g,N]$ is a healthy fundamental metric action. When $q_N[g,N]$ is eliminated directly into a finite-order local metric theory, its curvature-norm Hessian generically produces a nondegenerate metric-acceleration block and an opposite-residue quartic pole. Ordinary torsion-constrained connection reduction, regular auxiliary or BF/Legendre completion, generic same-metric Plebański simplicity, spectator six-null sectors, and curvature-dependent shifted metrics do not remove that physical rank with a constant constraint structure.

The surviving readout is the regulated compact-alignment response

$$Q_\Delta = M_*^2\left(\sqrt{q_N^2 + \Delta^2} - \Delta\right), \qquad \Delta > 0,$$

followed by exact first-order memory

$$(D_U + \omega_c)y = \omega_c Q_\Delta, \qquad Z = Q_\Delta - y,$$

and activation applied after memory. The compact parent has constant readout/alignment rank (44) per causal leg and adds zero physical auxiliary degrees of freedom. Memory contributes a rank-two block per leg. On an analytic weak-backreaction effective-field-theory branch, six independently retained normal-curvature jets can be removed by twelve second-class constraints. The resulting structural rank is

$$44_{\text{readout/alignment}} + 2_{\text{memory}} + 12_{\text{jets}} = 58$$

per causal leg and 116 for the doubled contour. These are module ranks, not the complete gravitational Dirac rank.

The conditional gravitational route is clock-adapted action-level order reduction with a boundary-selected constant-mean-curvature (CMC) clock, a varied material world tube, and a retained positive environment. It removes the gravitational scalar only when both the jet Jacobian and the augmented CMC–volume operator remain invertible below the EFT cutoff. The coefficient-complete jet tensor, complete Hamiltonian bracket, nonlinear secondary chain, global CMC existence, conservative contact terms, and microscopic environment are not yet derived. A positive rank-one Drude bath exists and can preserve the relevant local ranks, but its factorization ratio r remains open. The compact capacity Hessian is not the missing environmental QQ coefficient:

$$H^{\text{cap}}_{AB} = M_*^2 J^{-1}_{AB} \neq \Gamma_{QQ}, \qquad \chi^{\text{aux}}_{QQ} = 0$$

at fixed base geometry. The next calculation is therefore the covariant $Q_\Delta X_\alpha$ environment vertex and its spectral density ρ_{QQ}, followed by the coefficient-complete boundary-CMC Dirac and Ward audit.

The correct status is:

$$\boxed{\text{STF v9.1 is a coherent gravitational candidate, not a completed gravity theory.}}$$

Keywords: Selective Transient Field; two-clock theory; universal time; internal phase; compact alignment; causal memory; action-level order reduction; CMC gravity; Schwinger–Keldysh effective theory; curvature response; flyby observation map; gravitational constraints

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Version 9.0 adds a dated, additive audit layer to the frozen v8.2 content. Five adversarial gates — open-operator classification, environment vertex and horizon spectral supply, all-loop zero-DC protection, gravitational-wave emission, and merger production — were run against the frozen v8.1/v8.2 baselines by the independent derivation session, reviewed against sealed pre-registered rubrics, and are carried verbatim as Appendices W–AA with their decisive results integrated in §X. The layer's principal additions are the unique positive ideal Lorentz–Drude continuum associated with the exact selected response, $\rho^{\mathrm{D}}_{QQ}(\Omega) = (g_Q^2/\pi)\,\Omega\omega_c/(\Omega^2 + \omega_c^2)$, the Production-Support Preservation Theorem, the reduced advanced/noise deformed-identity obligation with its explicit acceptance criterion, the priced status of the zero-DC protection items, and four explicit numeric emission acceptance gates. The not-established ledger extends from 32 to 37 items. Zero results were withdrawn and none upgraded; the grade is unchanged: coherent gravitational candidate — not a completed gravity theory.

Version 9.1 closes the post-v9.0 construction sequence without converting it into a completion claim. The naive relative-coordinate compensator does not protect the physical static readout and does not change the $58/116$ module subtotal. The specified constrained-readout, linear-memory, finite-Gaussian quadratic core has an exact one-loop static zero, but the full-parent coefficient is not identifiable. Quantizing the varied world-tube crossover produces a positive matched bubble-plus-seagull residual and positive KMS noise, priced by the existing subtraction condition. An isolated canonical real B field cannot support a stable finite tube under the stated Derrick assumptions; a varied conserved material current can support a controlled thin-wall existence representative, but its coefficients and microscopic origin are new data. No displayed frozen sector supplies exact charge, compression energy, and derived B-binding simultaneously. The displayed compactification is metric-only, and the frozen linear STF activation breaks the $U(1)$ of a manually added complex partner. The parameter-free completion route therefore stops at the frozen compactification boundary. The ledger extends from 37 to 44 items; one post-v9.0 exploratory raw-bubble formula is superseded in place; no established v8.1, v8.2, v9.0, or Gate G1–G5 result is withdrawn; and the grade remains coherent gravitational candidate – not a completed gravity theory.

I. Introduction

I.A What this paper is

STF was discovered through a timing analysis of ultra-high-energy cosmic rays, gamma-ray bursts, and compact-binary mergers and was then reconstructed from General Relativity, topology, causal response, and compactification.

The original observational program returned a temporal structure — a 3.32-year period, a 71-day window, and a 54-year activation horizon — together with a curvature exponent, and the first STF Lagrangian was written to express what those data contained. That discovery record is the observational manuscript at uhecrtoday.com. The theoretical reconstruction then asked whether the observationally found anchors and phenomenological coefficients could be removed from the Lagrangian's input list and recovered from General Relativity, topology, compactification, and causal response. The project-paper chain on which that reconstruction relies is not background decoration: *Theory of Time* V4.3 supplies the universal/local temporal distinction; *The Structure of What Happens* V3.1 supplies the universal-history/local-measurement framework; *Framework Guide* V3.3 records the framework-wide dependency and claim discipline; and *First Principles* V7.9 remains the derivation record for downstream sectors where this paper expressly delegates to it.

Observation discovered the pattern; theory later reconstructed parts of it. A theoretical path does not become independent by erasing its discovery history, and an observation does not become an action input merely because it came first. Independence is a property of the dependency graph of each calculation. Version 8.2 therefore preserves the v8.1 distinction among discovery, calibration, derivation, validation, and prediction while adding the gravitational audit's separate grades of existence construction, closed route, and supersession.

That history imposes a strict dependency discipline: discovery, calibration, derivation, validation, and prediction are not interchangeable labels. A result does not become independent merely because it is later reconstructed, and a theoretical correspondence does not become a prediction if its target fixed an input.

Version 8.1 made the decisive conceptual correction from a one-clock scalar model to a two-clock framework. It nevertheless retained a local fixed-clock interaction as the central working action and left its gravitational completion open. The post-v8.1 audit calculated that obligation directly. It found a genuine obstruction to the most literal metric completion, closed several same-content repairs, and isolated one surviving route: a branch-restricted, clock-adapted, order-reduced open EFT. Version 8.2 records that result without overwriting the historical v8.1 source.

This paper is therefore three things at once:

1. a standalone statement of the surviving STF theorem and observational core;
2. a supersession record for gravitational claims that failed their mathematical gates;
3. a coefficient-honest candidate architecture whose remaining completion tests are finite and named.

It is not a declaration of gravitational completion. No result from any separate version-9 branch is used in the definitions, calculations, grades, or conclusions of this manuscript.

I.B Why two clocks

Every curvature-rate theory requires a direction along which the rate is taken. If that direction is generated by the STF amplitude itself,

$$n_\phi^\mu = \frac{\nabla^\mu \phi}{\sqrt{-\nabla\phi \cdot \nabla\phi}},$$

then an oscillatory dark-matter solution $\phi = A\cos(m_s t)$ makes the denominator vanish twice per period. Along an integral curve of a normalized-gradient clock the generating scalar is strictly monotone, whereas an oscillatory scalar is periodic. The two roles cannot be carried by the same real amplitude.

Gradient-clock obstruction. A differentiable periodic scalar amplitude cannot define a continuous global temporal ordering through a normalized timelike gradient across its turning points.

The conclusion is structural, not optional: STF needs a universal ordering and an internal phase. The universal field T_U supplies N^μ, causal orientation, and the normal/spatial decomposition of curvature. The phase Θ_I tells where the scalar is in its cycle. A local phase lift may synchronize with universal time on a finite domain, but it is not the global clock theorem.

Its content is not that the framework is inconsistent. It is that a distinction the framework already held is a mathematical necessity. *Theory of Time* V4.3 §10.3 states the two-clock ontology in full: universal time is ontologically real from the first global activation and supplies a physically real, globally coherent temporal background; local systems create their own time through closed temporal loops; and those local systems reference universal time as the common background for coordination. *The Structure of What Happens* V3.1 §§1.4 and 6.4 makes the same operational separation between the universal history and the internal clocks through which a subsystem measures it. What those papers state as ontology, the gradient-clock obstruction proves at the level of the field representation: the internal cyclic phase and universal ordering cannot be the same scalar amplitude. **[theorem]**

The universal clock N^μ orients every curvature derivative and defines the positive curvature state to which the response is applied; the internal phase Θ_I records where the field lies in its cycle. Conditional on a global phase lift and dynamical synchronization, universal time may be represented by an unwrapped phase and internal time by its cyclic projection, $\mathbb{R} \to S^1$, but the choice and dynamics of the carrier for T_U remain an open construction. Because N^μ depends on T_U only through its normalized gradient, it is invariant under any monotone relabelling $T_U \to f(T_U)$. The **Clock-Rate Invisibility Lemma** follows: the action knows which direction is future but not the operational rate $dT_U/d\tau_O$ at which universal time advances against a particular clock. Two clocks are necessary; their relative readout requires the observation map. **[lemma/open]**

The universal clock is hypersurface-orthogonal; it is not required to be covariantly constant. Its congruence may have expansion, shear, and acceleration. Rotation belongs to an internal material carrier such as the Earth-fixed congruence, not to N^μ itself.

I.C Five layers of the v8.2 theory

The framework must keep five layers separate.

1. **Theorem and observable core.** Two clocks, the clock-relative curvature state, the Peters translation, the no-work/holonomy structure, source–observer degeneracy, and the empirical inverse-problem discipline.
2. **Regulated readout.** Independent curvature components, compact polarization, Q_Δ, and the constant-rank readout/alignment parent.
3. **Conditional gravitational bridge.** Independently retained normal-curvature jets, action-level order reduction on an analytic branch, and a boundary-selected CMC temporal condition.
4. **Memory and environment.** Exact first-order high-pass memory, post-memory activation, a varied world tube, retained stress and noise, and the Schwinger–Keldysh doubled parent.
5. **Observation map.** The physical transaction by which tracking links, clocks, and estimators convert a universal history into measured records.

The fixed-clock local interaction of v8.1 belongs only to a prescribed-background diagnostic within layers one and four. It is no longer the fundamental gravitational action.

I.D The flyby, restated

The Earth-flyby relation

$$\Delta V_\infty = \frac{2\omega R}{c} V_\infty (\cos\delta_{\rm in} - \cos\delta_{\rm out})$$

must not be interpreted as a derived transfer of mechanical energy. Four results close that reading: a velocity-linear antisymmetric force satisfies $F \cdot u = 0$; a stationary asymptotically flat effective metric conserves Killing energy; scalar curvature magnitudes are even in spin to first order; and a stationary axisymmetric scalar obeys $k^\mu \nabla_\mu q = 0$ along a stationary or rigidly corotating Killing flow.

What survives is an observation-map structure. The pulled-back interaction is a connection one-form $\mathcal{A} = \gamma\phi\, dq$ with curvature $\mathcal{F} = \gamma\, d\phi \wedge dq$. Antisymmetry gives no work while a closed contour can carry holonomy. The factor two is the vorticity identity $\nabla \times (\boldsymbol{\omega} \times \mathbf{r}) = 2\boldsymbol{\omega}$. The R and declination dependence are the operator norm of the rotational clock channel over a closed carrier. Earth flybys are source–observer degenerate because the rotating gravitating body and rotating observational clock carrier coincide. Later planetary and continuously tracked nulls therefore close the universal source-force law and motivate, without proving, an observer/estimator branch.

The live prediction is a capacity-times-utilization relation,

$$\frac{\Delta\widehat{V}}{V_\infty} = \frac{2\Omega_O R_O}{c} [\eta_{\rm in} \cos\delta_{\rm in} - \eta_{\rm out} \cos\delta_{\rm out}],$$

where each η_a must be computed from the actual observation operator and must not be fitted to the anomaly.

I.E Claim taxonomy and supersession discipline

This paper uses nine labels:

- **theorem:** proved from stated mathematical premises;
- **derived:** follows from the declared action or construction;
- **conditional:** follows only if a named condition closes;
- **numerical:** reproduced from stated numerical inputs;
- **commitment:** a declared physical identification separable from the mathematics;
- **existence construction:** at least one parent with a stated property exists, without uniqueness;
- **closed:** a proposed implementation fails its own acceptance gate;
- **superseded:** historically present but replaced by a better-defined construction;
- **open:** a named calculation or datum is missing.

Historical intermediate results remain visible in the appendices because they establish why the surviving route is narrow. A closed route is not silently revived, and an existence construction is not counted as a prediction.

II. Inputs, Definitions, and Dependency Boundaries

II.A Four inputs and no hidden fifth fit

The framework uses four classes of input:

1. General Relativity, including the curvature tensor and Peters inspiral map;
2. the empirical UHECR/GRB/GW timing record, used as discovery and convergence data;
3. the topological closure record, including the $4\pi^2$ angular representative of the Hopf/anti-Hopf cup product;
4. stability and consistency requirements imposed on every proposed completion.

The environment spectral vertex introduced below is not a fifth empirical fit. It is an open constitutive/microscopic datum that must be derived or independently matched. The same is true of the regulator origin, contact terms, and the full CMC deformation.

II.B Empirical record and statistical caution

The retained temporal anchors are $T_I \simeq 3.32$ yr and $T_{II} \simeq 71$ d from the observational program, and a $53.88 \simeq 54$ yr outer window from the STF closure calculation conditional on the declared inner boundary $\tau_- = 0.1$ yr. The 10,117 UHECR–GRB pairs descend from 75 triple events and are not independent trials; event-level or block-permutation significance is therefore required alongside pair-level significance. This changes statistical wording, not chronology or the mathematical two-clock/flyby theorems.

II.C Clocks, curvature state, and regulated readout

Let

$$h_{\mu\nu} = g_{\mu\nu} + N_\mu N_\nu$$

be the positive spatial metric orthogonal to N^μ. Define the electric and magnetic Weyl tensors

$$E_{\mu\nu} = C_{\mu\alpha\nu\beta} N^\alpha N^\beta, \qquad B_{\mu\nu} = {}^*C_{\mu\alpha\nu\beta} N^\alpha N^\beta,$$

and the Bel–Robinson superenergy

$$\mathcal{W}_N = E_{\mu\nu} E^{\mu\nu} + B_{\mu\nu} B^{\mu\nu} \geq 0.$$

The intended STF curvature state is

$$q_N = \mathcal{R}_{\rm STF}(N) = \sqrt{R^2 + 8\mathcal{W}_N}.$$

It equals $\sqrt{C^2}$ in Schwarzschild, $|R|$ in conformally flat FLRW, remains real when C^2 crosses zero, and detects radiative Weyl curvature through $E^2 + B^2$. It omits the trace-free Ricci channel and is therefore selective rather than a complete Riemann norm.

In a clock-adapted orthonormal frame write the eleven-component state

$$\mathcal{C}^A = (R, \sqrt{8}\, E_{ij}^{\rm TF}, \sqrt{8}\, B_{ij}^{\rm TF}), \qquad A = 1, \ldots, 11, \qquad q_N^2 = \mathcal{C}_A \mathcal{C}^A.$$

The physical readout is not the exact unregulated support at the apex. Introduce $\Delta > 0$, a compact polarization $p_A p^A < 1$, and

$$Q_{\rm aux} = M_*^2 \left[p_A \mathcal{C}^A + \Delta\sqrt{1 - p^2} - \Delta \right].$$

The alignment equation

$$\mathcal{F}_A = \mathcal{C}_A - \Delta \frac{p_A}{\sqrt{1 - p^2}} = 0$$

has the unique solution

$$p_A^* = \frac{\mathcal{C}_A}{s}, \qquad s = \sqrt{q_N^2 + \Delta^2},$$

and gives

$$\boxed{Q_\Delta = M_*^2 (s - \Delta).}$$

At the apex $Q_\Delta = 0$, $p_A^* = 0$, and the tangent Hessian is finite. At high curvature it approaches $M_*^2 q_N$ up to a constant offset and $O(\Delta^2 / q_N)$ corrections. The selector annihilates the constant offset. The origin and normalization of Δ remain open.

Universal clock. T_U is a scalar with timelike gradient on the domain of the response,

$$N^\mu = -\frac{\nabla^\mu T_U}{\sqrt{-\nabla T_U \cdot \nabla T_U}}, \qquad D_U \equiv N^\mu \nabla_\mu.$$

N^μ is future-directed, unit, and hypersurface-orthogonal. By Frobenius its own vorticity vanishes: the universal clock supplies ordering, not rotation. **[definition]**

Internal phase and amplitude. Write $\phi = A \cos \Theta_I$. In the fixed-amplitude limit, $(\phi, v_\phi / m_s)$, with $v_\phi = \dot{\phi}$, moves on a circle of radius A, and

$$\Theta_I = \operatorname{atan2}\left(-\frac{v_\phi}{A m_s}, \frac{\phi}{A} \right)$$

is well defined away from zero amplitude, including at amplitude turning points. The amplitude is a local half-cycle chart of the clock, never its global coordinate. **[definition]**

Probe derivative. For a system with four-velocity $u^\mu = \Gamma(N^\mu + v^\mu)$ and $N \cdot v = 0$,

$$D_I q \equiv u^\mu \nabla_\mu q = \Gamma\,(D_U q + v^\mu \nabla_\mu q).$$

This exact kinematic identity separates curvature evolution, $D_U q$, from curvature sampling, $v^\mu \nabla_\mu q$. A stationary planetary field may have $D_U q = 0$ while a spacecraft crossing its gradient has $D_I q \neq 0$. **[exact identity]**

The 2π-Provenance Rule. The internal phase is a compact $U(1)$ coordinate, so one primitive recurrence spans 2π in canonical radian coordinates; the invariant statement is winding number one. Every 2π in this framework must carry one of three provenance labels: **(i)** conversion between angular frequency and a full recurrence, $T_s = 2\pi/\omega_s$; **(ii)** conversion between normalized integral cohomology and canonical angular representatives, including the $4\pi^2$ cup-product representative; or **(iii)** a physical law deliberately pairing a reduced correlation scale with a full cycle. Cases (i) and (ii) follow from a derived cycle or winding. Case (iii) requires an independent constitutive derivation. A mixed reduced/full pairing is not forbidden, but it cannot be presented as a causal identity; the corrected General Theory locality argument and the galactic a_0 route are the relevant open obligations. **[house rule]**

II.D Higher-dimensional parent and coefficient conventions

The retained ten-dimensional ancestor is a block-diagonal curvature-squared compactification,

$$ds_{10}^2 = e^{-6\sigma} g_{\mu\nu} dx^\mu dx^\nu + e^{2\sigma} \hat{g}_{mn} dy^m dy^n,$$

whose four-dimensional descendants include $g_{\mu\nu}$, the breathing scalar σ, and a scalar–Gauss–Bonnet coupling $A(\sigma)\mathcal{G}$. With $\mathrm{Re}\,T = e^{4\sigma}$, the Kähler normalization gives the canonical field $\phi_c = \sqrt{24} M_{\mathrm{Pl}} \sigma$. The compactification scale used in the existing calculation is $L_* = 3.64 \times 10^{-30}\ \mathrm{m}$, with $M_* = L_*^{-1}$.

The saturated low-frequency response coefficient is

$$\kappa = \frac{\zeta/\Lambda}{L_*^2}, \qquad \zeta/\Lambda = 1.35 \times 10^{11}\ \mathrm{m}^2,$$

so $\kappa \simeq 1.02 \times 10^{70}$ is dimensionless. This coefficient belongs to the norm-rate response. It is not the environmental diagonal weight g_Q^2, the scalar weight g_ϕ^2, or their ratio r.

The parent supports the regime-limited scalar–Gauss–Bonnet calculation; it does not derive the boundary-CMC clock, compact-alignment regulator, world-tube environment, or complete response kernel.

II.E Input and completion-status summary

OBJECT	ROLE	V8.2 STATUS
GR/Peters map	translates temporal anchors to separations	theorem/standard
empirical timing record	discovery and convergence	observed; not an action parameter
$4\pi^2$ cup-product representative	topological normalization	project theorem; SI bridge open
two temporal objects	global ordering plus internal phase	theorem/entailment

OBJECT	ROLE	V8.2 STATUS
$q_N^2 = R^2 + 8\mathcal{W}_N$	intended positive clock-relative curvature state	derived selection; parent projection open
Q_Δ	smooth bounded readout	theorem for $\Delta > 0$; regulator origin open
exact high-pass memory	static-response subtraction and causal bandwidth	derived
post-memory activation	regime selection after filtering	derived ordering; coefficient open
analytic jet reduction	removes six spurious jet pairs	conditional pass
boundary-selected CMC	temporal/gravitational scalar removal	conditional pass
varied world tube and total Ward identity	carrier of material/environment stress	conditional pass
positive rank-one Drude bath	local spectral existence construction	pass/exists; not unique
g_Q^2, g_ϕ^2, r	diagonal bath normalization	open
complete $\mathsf{A}(k)$, CMC deformation, and $\{H, H\}$	full gravitational coefficient algebra	open/underdetermined
full nonlinear gravitational completion	fundamental theory	not established

III. Construction and Gravitational-Completion Architecture

III.A Historical fixed-clock diagnostic and the extended parent

The v8.1 working interaction

$$S_{\rm rate} = \kappa \int d^4x \sqrt{-g}\, \phi D_U q_N[g, N]$$

remains useful as a scalar response model on a prescribed gravitational background and as the low-frequency diagnostic limit of the memory kernel. It is not the fundamental metric action of v8.2. Integrating it by parts removes the explicit derivative from q_N,

$$S_{\rm rate} = -\kappa \int \sqrt{-g}\, q_N \left(D_U\phi + \phi\nabla_\mu N^\mu\right),$$

but does not remove the metric accelerations contained nonlinearly in $q_N[g, N]$. Appendix S gives the obstruction.

The v8.2 architecture is instead an extended doubled parent. Its exact unknown coefficients are left symbolic:

$$\begin{aligned}\Gamma_{8.2} = {} & S_{\mathrm{EH+sGB}+\phi}[g_+, T_{U+}, \phi_+] - S_{\mathrm{EH+sGB}+\phi}[g_-, T_{U-}, \phi_-] \\ & + S_{\mathrm{jet}}[\mathcal{K}_\pm, \mathcal{F}_\pm; g_\pm, T_{U\pm}] + S_{\mathrm{ro}}[\mathcal{C}_\pm, p_\pm; \mathcal{K}_\pm, \mathcal{F}_\pm] \\ & + S_{\mathrm{mem}}[y_\pm, \rho_\pm; Q_{\Delta\pm}] + S_{\mathrm{tube}}[B_\pm; g_\pm, T_{U\pm}] + S_{\mathrm{env}}[X_{\alpha\pm}; g_\pm, B_\pm] \\ & + S_{\mathrm{int}}[\phi_\pm, Q_{\Delta\pm}, X_{\alpha\pm}, B_\pm] + S^{\mathrm{CMC}}_{\mathrm{bdy}}[g_\pm, T_{U\pm}] + S_{\mathrm{ct}}.\end{aligned}$$

Every auxiliary, material variable, environment mode, and metric copy is varied before any physical limit or elimination. The order is essential: eliminating the retarded environment first and then varying a single-copy action loses its stress and generically destroys the Ward bookkeeping.

This expression is an architecture, not a coefficient-complete action. S_{ct} contains the symmetry-allowed conservative contacts that present data do not fix; S_{int} contains an environmental vertex whose diagonal QQ normalization is open. Those omissions are displayed rather than concealed.

III.B Compact alignment and constant readout rank

Introduce canonical readout variables $(\mathcal{C}^A, \Pi_A)$ and compact polarizations (p^A, ϖ_A). Let $\widehat{\mathcal{C}}^A$ denote the clock-resolved curvature representative supplied by the retained jet parent. The nontrivial one-leg constraints are

$$\Phi_I = (\Pi_A, \chi_A, \varpi_A, \mathcal{F}_A), \qquad \chi_A = \mathcal{C}_A - \widehat{\mathcal{C}}_A.$$

With $J_{AB} = -\partial\mathcal{F}_A/\partial p_B$ and arbitrary antisymmetric self-bracket $\Omega_{AB} = \{\chi_A, \chi_B\}$, the Dirac matrix can be ordered as

$$\mathbb{D}_{\mathrm{ro}} = \begin{pmatrix} 0 & -I & 0 & -I \\ I & \Omega & 0 & 0 \\ 0 & 0 & 0 & J \\ I & 0 & -J^T & 0 \end{pmatrix}.$$

The alignment Jacobian is

$$J_{AB} = \Delta\left[\frac{\delta_{AB}}{\sqrt{1-p^2}} + \frac{p_A p_B}{(1-p^2)^{3/2}}\right].$$

At the solution $p^* = \mathcal{C}/s$, its ten tangential eigenvalues and one radial eigenvalue are

$$\lambda_\perp = s, \qquad \lambda_\parallel = \frac{s^3}{\Delta^2},$$

which are positive for all finite q_N when $\Delta > 0$. Thus

$$\det \mathbb{D}_{\mathrm{ro}} = (\det J)^2 \neq 0, \qquad \operatorname{rank} \mathbb{D}_{\mathrm{ro}} = 44.$$

The doubled readout rank is (88). The (44) new phase-space dimensions are removed by (44) second-class constraints, so the module adds no physical degree of freedom. Moreover,

$$(\mathbb{D}_{\mathrm{ro}}^{-1})_{\chi\chi} = 0,$$

and the Dirac bracket of two base gravitational observables is unchanged by this module alone.

The tangent response is

$$P_A^{\mathrm{eff}} = \frac{\partial Q_\Delta}{\partial \mathcal{C}^A} = M_*^2 \frac{\mathcal{C}_A}{s},$$

and

$$H_{AB}^{\mathrm{cap}} = \frac{\partial^2 Q_\Delta}{\partial \mathcal{C}^A \partial \mathcal{C}^B} = M_*^2 \left(\frac{\delta_{AB}}{s} - \frac{\mathcal{C}_A \mathcal{C}_B}{s^3} \right) = M_*^2 (J^{-1})_{AB}.$$

This is a capacity tangent tensor, not a propagator or bath self-energy.

III.C Exact memory and post-memory activation

The retarded selector is

$$K_{\mathrm{sel}}^R(t) = \delta(t) - \omega_c e^{-\omega_c t}\Theta(t), \qquad K_{\mathrm{sel}}^R(\omega) = \frac{-i\omega}{\omega_c - i\omega}.$$

It obeys $K_{\mathrm{sel}}^R(0) = 0$, tends to the local rate form at $|\omega| \ll \omega_c$, and saturates at high frequency. A local first-order realization is

$$(D_U + \omega_c) y = \omega_c Q_\Delta, \qquad Z = Q_\Delta - y.$$

The memory-adjoint pair contributes a rank-two second-class block per causal leg, independent of whether Z vanishes. The activation amplitude may cross zero, but it does not multiply the matching, alignment, memory, or jet constraints.

The canonical order is

$$Q_\Delta \longrightarrow y \longrightarrow Z \longrightarrow \mathcal{A}(Z; q_N, \delta_B) \longrightarrow J_\phi.$$

One smooth representative uses a positive apex regulator δ_B, for example through

$$\Upsilon_Z = \frac{\omega_c |Z|}{M_*^2 (q_N^2 + \delta_B^2)^{3/4}},$$

followed by a bounded gate. The choice establishes a regular candidate ordering; it does not derive the activation coefficient, δ_B, or the physical production surface.

For self-similar binaries, the unregularized ratio

$$\Xi_N = \frac{|D_U q_N|}{q_N^{3/2}}$$

is independent of the total mass at fixed dimensionless separation. It is undefined at the flat apex. Appendix Q proves that no nonconstant exactly scale-invariant gate can also be continuous there. The regulator is therefore structural, not cosmetic.

III.D Independently retained curvature jets and analytic order reduction

The state $R \oplus E_{ij}^{\mathrm{TF}}$ contains six independent normal-curvature directions. Off shell, they depend on the normal metric jet $\mathcal{L}_N K_{ij}$; two metrics may have identical ADM data (h_{ij}, π^{ij}) and spatial derivatives while differing in those jets. The full curvature is therefore not an exact off-shell function of ordinary ADM phase space.

Introduce independent clock-adapted symmetric tensors

$$(\mathcal{K}_{ij}, \rho^{ij}), \qquad (\mathcal{F}_{ij}, \Pi_{\mathcal{F}}^{ij}),$$

representing extrinsic curvature and its normal derivative before reduction. Vary the extended action first. On the physical retarded branch, require analyticity in a weak STF backreaction parameter ϵ_{STF}. The leading equations set

$$\mathcal{K}_{ij} = \mathscr{K}_{ij}, \qquad \mathcal{F}_{ij} = -\left(\mathscr{Q}_{ij} - \frac{1}{2}h_{ij}\mathscr{Q}\right) + O(\epsilon_{\mathrm{STF}}), \qquad \rho^{ij} = O(\epsilon_{\mathrm{STF}}),$$

with $\rho^{ij} = 0$ on the Einstein branch. Linearizing the six jet constraints gives

$$\mathsf{J}_{\mathrm{jet}}(k) = I_6 + \epsilon_{\mathrm{STF}}\mathsf{A}(k).$$

A sufficient constant-rank condition is

$$\boxed{|\epsilon_{\mathrm{STF}}|\,\|\mathsf{A}(k)\|_2 < 1}$$

for all physical momenta below the EFT cutoff. Then the six jet pairs supply a rank-twelve second-class block and add no physical mode on that analytic branch.

The cross-Schur corrections with the readout and leading memory blocks vanish because

$$(\mathbb{D}_{\mathrm{ro}}^{-1})_{\chi\chi} = 0, \qquad (\mathbb{D}_{\mathrm{mem}}^{-1})_{\Pi_\ell\Pi_\ell} = 0.$$

The combined one-leg structural rank is therefore

$$\boxed{44 + 2 + 12 = 58}, \qquad \boxed{116 \text{ doubled}}.$$

This calculation conditionally removes the six spurious jet pairs. It does not by itself prove that only two graviton polarizations remain, because lapse, shift, the CMC temporal block, all secondary chains, and the coefficient-complete deformation must still be included.

III.E Boundary-selected CMC time

The conditional temporal architecture uses

$$\chi_{\mathrm{CMC}}(x) = K(x) - \langle K\rangle_\Sigma = 0$$

as a boundary-selected condition paired with the Hamiltonian constraint. The subtraction of the slice average retains the global volume mode. The augmented CMC–volume Jacobi operator has the schematic form

$$\mathbb{J}_\epsilon = \mathbb{J}_0 + \epsilon_{\mathrm{STF}}\delta\mathbb{J},$$

where $\mathbb{J}_0$ is the GR/matter operator. A sufficient condition for invertibility is

$$\boxed{\left\|\epsilon_{\mathrm{STF}}\mathbb{J}_0^{-1}\delta\mathbb{J}\right\|_2 < 1.}$$

On a flat FLRW background,

$$\mathcal{J}_0(k) = \frac{k^2}{a^2} - 3\dot{H}.$$

It is positive for standard matter and de Sitter backgrounds, but a phantom regime with $\dot{H} > 0$ can create a finite-momentum zero. A rank change at such a surface fails the completion there.

If the augmented Jacobi operator is invertible, the jet bound holds, the momentum constraints retain their standard rank, and the full Ward identity closes, the Hamiltonian constraint plus CMC condition remove the gravitational scalar and leave two tensorial gravitational configuration degrees of freedom. This is a conditional count, not a global theorem of the incomplete action.

III.F Schwinger–Keldysh environment, contacts, and Ward identity

The general quadratic physical-sector influence functional has the form

$$\Gamma^{(2)} = \int \Psi_a^T K^R \Psi_r + \frac{i}{2} \int \Psi_a^T N \Psi_a, \qquad N(\omega, \mathbf{k}) \succeq 0.$$

The diagonal diffeomorphism Ward projector removes gauge directions but does not fix conservative physical contacts. On a homogeneous isotropic background, a parity-even six-jet contact has two coefficients,

$$C_{\rm hom} = c_0 P_{\rm tr} + c_2 P_{\rm TF}.$$

At finite momentum, the scalar 2×2 symmetric block contributes three functions and the vector and tensor blocks one each: five parity-even conservative form factors. Strong zero-DC response removes constant terms but leaves real $O(\omega^2)$ subtractions. KMS and positivity constrain absorptive/noise data and do not determine these contacts.

The doubled kernel obeys, when K^R is invertible,

$$|\det \mathbb{K}_{\rm CTP}| = |\det K^R|^2.$$

Positive noise therefore cannot repair a singular retarded block.

For the complete unintegrated parent, diagonal diffeomorphism invariance gives

$$2\nabla_\mu \mathcal{E}_g{}^\mu{}_\nu = \sum_A \mathcal{E}_A \nabla_\nu \Psi^A$$

up to the standard tensor-index terms for non-scalars. Total stress conservation follows only when the clock, compact readout, jets, memory, world tube, environment, boundary data, and matter equations are all imposed. Freezing any carrier produces a source-force defect rather than an autonomous Ward identity.

III.G Positive Drude existence construction and the open (QQ) normalization

A minimal common bath can couple to

$$\mathcal{O}_g = g_\phi \phi + g_Q \widetilde{Q}_\Delta, \qquad \widetilde{Q}_\Delta = W(B) Q_\Delta,$$

with the smooth material window $W(B) = B^2(3 - 2B)$. A rank-one Drude bath produces

$$\Sigma^R_{ij} = g_i g_j K^R_{\rm sel}, \qquad N_{ij} = g_i g_j N_D \succeq 0.$$

For a fixed cross coefficient $\gamma_\times = g_\phi g_Q$, every positive rank-one factorization is

$$g_\phi^2 = |\gamma_\times| r, \qquad g_Q^2 = \frac{|\gamma_\times|}{r}, \qquad r > 0, \qquad [r] = 3.$$

A cross-only noise matrix would have eigenvalues of opposite sign and is forbidden. A switched nondegenerate direct kinetic contact $W^2 D_{\rm ct} \dot{x}^2$ changes primary rank between inactivity and activation, while an always-on one adds new jet modes. Within the minimal auxiliary-jet route this selects

$$D_{\rm ct} = 0.$$

For a positive pre-bath jet block J_0, the rank-one update satisfies

$$\det J_x^R = \det J_0 \left[1 + \alpha K^R_{\rm sel} \ell^T J_0^{-1} \ell\right], \qquad \alpha \geq 0,$$

and the shifted relaxation pole remains in the stable half-plane. This proves existence and local rank preservation under stated bounds. It does not fix r.

The source calculation for the compact parent is decisive. Coupling $j_Q Q_{\mathrm{aux}}$ leaves $p^*(\mathcal{C})$ unchanged and shifts only a multiplier. At fixed base geometry,

$$W_{\mathrm{aux}}[j_Q] = \int j_Q Q_\Delta, \qquad \boxed{\chi^{\mathrm{aux}}_{QQ} = \frac{\delta^2 W_{\mathrm{aux}}}{\delta j_Q \delta j_Q} = 0.}$$

The physical tree response is instead composite,

$$\chi^{R,\mathrm{tree}}_{QQ} = L_a G^{R,ab}_{\mathrm{grav+CMC}} L_b,$$

plus contact and environmental terms. Since $[H^{\mathrm{cap}}] = 0$, $[\Gamma_{QQ}] = -4$, and $[\chi_{QQ}(k)] = 4$, these objects cannot be identified. The balanced normalized choice $\hat{r} = 1$ is an additional constitutive principle. At the declared benchmark $|\widehat{\gamma}_\times| = 1.6295 \times 10^{30}$, it preserves algebraic rank but moves the transient pole to an approximately 6.77×10^{29}-year timescale. It is not promoted as a viable closure.

III.H Couplings, timing, and parameter ledger

For a reference $30 + 30 M_\odot$ circular binary, Peters' law gives

$$t(1466 R_S) = 54.07\ \mathrm{yr}, \quad t(730 R_S) = 3.324\ \mathrm{yr}, \quad t(360 R_S) = 71.82\ \mathrm{d}.$$

The near-halving ratios map to the fourth power in time. Observation supplied the central and inner temporal anchors; the closure calculation supplied the outer anchor conditional on $\tau_- = 0.1$ yr; Peters translated them into separations. The central period gives

$$m_s = \frac{h}{c^2 T_s} = 3.94 \times 10^{-23}\ \mathrm{eV}/c^2.$$

The reduced response time $\hbar/(m_s c^2) = 0.529$ yr and the full period $h/(m_s c^2) = 3.324$ yr must not be interchanged.

For the v8.1 curvature-rate observable, at fixed $x = r/R_S$,

$$q_N \propto M^{-2} x^{-3}, \qquad |D_U q_N| \propto M^{-3} x^{-7}.$$

A fixed dimensional threshold therefore gives $x_* \propto M^{-3/7}$ and cannot select the same pre-merger radius over the full compact-binary mass range.

QUANTITY	VALUE OR DEFINITION	STATUS
T_s	3.324 yr	observed/converged anchor
m_s	3.94×10^{-23} eV/c^2	phase conversion from T_s
ζ/Λ	$1.35 \times 10^{11}\ \mathrm{m}^2$	conditional parent/matching datum
L_*	$3.64 \times 10^{-30}\ \mathrm{m}$	compactification calculation
κ	1.02×10^{70}	saturated low-frequency coefficient
Δ	compact-readout crossover	required; microscopic origin open
δ_B	apex regularizer for activation	required; origin open

QUANTITY	VALUE OR DEFINITION	STATUS
ω_c	memory bandwidth	matched near the internal scale; UV derivation open
$44/88$	readout/alignment ranks	theorem for $\Delta > 0$
$46/92$	readout/alignment plus memory	theorem; module rank only
$58/116$	plus analytic jet constraints	conditional structural rank
c_0, c_2 / five contacts	homogeneous/finite-k conservative data	open
g_Q^2, g_ϕ^2, r	bath diagonal weights/factorization	open
$\mathsf{A}(k), \delta\mathbb{J}$	jet and CMC deformations	coefficient-incomplete

III.I Regimes and boundaries

The architecture distinguishes: the regulated apex $q_N = 0, \Delta > 0$; unsaturated $q_N \ll \Delta$; crossover $q_N \sim \Delta$; saturated $q_N \gg \Delta$; memory zero $Z = 0$; activation off/crossover/on; internal amplitude turning points; finite memory frequency $\omega \sim \omega_c$; the analytic weak-backreaction branch; the jet boundary $\det \mathsf{J}_{\mathrm{jet}} = 0$; the CMC boundary $\det \mathbb{J}_\epsilon = 0$; and the excluded sharp limit $\Delta = 0, q_N = 0$. Structural constraints remain present across response zeros because no constraint is multiplied by the activation amplitude. The complete gravitational theory fails on any surface where its full Dirac rank changes.

IV. Discovery, Calibration, Validation, and Prediction

IV.A Dependency discipline

A quantity is a *prediction* only if the calculation producing it does not use the observation against which it is tested. A quantity is a *calibration* if it does. A quantity is a *validation* if an independent calculation reproduces an observation it did not use. A *discovery* is the empirical route by which the pattern or candidate structure was first found; later reconstruction does not erase that history. Version 7.9 counted several calibrations as validations, and v8.1 reassigned them. Version 8.2 preserves that correction and adds three gravitational-audit distinctions: an *existence construction* proves that at least one parent with a stated property exists, not that it is unique or phenomenologically correct; a *conditional bridge* supplies no prediction until its conditions and coefficients are independently fixed; and a *closed* or *superseded* realization remains in the record rather than being silently removed. These rules apply equally to the gravitational parent, flyby observation map, threshold bridge, environment, and downstream particle constructions.

IV.B Timing convergence

The genuine convergence is that a closure-generated outer time, conditional on one declared inner boundary, and two observed times lie on one Peters trajectory at near-exact successive halvings of separation. The separations $730R_S$ and $360R_S$ are downstream images of the observed times relative to the outer branch. They are not independent threshold predictions. The fixed-threshold normalization and production world tube remain open.

IV.C Claims removed from the validation ledger

Removed from the validation ledger, with the reason: the "98%" validation of $(\zeta/\Lambda)_{\mathrm{SI}}$ by flyby amplitude, because the amplitude was calibrated to Anderson and the mechanical mechanism is withdrawn; $K = 2\omega R/c$ as derived from the minimal STF force, because it rests on an endpoint difference of a non-gradient force; the Earth/Jupiter/Venus reconstruction after fixing $\widehat{B}$ by the Anderson match, because it is an identity rather than a prediction; the Ulysses ephemeris discrepancy read as a direct $955.6\,\mathrm{mm\,s^{-1}}$ velocity detection; the balance of spacecraft energy gain against planetary rotational energy loss, because the interaction does no work; the single-field DHOST calculation as proof that the two-clock theory is ghost-free; and the binary-dephasing bounds 10^{-20}–$10^{-14}\,\mathrm{rad}$, because they were calibrated from the withdrawn flyby amplitude. These removals correct logical status; they do not delete the numerical coincidences, and the corrected flyby record in Appendix R shows why the Earth coincidence remains significant. **[withdrawn/reclassified]**

The post-v8.1 gravitational audit additionally removes as validations or completions: a Horndeski/DHOST class label for the local norm-rate action; a fixed threshold as a universal selector of $730R_S$; exact connection, BF, Plebański, six-null, or shifted-metric repairs; zero-DC, KMS, or spectral positivity as a complete conservative-contact match; the balanced bath as derived; and the compact-capacity Hessian as the environmental QQ response. Each is retained at its actual v8.2 grade: closed, conditional, existence-only, or open.

IV.D Present theorem and derivation core

RESULT	GRADE	SCOPE
gradient-clock obstruction	theorem	periodic scalar amplitude
two temporal objects required	theorem/entailment	scalar representation of universal ordering
Clock-Rate Invisibility	lemma	normalized-gradient universal clock
positive q_N state	derived selection	trace plus Weyl superenergy
direct local metric realization	closed generically	finite-order reciprocal metric action
compact Q_Δ identities	theorem	$\Delta > 0$
readout/alignment rank 44	theorem	one causal leg
exact memory rank 2	theorem	one causal leg
analytic jet rank 12	conditional theorem	weak-coupling bound
combined ranks $58/116$	conditional derived	structural modules only
boundary-CMC two-tensor count	conditional pass	both invertibility bounds plus Ward closure
positive Drude bath	existence construction	minimal rank-one environment
intrinsic auxiliary χ_{QQ}	zero theorem	fixed base geometry
physical QQ response	inherited/open	gravity, CMC, contacts, environment
Peters hierarchy	calculation	reference binary and declared provenance
no-work holonomy	derived	connection pullback

RESULT	GRADE	SCOPE
source–observer degeneracy	theorem	Earth flybys
scalar–Gauss–Bonnet tensor speed	calculation	regime-limited parent

IV.E Conditional extensions and the finite-(k) warning

Downstream cosmology, dark matter, particle, flavour, closure, and observational constructions retain their previous dependency grades. In the companion scalar–memory calculation, the unsuppressed cosmological split-leg realization has a finite-k Floquet resonance near $\lambda_{\rm res} \simeq 2.04$ pc. Hubble damping requires a suppression $\eta_{\cos} \lesssim 3.23 \times 10^{-20}$ at the declared benchmark. This closes the unsuppressed realization, not STF. Whether $\eta_{\cos}$ is the same operator as the earlier dark-matter capacity projection remains open.

The response-matched scalar–Gauss–Bonnet benchmark belongs in this conditional-extension ledger. Recalculation gives

$$|\delta c_T|_{\rm envelope} \simeq 3.6 \times 10^{-30}, \qquad |\mathcal{R}_{\rm 2C}|_{z=1} \sim 2.6 \times 10^{-37}\,{\rm s}^{-1}.$$

For the presently recorded v8.1 realization this is effectively a null prediction observationally. The tensor-speed value is the response-matched instantaneous envelope; the cross-messenger value is conditional on the same recorded realization and observation map. Appendix N remains the calculation and withdrawn-record home, while this section is the correct main-body location for the corrected benchmark and its dependency grade. It is not an item for the §VIII.F “not established” ledger because it is a calculated conditional benchmark, not a missing theorem. **[conditional numerical benchmark]**

IV.F The $11/8$ functional form

The blind likelihood returns $n = 11/8$ and a mean period 3.31 yr. It is an observational-statistical result independent of the Peters arithmetic and is retained as a convergence check, not as a gravitational input.

V. Falsification and Discrimination Program

V.A Gravitational and response tests

The candidate fails on any background or regime in its claimed domain if one of the following occurs:

1. the full primary/secondary Dirac rank changes at inactivity, crossover, saturation, the regulated apex, a memory zero, or an internal-phase turning point;
2. $\det(I_6 + \epsilon_{\rm STF}\mathsf{A}) = 0$ below the EFT cutoff;
3. the augmented CMC–volume operator develops a physical zero without a replacement constraint;
4. the reduced physical kernel acquires a negative-energy pole, gradient instability, or loss of hyperbolicity;
5. a Ward defect remains after every varied material and environment equation is imposed;
6. the noise kernel fails $N \succeq 0$;

7. a static portal survives after the claimed zero-DC renormalization condition;
8. the independently derived conservative contacts violate the jet or CMC bounds;
9. the microscopic environment cannot satisfy the positive-semidefinite spectral inequalities;
10. weak-field, binary-pulsar, or multimessenger constraints exclude the coefficient-complete theory.

Finding a failure in the conditional order-reduced parent closes that realization. It does not by itself prove that every possible STF gravitational completion is impossible.

The response-matched scalar–Gauss–Bonnet realization supplies a further realization-specific falsifier. Its recorded envelope is $|\delta c_T|_{\mathrm{envelope}} \simeq 3.6 \times 10^{-30}$ and its cross-messenger residual at $z = 1$ is $|\mathcal{R}_{2\mathrm{C}}| \sim 2.6 \times 10^{-37}\,\mathrm{s}^{-1}$. “Effectively a null prediction observationally” means that a present non-detection neither validates nor falsifies STF: the signal is far below foreseeable sensitivity. A reliable differential-propagation measurement above the response-matched envelope would falsify that recorded scalar–Gauss–Bonnet realization or its normalization, not every possible STF completion. The independent rank, Ward, pole, hyperbolicity, preferred-frame, static-response, flyby-utilization, and production-map falsifiers in this section are unchanged.

Carried over from v8.1 unchanged: a detected sign-flip of curvature-rate response that locks to the 1.66-year half-cycle falsifies the phase assignment — the amplitude, not the phase, would then orient the coupling — and a nonzero response to *static* curvature falsifies the zero-mode subtraction.

V.B Late-inspiral tests

The temporal anchors must continue to organize on the Peters a^4 hierarchy. A population of associated transients whose lead times do not scale consistently with the declared clock and production world tube would falsify the channel assignment. Mass-universal activation at a fixed $x = r/R_S$ cannot be claimed from a fixed dimensional curvature-rate threshold; an independently derived post-memory law must state its mass and environment dependence before population testing.

V.C Flyby measurement tests

The observer-clock branch predicts:

- the bound

$$\left|\frac{\Delta\widehat{V}}{V_\infty}\right| \leq \frac{2|\Omega_O|R_O}{c}(\cos\delta_{\mathrm{in}} + \cos\delta_{\mathrm{out}});$$

- utilization coefficients η_a computed from the orbit-determination design matrix, with detections clustering at larger utilization and nulls near zero under a preregistered rank-correlation test;
- dependence on the observational carrier and link mode rather than solely on the encountered planet;
- no common change in asymptotic mechanical energy;
- different signatures for a common no-work deflection and a link/clock holonomy.

The decisive experiment uses one encounter observed simultaneously by coherent two-way, three-way, one-way onboard, range, and angular tracking. A work-producing force, a common transverse deflection, a link-dependent clock residual, and an estimator projection have distinguishable multi-observable signatures.

V.D Cosmic Bell and quantum tests

Inherited from the universal-embedding program: curvature-, phase-, or background-dependent modulation of normalized Bell correlations would falsify the common-mode/no-local-mechanism result; controllable signaling through the advanced closure arc would falsify no-signaling marginals. These tests do not complete the gravitational constraint algebra.

V.E Closure–capacity and one-bit tests

A marginal loop on a zero write stream, a second-order anesthesia transition without hysteresis, or a biography migrating off the Peters rungs would falsify their respective companion conjectures. A topologically fixed closure certificate has zero controllable signaling capacity if its distribution is invariant under local settings; it cannot carry the continuous quantity $\omega R/c$.

V.F Extension-specific tests

Any prediction that requires the unfinished environment or gravitational bridge must be labelled conditional. The cosmological branch must satisfy its finite-k stability bound. The dark-matter branch must confront Lyman-α constraints with the actual self-interaction and capacity projection. The UHECR/GRB sectors require a production world tube and visible-sector vertex before event rates become predictions.

V.G Minimum completion criteria

Gravitational completion requires, in one coefficient-complete parent:

- two tensorial gravitational configuration degrees of freedom in the claimed domain;
- constant full Dirac rank across all named regimes and boundaries;
- the full pre-gauge Hamiltonian and momentum-constraint algebra;
- all nonlinear secondary chains;
- an independently derived $Q_\Delta X_\alpha$ vertex and ρ_{QQ};
- matched conservative contacts;
- total Ward closure with material/window/environment stress;
- positive noise and stable retarded poles;
- nonlinear hyperbolicity and a bounded reduced Hamiltonian;
- acceptable PPN, preferred-frame, fifth-force, compact-body, binary-pulsar, cosmological, black-hole, and merger behavior;
- a UV or microscopic account of Δ, δ_B, and the zero-DC renormalization condition.

The audit layer attaches four numeric acceptance gates to any coefficient-complete parent, to be passed simultaneously on one common branch (Gate G4, §X.D, Appendix Z): total Hulse–Taylor orbital-decay correction below approximately 3.59×10^{-3}; PSR J1738+0333 flux correction below approximately 1.81×10^{-1}; a GW170817 chirp-rate envelope below approximately 6.67×10^{-3}; and $|c_T/c - 1| \lesssim 10^{-15}$. The same parent must satisfy the explicit deformed-identity acceptance criterion of Gate G1 (Appendix W §VI.G).

VI. Extension Sectors After the Gravitational Revision

Cosmology. In conformally flat FLRW, $q_N = |R|$. Branch B suppresses the late-time source by two powers of H relative to the earlier expectation, so dark-energy sourcing remains conditional on the threshold normalization; the attractor and $w(z)$ corrections remain in Appendix M of the V7.9 derivation record. The high-pass kernel suppresses slowly varying backgrounds. The unsuppressed finite-k split-leg realization fails its Floquet/Hubble-damping gate, with

$$\lambda_{\rm res} \simeq 2.0396\,\mathrm{pc}, \qquad \eta_{\cos} \lesssim 3.23 \times 10^{-20}, \qquad \eta_{\cos} p_0 \simeq 4.9 \times 10^{-10}.$$

The last product confirms that the weak-feedback bound is self-consistent after suppression. This closes the constant unsuppressed cosmological split-leg realization, not STF; a suppressed or curvature-activated realization remains viable. Global solutions of the full boundary-CMC environment parent are not known. **[derived/conditional]**

This finite-k result does **not** supersede Branch C. For a declared cosmological carrier and curvature profile $q \propto a^{-n}$,

$$D_U q = -nHq,$$

while the response kernel suppresses that slowly varying source by $H/\omega_s \simeq 4 \times 10^{-11}$. Branch C is a proved kinematic carrier result; the Floquet scan is a stability test of an unsuppressed activated split-leg perturbation system. They concern different layers and are complementary. No withdrawal is therefore added to Appendix P. **[Branch C proved]**

Ultralight scalar and galactic sector. The mass $m_s \simeq 3.94 \times 10^{-23}\,\mathrm{eV}$ remains compatible with a long-coherence scalar interpretation. The stationary-source result $D_U q = 0$ for a carrier stationary relative to a galaxy is a carrier fork, not a wall: for a cosmological carrier, Branch C proves $D_U q = -nHq \neq 0$. The latter channel is nevertheless kernel-suppressed by $H/\omega_s \simeq 4 \times 10^{-11}$, so direct curvature-rate sourcing is negligible in either carrier realization. What survives is the ultralight-condensate sector itself: $w = 0$, Schrödinger–Poisson dynamics, kiloparsec-scale coherence, and solitonic cores. The phonon–baryon vertex descended from the withdrawn cross-disformal coupling and falls with it. **[Branch C proved]**

The MOND scale $a_0 = cH_0/(2\pi)$ is a conditional target, not a result. The arithmetic identity

$$\frac{H\bar{\lambda}_C}{T_s} = \frac{cH}{2\pi}$$

is exact: the mass cancels and the 2π is the reduced-length/full-period ratio. What remains underived is the **Correlation–Cycle Write Principle**: why one inverse-mass spatial correlation length and one complete internal recurrence are the spatial and temporal write intervals of galactic dynamics, with unit gain into the baryonic lapse. This is a case-(iii) pairing under the §II.C 2π-Provenance Rule and requires an independent constitutive derivation. **[identity/conditional selection]**

The proposed **Clock-Gradient Marginality** route still has three undischarged clauses: **(i)** that one inverse-mass correlation length is the spatial write cell; **(ii)** that one complete internal phase is its temporal write interval; and **(iii)** that universal strain transfers to the baryonic lapse with unit gain. The corpus's former locality argument does not discharge these clauses. Its original proof asserted $\tau_c = \bar{\lambda}_C/c \simeq 3.32$ yr, which is false by exactly 2π (the complete period is $T_s = 2\pi\bar{\lambda}_C/c$), so the causal-cell volume $V_{\rm local} = (c\tau_c)^3 = (2\pi)^3\bar{\lambda}_C^3$ had been understated by $(2\pi)^3 = 248$. The corrected General Theory discussion therefore supplies no derivation of a_0; it identifies the missing constitutive bridge. **[open theorem clauses]**

The free-field Lyman-α exclusion remains the condensate interpretation's most severe live constraint, with m_s roughly a factor 500 below the quoted free-field bound. Whether the compactification-induced $\phi^2 I_4$ self-interaction, which reaches order unity relative to gravity near $z \simeq 5 \times 10^4$, changes that bound is a named open calculation. The finite-k activation/capacity audit does not supersede this framing: it constrains cosmological feedback and projection, whereas Lyman-α constrains small-scale structure in the actual interacting condensate. **[open phenomenology]**

Inflation. The I_4-based curvature-squared parent enhances the early-universe response. Quantitative inflationary predictions must be recomputed in the regulated, order-reduced architecture, with the former saturation model retained only as a benchmark. The detailed V7.9 inflation calculation and its status are preserved in Appendix J of the *First Principles V7.9* derivation record. **[recalculation target]**

Particle, flavour, and compactification constructions. These sectors are not superseded by the gravitational audit and retain their existing grades in the *First Principles V7.9* derivation record: Standard-Model unification in Appendix K; the CICY construction in Appendix Q; flavour and the phase-lag CP mechanism in Appendix R; Weil–Petersson numerics in Appendix S; the full ten-dimensional reduction in Appendix L; cosmology in Appendix M; MOND in Appendix I; inflation in Appendix J; and dipole radiation in Appendix H. In particular, CICY #7447/$\mathbb{Z}_{10}$, flavour, CP-phase, Weil–Petersson, and D3/duality-wall studies remain downstream UV avenues at their own stated grades. None supplies the infrared boundary-CMC/environment vertex required by v8.2.

The ten-dimensional parent stands, but the retarded-response map from that parent to the local rate operator remains a constitutive completion target rather than a proved reduction. The gravitational revision neither upgrades nor withdraws any of the delegated sector calculations unless an explicit coupling calculation reaches them. **[conditional parent bridge]**

UHECR/GRB production — an open gap, stated plainly. The displayed v8.2 architecture has no production channel for either observational anchor. V7.9's phenomenological fermion vertex $g_\psi \phi \bar{\psi} \psi$ — the framework's only link to the UHECR record in which it was discovered — was dropped in the V7.9-to-v8.1 triage. The Maxwell equation is homogeneous in $F_{\mu\nu}$, so starting from $F_{\mu\nu} = 0$ a nonzero STF scalar generates no classical photons; the residual photon coupling is sequestered, and on-shell decay of an ultralight scalar yields ultralow-energy photons rather than gamma rays. **[open]**

The consequence is the **Production-Map Non-Entailment result**: the displayed action and its derived linear response kernel determine a local scalar response once the coupling, clock, and boundary data are supplied, but they determine no event-rate functional $\Gamma_{\rm UHECR}(\tau)$ or $\Gamma_{\rm GRB}(\tau)$. They specify neither a production world tube nor a visible-sector production functional. Restoring the discovery-record vertex is not a one-line repair; a modulus Yukawa must first be shown consistent with the Appendix O sequestering analysis before it can carry a grade stronger than phenomenological. **[non-entailment result]**

The named missing inputs are the covariant production surface $\Sigma_{\rm prod}$, self-field treatment, sequestering-consistent visible-sector vertices, the channel-threshold ratio, and the inner boundary $\tau_- = 0.1\,\mathrm{yr}$. Until they close, references to the UHECR/GRB anchors describe the discovery record and timing structure, not event rates entailed by the action. **[open items]**

Universal embedding and Bell. The framework is Born- and Bell-compatible, not Born-deriving; the Cosmic Bell test has no jurisdiction over the future-boundary structure merely because that structure is written with an advanced arc. These companion-paper claims neither repair nor worsen the gravitational Dirac algebra without an explicit coupling calculation.

Closure, capacity, and the one bit. The broader closure and one-history constructions retain their companion-paper grades. The zero-capacity corollary needed by the one-bit lemma is sharper: if the closure certificate w is topologically fixed for every admissible completed transaction and its distribution is invariant under all local instrument settings a, b, then

$$P(w \mid a, b) = P(w),$$

and the advanced sector has zero controllable signaling capacity. A one-bit closed/open certificate also cannot carry the continuously varying real number $\omega R/c$; that quantity must reside in an ordinary retarded field, a boundary condition, or a conventional exterior multipole. Likewise,

$$\frac{1}{4\pi^2} \int \omega_R \wedge \omega_A = 1$$

normalizes a completed transaction but does not fix a dynamical amplitude or set the flyby coupling to unity. **[zero-capacity corollary/one-bit limitation]**

VII. Consistency with Existing Constraints

VII.A Tensor speed

For the scalar–Gauss–Bonnet parent $f(\phi)\mathcal{G}$, a constant coupling is topological in four dimensions and the tensor correction enters through time variation:

$$\alpha_T \simeq \frac{8(\ddot{f} - H\dot{f})}{M_{\mathrm{Pl}}^2}.$$

The response-matched recalculation gives

$$|c_T/c - 1| \lesssim 7 \times 10^{-41}$$

in the tracking regime and

$$|\delta c_T|_{\mathrm{envelope}} \simeq 3.6 \times 10^{-30}$$

for the instantaneous oscillating-regime envelope. The associated conditional cross-messenger residual is

$$|\mathcal{R}_{2\mathrm{C}}|_{z=1} \sim 2.6 \times 10^{-37}\,\mathrm{s}^{-1}.$$

Thus the presently recorded v8.1 scalar–Gauss–Bonnet realization is effectively a null prediction observationally and remains far below the multimessenger tensor-speed bound. The statement is explicitly limited to that response-matched scalar–Gauss–Bonnet route. It is not a tensor calculation of the coefficient-incomplete split-leg boundary-CMC parent, and it does not establish that every possible STF completion has the same envelope. **[calculation/conditional benchmark]**

VII.B PPN, fifth forces, and compact bodies

Diffeomorphism covariance does not force preferred-frame PPN coefficients to vanish. The independent clock defines a physical foliation. A coefficient-complete weak-field solution and matter matching are required for $\alpha_1, \alpha_2, \alpha_3$, fifth-force strength, and light propagation. Compact-body charges and dipole radiation are unknown. Flyby-calibrated dephasing bounds remain withdrawn.

VII.C Stability and causality

The direct finite-order local norm-rate metric action is generically closed by the quartic-pole calculation. The surviving architecture is an open EFT and must be assessed through its retarded kernel, local retained-environment parent, complete constraints, and reduced Hamiltonian. Causality of the selector follows from retarded support; that alone does not prove hyperbolicity or positivity of the gravitational system.

VII.D Constraint ledger

CONSTRAINT	V8.2 STATUS	DECISIVE MISSING CALCULATION
direct local metric ghost freedom	generically failed	none within that route
compact readout rank	passed for $\Delta > 0$	microscopic regulator origin
exact memory	passed	UV spectral continuation
analytic jet removal	conditional pass	coefficient-complete $\mathsf{A}(k)$
gravitational scalar removal	conditional pass	complete $\delta\mathbb{J}$, global CMC domain
full Hamiltonian algebra	open	$\{H[N], H[M]\}$ and secondary chains
total Ward identity	conditional pass	explicit environment/world-tube parent
noise positivity	existence pass	microscopic spectrum and nonlinear completion
tensor speed	passed on sGB parent	completed-parent tensor action
PPN/preferred frame	open	weak-field solution and matter matching
binary pulsars	open	compact-body charges
cosmological stability	conditional/failing when unsuppressed	completed background and finite-k spectrum

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VIII. Discussion

VIII.A What survived the gravitational audit

The audit did not erase STF's primary path. It clarified which parts are structural and which implementation was overclaimed. Two clocks remain forced. The clock-relative curvature state remains the intended observable. Regulated capacity, causal memory, post-memory activation, varied carriers, and the observational inverse-problem program remain. The closed local action is replaced by a narrower EFT bridge that retains rather than algebraically hides the degrees of freedom whose constraints must be counted.

VIII.B Why the closed routes matter

Torsion, regular BF/Legendre, same-metric Plebański, spectator gauge nulls, and shifted metrics fail for different reasons, but they share one lesson: adding variables or changing representation is not degeneracy. A viable constraint must act on the physical higher-derivative sector, survive activation zeros, and generate the necessary secondary chain. Covariance may coexist with an unhealthy phase space; Ward closure does not substitute for a Dirac proof.

VIII.C What the late-inspiral numbers establish

The timing hierarchy remains an unusual convergence between one conditional theoretical outer anchor, two observations, and the pre-existing Peters (a^4) map. It does not establish the activation normalization, production world tube, or gravitational parent. Its scientific value is preserved precisely by keeping those dependencies visible.

VIII.D Measured and observed

The flyby program operationalizes the framework's distinction between a physical history and its record. A Doppler estimator may report a scalar ΔV_∞ for a transverse no-work perturbation or a link phase residual. Continuous multi-observable tracking can remove that degeneracy. The framework is falsifiable because the capacity, carrier, link-mode, and utilization laws make different predictions from a source force.

VIII.E What is genuinely first-principles

First-principles at the present level: the gradient-clock obstruction; the need for two temporal objects; the positive clock-relative decomposition; the compact-alignment solution and Hessian; the constant readout rank; exact memory; the local-action obstruction; the no-go results for the tested same-content repairs; the conditional jet and CMC invertibility theorems; the contact-count theorems; the fixed-base auxiliary QQ source theorem; the Peters translation; the no-work, vorticity, operator-norm, and source–observer theorems; and the scalar–Gauss–Bonnet tensor calculation.

Not first-principles: the microscopic value of Δ; the activation regularizer and gain; the complete jet and CMC coefficients; the environment spectrum; r; the production map; the flyby utilization coefficients; a global clock solution; PPN safety; or a UV completion of the full bridge.

VIII.F Explicitly not established

Version 9.1 does not establish:

1. a coefficient-complete fundamental gravitational action;
2. the complete pre-gauge Hamiltonian constraint algebra;
3. the full nonlinear secondary-constraint chain;
4. constant full Dirac rank outside the analytic weak-backreaction branch;
5. nonlinear hyperbolicity or positivity of the complete reduced Hamiltonian;
6. global existence or uniqueness of boundary-selected CMC slices;
7. a regular CMC branch through every black-hole or merger geometry;
8. the microscopic origin of Δ or δ_B;
9. a universal mass-independent activation coefficient;
10. a microscopic covariant $Q_\Delta X_\alpha$ vertex;
11. the diagonal spectral density ρ_{QQ};
12. g_Q^2, g_ϕ^2, or r;
13. the two homogeneous or five finite-momentum conservative contacts;
14. a UV-complete Drude continuation;
15. an all-loop zero-DC Ward identity — Gate G3: a sufficient protective translation symmetry is identified but is not realized by the frozen architecture; Appendix AB proves that the tested compensator shifts

only a redundant common coordinate and leaves the physical relative-readout contact symmetry allowed; the regulated apex, material window, measure, state, regulator, boundaries, and anomaly structure remain unresolved; open, priced (§X.C; Appendices Y and AB);

16. quantum or radiative stability — the specified quadratic core has an exact one-loop static zero, but Appendix AC proves that the full coefficient and beta function are not identifiable from the frozen parent; Appendix AD derives a positive matched world-tube crossover residual when the carrier is quantized, requiring the same order-by-order subtraction; open, priced (§X.C; Appendices Y and AC–AD);
17. nonlinear KMS/noise closure;
18. complete system-plus-environment anomaly freedom;
19. PPN and preferred-frame consistency;
20. fifth-force safety;
21. compact-body charges or binary-pulsar consistency;
22. global cosmological solutions of the completed parent;
23. black-hole or merger solutions of the completed parent;
24. a UHECR or GRB production operator — Gate G5: Appendix AF supplies a varied neutral material support and rest frame but no polarization–magnetization tensor; Appendices AG–AH find no frozen microscopic charged bridge or compactification-derived replacement; microscopic matching, plasma projection, sequestering compatibility, and pre-merger support remain unproved (§X.E; Appendices AA and AF–AH);
25. the 71-day production-threshold ratio — Gate G5: remains an independently normalized ratio target, $\mathfrak{R}_{\rm ch} \simeq 2.41 \times 10^3$; no material-current, real-scalar, or compactification coefficient derives it (§X.E; Appendices AF–AH);
26. the 0.1-yr inner production boundary — Gate G5: wholly unsupplied; the post-v9.0 material and compactification chain supplies no lower support endpoint (§X.E; Appendices AF–AH);
27. flyby utilization coefficients η_a;
28. a complete UV/string realization of the gravitational bridge;
29. any status imported from a separate version-9 branch — the quarantined separate-session draft formerly labeled “V9.0” remains excluded. Local post-v9.0 uses of “item 29” as shorthand for the world-tube-support frontier are an editorial numbering collision, not a change to this canonical item; v9.1 assigns those obligations to items 41–44 (§XI.F).
30. the Curvature-Polarization Saturation Theorem (Appendix D.7);
31. the Capacity-Normalized Curvature Theorem (Appendix D.7);
32. the Clock-Euclideanization Theorem (Appendix E.5);
33. the coefficient-complete reduced advanced/noise deformed identity and equation count for the coupled metric–readout–memory–jet–world-tube system (Gate G1 explicit acceptance criterion, Appendix W §VI.G);
34. a microscopic determination of g_Q^2 and the factorization ratio, a UV continuation of the ideal Lorentz–Drude continuum selected by the exact v8.2 response, and promotion or exclusion of the conditional warm-horizon supplier; Appendix AF supplies only the positive spectral-sum form after unknown normalized material overlaps are given (Gate G2; Appendices X and AF);
35. a realized, anomaly-free protective translation symmetry of the full parent, or the coefficient-complete one-loop c_{QQ} quantifying the unprotected subtraction cost; Appendix AB closes the naive compensator route, Appendix AC proves full-parent non-identifiability, and Appendix AD computes the

matched local crossover formula without fixing its microscopic number (Gate G3; Appendices Y and AB–AD);

36. a coefficient-complete binary emission calculation passing the Hulse–Taylor 3.59×10^{-3}, J1738 1.81×10^{-1}, GW170817 chirp 6.67×10^{-3}, and 10^{-15} tensor-speed gates on one common branch (Gate G4, Appendix Z §§X–XI);
37. a pre-merger production precursor with support on the covariant production surfaces, and independent derivations of the $\simeq 2.41 \times 10^3$ channel ratio and the 0.1-yr inner boundary (Gate G5, Appendix AA §X).
38. a relative-coordinate/Stueckelberg implementation that acts nontrivially on the physical curvature-carrying readout, forbids its static contact, preserves the complete quantum boundary problem, and yields a valid replacement constraint algebra; the tested common compensator fails these conditions and does not imply $58/116 \to 59/118$ (Appendix AB).
39. a unique full-parent one-loop static QQ coefficient or beta function; the constrained-readout, linear-memory, finite-Gaussian core gives an exact zero, while admissible interacting completions give different results (Appendix AC).
40. a parameter-free matched world-tube crossover coefficient; the bubble-plus-seagull result and positive KMS noise are derived, but depend on V_B''/Z_B, microscopic overlaps, transverse completion, cutoff, and subtraction scheme (Appendix AD).
41. an isolated stable finite-radius canonical B tube; this route is closed under the stated Derrick assumptions, while any supported tube requires an additional varied pressure, charge, flux, boundary, or gravitational sector (Appendix AE).
42. a frozen-derived varied conserved-material-current completion; a Brown-current thin-wall representative conditionally selects a stable radius and repairs the fixed-source Ward defect, but its equation of state, binding, smooth spectrum, material degrees, and total rank are new and uncompleted (Appendix AF).
43. a frozen microscopic sector satisfying exact localized charge, coefficient-complete support, and derived B-binding simultaneously; the real scalar supplies only an approximate nonrelativistic number and conditional quantum-pressure radius, with the exact stability problem Floquet rather than static (Appendix AG).
44. a compactification-derived exact complex/axionic charge and coefficient-complete B-binding compatible with the frozen linear activation; the displayed metric-only reduction supplies neither, and adding an invariant complex activation defines a new theory branch (Appendix AH).

VIII.G Executed frontier and frozen research boundary

The v9.0 frontier began with the microscopic $Q_\Delta X_\alpha$ vertex and ρ_{QQ}. Gate G2 supplied a covariant vertex class and the unique positive ideal Lorentz–Drude continuum selected by the exact response, but left its microscopic normalization open. The post-v9.0 sequence then tested the strongest available zero-DC compensator, the identifiable one-loop coefficient, the varied world-tube crossover, finite support, a varied material current, the frozen microscopic sectors, and the compactification route. Appendices AB–AH carry that executed chain.

The chain ends at a controlled construction boundary. The frozen architecture does not derive the exact charged carrier or B-binding needed to define a coefficient-complete enlarged parent. Consequently no enlarged Dirac total, physical Floquet spectrum, numerical-relativity waveform, or production rate is quoted. Downstream calculation cannot replace missing operators.

The permitted programme inside frozen STF is now consolidation and testing of the candidate at its existing grade: preserve the two-clock and observational theorem core; apply the existing response, emission, production-support, and population falsifiers; and report nulls or failures without adding coefficients. Any renewed completion programme must first choose an explicit new microscopic or compactification parent, derive its fields and couplings, and version it as a new theory branch rather than as a parameter-free consequence of v8.1/v8.2.

IX. Conclusion

STF v9.1 retains the framework's central discovery: an oscillatory internal phase and a universal ordering cannot be the same clock. It retains the clock-relative curvature state, bounded response, causal memory, late-inspiral timing convergence, and measurement-centered flyby program. It also records a decisive correction. The direct local reciprocal curvature-norm metric action is generically not healthy, and the tested same-content representations do not cure it.

The surviving route is an action-level order-reduced open EFT on an analytic branch. Its regulated compact readout and exact memory are constant-rank modules. Its independent curvature jets and boundary-CMC clock conditionally remove the spurious jet pairs and gravitational scalar. Its positive environment can exist without changing those ranks. But the complete jet coefficients, CMC bracket, environment spectrum, contact terms, and weak/strong-field solutions remain open.

The revision therefore strengthens STF by narrowing its live claim to what the calculations support:

$$\boxed{\text{coherent gravitational candidate — not a completed gravity theory.}}$$

The next step is not another change of variables. It is the microscopic $Q_\Delta X_\alpha$ vertex and ρ_{QQ}, followed by the complete boundary-CMC Dirac and Ward calculation. Gate G2 (§X.B, Appendix X) has since supplied the covariant vertex class and the unique selected continuum; the microscopic coefficient g_Q^2 and the boundary-CMC Dirac/Ward calculation remain the next step.

Frozen-consolidation disposition (v9.1). The seven-record chain in Appendices AB–AH has now executed the construction frontier named above. It rules out the naive compensator, identifies the exact Gaussian one-loop zero and the non-identifiability of the interacting completion, derives the matched world-tube crossover price, closes the isolated static B-tube subclass, constructs but does not derive a varied material-support extension, and finds no frozen microscopic or compactification sector that supplies exact charge and B-binding together. The parameter-free completion push therefore stops at the frozen compactification boundary. This is a closure of one construction programme, not a withdrawal of the surviving STF candidate and not a proof that no different theory can be built. The grade remains unchanged.

Acknowledgements

The June–August 2026 derivations and the post-v8.1 gravitational-completion audit were conducted through adversarial calculation sessions with independent machine-assisted reproduction. All checkpoint scripts were rerun from clean packages before this revision. The observational discovery record is maintained at uhecrtoday.com.

Conflict of Interest

The author declares no conflict of interest.

Appendices — Derivation and Supersession Records

X. The Five-Gate Audit Layer (28 August 2026)

After the v8.2 release was frozen, five adversarial audit gates were run against it by the independent derivation session — each graded against the frozen v8.1 and v8.2 baselines, each with the separate version-9 draft excluded (ledger item 29), each reviewed on the verification side against a sealed pre-registered rubric, and each accompanied by a NumPy reproduction script whose numerical claims were independently re-derived before acceptance. All five gates returned with zero withdrawals and the grade unchanged. This section states each gate's decisive result and its consequence; the complete records are carried verbatim as Appendices W–AA.

GATE	RECORD (PAPER FILE, SHA-256)
G1 — Open-operator and deformed-identity classification	`STF_V8_2_Open_Operator_Deformed_Identity_Classification_Gate_V1_0.md`, `fb54d267706e2a571592786f6b942e047d236ee49b243a1c66d3faf289b8fee1`
G2 — Covariant Q_Δ-environment vertex and horizon spectral gate	`STF_V8_2_Covariant_QDelta_Environment_Vertex_and_Horizon_Spectral_Gate_V1_0.md`, `6164626560f1becbd33f958876967c99ec097d88a1a158a4b89dd866c19525c9`
G3 — All-loop zero-DC protection and quantum stability	`STF_V8_2_All_Loop_Zero_DC_Protection_and_Quantum_Stability_Gate_V1_0.md`, `f6c0284dc3d58064b9b5cc61c9b561d110c84a44297278e7788b160bbd737228`
G4 — Gravitational-wave emission audit	`STF_V8_2_Gravitational_Wave_Emission_Audit_Direct_Local_and_Analytic_Parent_V1_0.` `a78576364bc446ee5e6b77e8e3c778ef49e4f17b3a0cb60a4152d72b7ab01ac7`
G5 — Merger-production	`STF_V8_2_Merger_Production_Activation_Timing_Surface_and_Visible_Vertex_Gate_V1_0` `3571f0b8e1cc22b5d044b00425ecb19d77e47ff6b810ab146b36e9c5302c7d64`

GATE	RECORD (PAPER FILE, SHA-256)
activation and timing gate	

X.A Gate G1 — Open-operator classification and the deformed-identity obligation (Appendix W)

The gate classifies every named module of the doubled parent against the Schwinger–Keldysh open-EFT consistency framework of Christodoulidis and Christodoulidis–Gong. The decisive separation is between the finite unintegrated parent and its reduced open description: compact readout, retained curvature jets, boundary-CMC selection, and the varied world tube are not dissipative operators, and the local memory pair and finite oscillator environment enlarge the varied parent — only after environmental elimination do the retarded and noise kernels become genuine open operators. The existing total Ward identity therefore remains valid at exactly its declared conditional level; it is not replaced by a deformed nonconservation law. The framework exposes one additional open obligation: the coefficient-complete reduced influence functional must possess an advanced/noise deformed identity with the correct scalar, vector, and tensor equation count, and no present calculation shows that the metric response induced by the unfinished covariant $Q_\Delta X_\alpha$ vertex is the special trace-adjusted canonical-momentum operator. The explicit acceptance criterion is Appendix W §VI.G; it is ledger item 33.

X.B Gate G2 — The environment vertex and the selected Lorentz–Drude continuum (Appendix X)

The gate performs the immediate environmental calculation declared in §V.G: a covariant uneliminated vertex class $S_{QX} = -\sum_s s\int d^4x\sqrt{-g_s}\,\widetilde{Q}_{\Delta,s}\mathcal{F}_{Q,s}$ with $\mathcal{F}_Q = \sum_\alpha c_\alpha(\mathcal{I})X_\alpha$, and the spectral density the selected kernel forces. Requiring the exact selected response $\Sigma^R_{QQ}(z) = g_Q^2(-iz)/(\omega_c - iz)$ fixes the positive ideal continuum uniquely through the retarded discontinuity:

$$\rho^{\mathrm{D}}_{QQ}(\Omega) = \frac{g_Q^2}{\pi}\frac{\Omega\,\omega_c}{\Omega^2+\omega_c^2}, \qquad \mathcal{N}_{QQ}(0) = \frac{4g_Q^2}{\beta\omega_c}.$$

The warm-horizon environment of the linked decoherence papers supplies, conditionally, an additive Ohmic slope only after a covariant world-tube projection $\mathcal{F}_H = \lambda_H P_A\,\delta\mathcal{C}^A_H$ with $P_A = M_*^2\mathcal{C}_A/\sqrt{q_N^2+\Delta^2}$ is specified, subject to an explicit double-counting gate against G_{grav} and an eight-condition acceptance list (Appendix X §X). The unintegrated vertex is a diagonal-covariant scalar and preserves the established 58/116 structural subtotal. The microscopic Wilson coefficient g_Q^2, the factorization ratio, and the ultraviolet completion remain open: ledger item 34.

X.C Gate G3 — Zero-DC protection priced (Appendix Y)

A sufficient protective condition for ledger items 15 and 16 exists: a non-anomalous diagonal translation of the physical readout and its retained environment, $\delta\widetilde{Q}_{\Delta,\pm} = \epsilon$, $\delta X_{\alpha,\pm} = \lambda_\alpha\epsilon$, $D_U\epsilon = 0$, yields a 1PI Ward identity forbidding an undifferentiated static Q_aQ_r contact. A spacetime-constant ϵ protects only $K^R(0,\mathbf{0}) = 0$, whereas protection of $K^R(0,\mathbf{k})$ throughout the finite-momentum domain requires a line-wise subsystem symmetry $\epsilon = \epsilon(\sigma^A)$ with compatible transverse terms and boundary data; a Gaussian environment written through the relative coordinates $X_\alpha - \lambda_\alpha\widetilde{Q}_\Delta$ realizes the corresponding common translation exactly inside that subtheory. The frozen architecture does not realize it globally: a curvature transformation shifting Q_Δ by a constant is singular at the regulated apex $q_N = 0$; shifting by ϵ/W is singular where the material window is off; and a window-weighted bath translation fails through activation whenever $D_U W \neq 0$. Items 15 and 16 therefore remain open — now priced. Without an architectural symmetry the minimum cost is order-by-order tuning of one static QQ counterterm in the selected channel, $c_{QQ}^{(L)} = -\Sigma_{QQ}^{R,(L)}(0)$ — two homogeneous or five finite-momentum conditions in the full conservative response — at every perturbative order. The alternative is a regular relative-coordinate/Stueckelberg completion with a renewed rank, boundary, anomaly, and Ward audit; the variationally-trivial spectator route would protect most strongly but removes the physical response channel. Ledger item 35.

X.D Gate G4 — Emission audit: second closure of the direct action, acceptance gates for the parent (Appendix Z)

The direct local q_N metric action fails independently of its ghost pole. Its rate form is the $|\omega| \ll \omega_c$ truncation of the exact memory kernel, while binary-pulsar frequencies exceed $\omega_c \simeq m_s$ by more than 3.4×10^3 and a 10 Hz angular frequency exceeds it by about 1.05×10^9; the truncation over-extrapolates the exact response by those factors, so the direct action is neither a healthy fundamental metric theory (the original v8.2 closure) nor a controlled emission approximation at the reviewed observations. The locally frozen pole diagnostic $m_{\rm gh}^2 = M_{\rm Pl}^2 q_N/(2\kappa|A|)$ places the extra pole inside, not above, the active force/radiation windows of the linked ghost-flux analysis. The analytic order-reduced parent passes the conditional no-ghost-emission gate — order reduction expands rather than resums the fourth-order denominator, so no independent ghost pole arises below the EFT cutoff, conditional on the jet and CMC bounds and closure of the reduced constraint algebra — while binary-pulsar and GW170817 consistency remain open, with the four numeric acceptance gates now attached to §V.G. The exact memory is already saturated at pulsar and LIGO frequencies and supplies no high-frequency suppression. Ledger item 36.

X.E Gate G5 — Merger production and the support theorem (Appendix AA)

Production-Support Preservation Theorem. If the physical merger operator vanishes before coalescence, every finite multiplicatively gated version of it also vanishes there: a bounded scalar activation factor cannot make a material current, post-merger ejecta, a remnant accretion flow, or a shock exist on an earlier hypersurface. In the linked BNS mechanism, nuclei reach maximum rigidity approximately 0.15–0.77 day after merger; in the linked AGN-disk mechanism, shock breakout follows the gravitational wave by 11.264 s, and the S241125n association is itself a 1.8σ candidate. Post-merger channels therefore cannot carry the pre-merger STF anchors. The gate nevertheless supplies covariant production surfaces — the transverse maximum-rigidity surface $\mathfrak{F}_{A,Z} = 0$ and a covariant shock-breakout surface — and narrows ledger item 24 to a gauge-consistent antisymmetric material-polarization vertex class $(Q_\Delta/\Lambda_i^4)\,\mathcal{G}_i(\Upsilon_Z) W_i \mathcal{M}_i^{\mu\nu} F_{\mu\nu}$ with structurally conserved production current. The channel-threshold requirement is made explicit and is not derived: $\mathfrak{R}_{\rm ch} = (3.3\,{\rm yr}/71\,{\rm d})^{11/4} \simeq 2.41 \times 10^3$ is a requirement on independent canonical matching. Items 24, 25, and 26 remain open as stated. Ledger item 37.

X.F Independent literature context

The audit layer engages the 2025–2026 literature directly: the open-EFT deformed-identity framework (Christodoulidis; Christodoulidis–Gong) is the mathematics class of G1; the DHOST quantum-protection analysis (Braga–Jimenez–Matarrese) frames G3; the ghost-flux observational program (Lambiase–Mukohyama–Poddar–Rescigno) frames G4; the warm-horizon decoherence results (Wilson-Gerow–Dugad–Chen; Danielson–Satishchandran–Wald; Danielson–Kudler-Flam–Satishchandran–Wald) frame G2; and the BNS–UHECR and AGN-disk GRB mechanisms (Farrar; Zhang et al.) are the post-merger source models tested by G5. These are independent developments: convergence is not influence, and none of them confirms the framework. Full citations appear in the audit-layer reference block and in each appendix's own reference list.

X.G What the audit layer changes and does not change

Zero results were withdrawn and none upgraded. The additions are: the deformed-identity obligation with its explicit acceptance criterion (G1); the unique positive ideal Lorentz–Drude continuum associated with the exact selected response and the conditional, double-counting-gated horizon supply (G2); the priced status of items 15 and 16 (G3); the second, independent closure of the direct local action and the four numeric acceptance gates (G4); and the Production-Support Preservation Theorem, the covariant production surfaces, and the narrowed but still-open item 24 (G5). The not-established ledger extends from 32 to 37 items; §V.G gains the acceptance gates; every other statement of the carried v8.2 content is unchanged. The grade is unchanged:

$$\boxed{\text{coherent gravitational candidate — not a completed gravity theory.}}$$

XI. The Frozen-Consolidation Layer (29 August 2026)

After v9.0 was frozen, seven successive calculations tested whether its named open obligations could be closed without changing the theory. Each used the frozen v8.1/v8.2 physics baseline, treated v9.0 only as an audit ledger, excluded the quarantined alternative version-9 architecture, and shipped with a NumPy-only checker. The records are carried as Appendices AB–AH.

RECORD	DECISIVE RESULT	APPENDIX
Relative-coordinate Stueckelberg viability, 121468a1…a7fd8d3	common shift removes a redundant coordinate but permits the physical static contact; no $59/118$ promotion	AB
One-loop static QQ identifiability, 327eb75d…5eeebb4	quadratic core exactly zero; full coefficient and beta function not identifiable	AC
Varied world-tube crossover loop/noise, bb89b94d…fb9e5b7	matched bubble plus contact seagull is positive and KMS-consistent; exact zero DC must be rematched	AD
Finite world-tube Derrick/material support, 9dbe34ad…01ba05ae	isolated static real-B tube fails; finite support requires an additional varied sector	AE
Varied conserved-material-current bridge, 6f065043…5a6e19c0	a controlled Brown-current representative selects a stable radius, but its coefficients are added data	AF
Microscopic-current identifiability/real-scalar Floquet, de2ed85f…9799a11	no frozen sector supplies exact charge, support, and binding; real scalar is approximate and Floquet-controlled	AG

RECORD	DECISIVE RESULT	APPENDIX
Compactification exact-charge/B-binding stop gate, 93633e12…395a19c	metric-only reduction and frozen activation fail both acceptance conditions; stop rule fires	AH

XI.A Protective-symmetry disposition

The common-shift compensator is regular only because the physical relative coordinate $y = q - R$ is invariant. The operator $y_a y_r$ is therefore allowed. The correct primary generator is

$$\Phi = p_q + p_R + \sum_\alpha \lambda_\alpha p_{X_\alpha} \approx 0,$$

and a regular gauge fixing removes the compensator without adding a physical mode. This does not close G3, does not supply the gravitational advanced/noise identity, and does not change the $58/116$ structural subtotal.

XI.B One-loop and crossover disposition

The fixed-base constrained readout, isolated linear memory, and matched finite Gaussian bath have

$$\delta c^{(1)}_{0,\mathrm{quad}} = 0.$$

That zero follows from Q-independent quadratic Hessians, not a symmetry. The full coefficient is non-identifiable because the frozen action does not fix the interacting bath, composite gravitational propagator, carrier background, boundary operator, or ultraviolet prescription. Once the canonical varied carrier and matched $W(B)^2$ contact are both fluctuated, the local one-line zero-temperature result is

$$\delta c^{(1)}_{0,BX} = \frac{g^2}{2\Omega^2(m_B + \Omega)} > 0.$$

Its spectral weight and KMS noise are positive. Restoring exact zero DC requires the order-by-order local subtraction already priced by G3.

XI.C Finite-support disposition

The isolated canonical real B scalar cannot support a stable finite static tube under the stated three-dimensional Derrick assumptions. A varied conserved current can supply the missing compression pressure. In the controlled thin-wall representative,

$$E(R) = (m - g)N + 4\pi\sigma R^2 + AR^{-p}, \qquad R_*^{p+2} = \frac{pA}{8\pi\sigma},$$

with $E''(R_*) > 0$. This is an existence construction, not a frozen STF prediction: its equation of state, binding gap, smooth interface spectrum, moving boundary, microscopic overlaps, material constraint chains, and CMC coupling remain open. A neutral barotrope also supplies no visible polarization–magnetization tensor.

XI.D Microscopic and compactification disposition

No displayed frozen sector simultaneously provides an exact localized charge, coefficient-complete support energy, and a derived coupling to B. The real scalar has only an emergent nonrelativistic number, while the retained response sees its $2\omega_s$ harmonic with

$$|K(2\omega_s)| = \frac{2}{\sqrt{5}}.$$

Its exact localized stability problem is therefore a constrained open Floquet problem, but the coefficient matrix cannot be built without the missing binding and background. The displayed ten-dimensional reduction is block-diagonal and metric-only, producing a real breathing mode but no independent axion. Even a manually added complex partner does not preserve an exact $U(1)$ with the frozen linear activation:

$$\nabla_\mu j^\mu = -\kappa\chi\mathcal{S}.$$

An invariant quadratic replacement, a true axionic parent, V_B, and g_B would define a new branch with new coefficients and constraints.

XI.E Ward, rank, and gate disposition

The conditional total diagonal diffeomorphism identity is retained. A fully varied material current repairs the fixed-source force defect inside its added subtheory, but no post-v9.0 calculation supplies the coefficient-complete reduced advanced/noise identity or the complete gravitational Dirac algebra. The $58/116$ number remains only the established readout–memory–jet structural subtotal. G1, G2, G3, and G5 remain open; G4 remains as previously audited.

XI.F Supersession, numbering, and withdrawal control

One post-v9.0 exploratory formula is superseded. Appendix AC's raw negative B–X bubble is retained as the withdrawn intermediate record; Appendix AD shows that the selected channel must also fluctuate the mandatory $W(B)^2$ contact, giving the positive matched bubble-plus-seagull result. Appendix AC's broad statement that the world-tube action was absent is likewise narrowed: the canonical action and $Z_B > 0$ existed, while V_B, the stable tube, state, boundary spectrum, and microscopic coupling did not.

The phrase "item 29" was used locally in two post-v9.0 records for the world-tube-support frontier. Canonical v9.0 item 29 instead quarantines the unrelated alternative version-9 branch. Version 9.1 preserves that canonical meaning and assigns the post-v9.0 support and compactification obligations to items 41–44.

No established v8.1, v8.2, v9.0, or Gate G1–G5 result is withdrawn. The only withdrawal is the explicitly identified post-v9.0 raw intermediate formula.

XI.G Stop rule and final status

The frozen parameter-free route fails both upstream acceptance conditions:

$$\boxed{\begin{aligned}&\text{frozen compactification} \Rightarrow \text{exact charged material bridge: FAIL,}\\ &\text{frozen compactification} \Rightarrow \text{derived } B\text{-binding: FAIL.}\end{aligned}}$$

No enlarged rank, Floquet spectrum, numerical-relativity waveform, or production normalization is computed from an undefined enlarged parent. Frozen STF is consolidated at its existing grade. Any future UV completion must be versioned and graded as a new theory branch.

$$\boxed{\text{coherent gravitational candidate -- not a completed gravity theory.}}$$

Every derivation the main body relies on is given here in full. Appendix bodies are the v8.1 derivation records verbatim; each closes with a ***Gravitational revision (v8.2)*** *note recording what the post-v8.1 audit changed, superseded, or left open. Appendices P and S–V are new in v8.2.*

Appendices W–AA are the five audit-gate records of the 28 August 2026 program, new in v9.0 and carried verbatim from the accepted gate packages; each retains its own abstract, claim ledger, reproducibility section, and references. Internal section numbers cited inside Appendices W–AA are local to each appendix.

Appendices AB–AH are the seven post-v9.0 frozen-consolidation records of 28–29 August 2026. Their scientific bodies are carried in full with Markdown heading levels adjusted for nesting and fifteen missing-backslash LaTeX quad transport defects repaired in the consolidated rendering; source hashes and original standalone packages are included with this release. Internal section numbers in AB–AH are local to each appendix.

Tags used below: **[standard]**, **[reproduced]**, **[theorem]**, **[conditional]**, **[existence]**, **[closed]**, and **[open]**. Sign convention $(-+++)$; $c = \hbar = 1$ unless units are shown.

Appendix A — Peters Hierarchy and Closure Provenance

A.1 The formula. For a circular binary of masses m_1, m_2, $M = m_1+m_2$, $\mu = m_1m_2/M$, the Peters time to merger from separation a is t_merge(a) = (5/256) $c^5a^4/(G^3\mu M^2)$. [standard]

A.2 Direct evaluation, 30+30 M_⊙. R_S = $2GM/c^2 = 1.772 \times 10^5$ m. t(1466 R_S) = 54.07 yr; t(730 R_S) = 3.324 yr; t(360 R_S) = 71.82 d. [reproduced]

A.3 The halving structure. $t \propto a^4 \Rightarrow t(a/2) = t(a)/16$. $(1466/730)^4 = 16.26$; $(730/360)^4 = 16.91$. Observed ratios: 54/3.3 = 16.36; 3.3 yr/71 d = 16.98. The temporal hierarchy is the a^4 image of successive near-halvings of separation. [reproduced]

A.4 What GR does and does not do (provenance corrected, August 2026). GR supplies the times at given separations and the a^4 law connecting them; it originates none of the three physical anchors. The correct derivation history: observation → {3.3 yr, 71 d}; STF Lagrangian → 54 yr (via the closure theorem, A.6); Peters = the common translator. Using the Lagrangian-forced 54-yr anchor at ≈1466 R_S: a(3.3 yr) = 1466(3.3/54)^{1/4} = 728.9 R_S and a(71 d) = 1466((71/365.25)/54)^{1/4} = 359.1 R_S — the origin of the 730 and 360 R_S levels. STF assigns the three points their physical roles (outer activation boundary; principal Compton phase; later photon/GRB phase); the near-halving hierarchy was the unexpected convergence. An earlier version of this appendix stated that all three times were found first and the Peters sequence was the surprise; that told the story observation-first for all three, hiding the load-bearing theoretical result (the Lagrangian-forced outer anchor) while overstating the independence of 730 R_S. [reproduced — back-projections and Peters evaluations verified; supersedes both V7.9's "Peters converts STF-selected separations" and the August draft's observation-first narrative]

A.5 The late-inspiral curvature rate. At 730 R_S, $\sqrt{K} = \sqrt{48}\, GM/(c^2r^3) = 2.8 \times 10^{-19}$ m^{-2}, Peters $\dot{r} = 0.31$ m/s, and $\mathcal{D}$_GR ≈ $3\sqrt{K}\,\dot{r}/r \approx 2 \times 10^{-27}$ m^{-2}s^{-1} — the scale V7.9 quoted as $\mathcal{D}$_crit (Appendix Q). [reproduced] *Convention note (August 2026):* this evaluation uses the total mass M in the one-hole proxy; the external-tidal convention (companion of mass M/2 at separation a) gives √K_ext = 1.42×10^{-19} m^{-2} and $\mathcal{D}$_ext = 1.01×10^{-27} m^{-2}s^{-1}. The factor-2 spread between conventions is one instance of the production-location ambiguity that Appendix Q.6 shows is load-bearing.

A.6 The 54-year closure theorem, its boundary condition, and the 71-day circularity (added August 2026). [reproduced — all numbers independently re-derived]

(i) The universality theorem. Write the source and threshold scalings as $\Phi_S = A_0 M_c^p \tau^{-n}$ and $\Phi_{crit} = B_0 M_c^q$. Activation $\Phi_S(\tau_+) = \Phi_{crit}$ gives $\tau_+ = (A_0/B_0)^{1/n} M_c^{(p-q)/n}$, so **$p = q \Rightarrow \tau_+$ is independent of chirp mass** — the outer anchor is universal. This is a theorem of the scaling structure. It does not, by itself, evaluate τ_+: the normalizations (or an observational closure) are still required.

(ii) The closure. For the Phase-I emission density $p_I(\tau) \propto \tau^{-n}$ on $[\tau_-, \tau_+]$, the centroid $\bar{\tau}_I$ is strictly monotone in τ_+ for $1 < n < 2$, so the outer endpoint is unique given $(\bar{\tau}_I, n, \tau_-)$. With the framework's inputs $n = 11/8$, $\bar{\tau}_I = 3.31$ yr, $\tau_- = 0.1$ yr: **$\tau_+ = 53.8804$ yr ≈ 54 yr** (the few-day propagation correction moves it to ≈ 54.0). This is exact and reproduced, including monotonicity. **Status: theorem (universality and uniqueness); derived conditional (the value 54, on τ_-).**

(iii) The hidden premise, declared. $\tau_- = 0.1$ yr entered silently: the published Test-40a table's uniform-profile entry is $(0.1+54)/2 = 27.05$ yr, exactly the reported value, which reconstructs the boundary. The result is highly sensitive to it: $\tau_- = 0.05 \to \tau_+ = 85.10$ yr; $0.1 \to 53.88$; $0.2 \to 33.48$; $0.5 \to 17.12$. **Deriving the 0.1-yr inner cutoff is a named open item — and it is known not to belong to the universal-clock sector:** by Clock-Rate Invisibility, an action depending on T_U only through N^μ cannot fix an absolute interval, so the cutoff must come from UHECR production dynamics (the same sector as the open production operators, §VI).

(iv) The 71-day derivation as previously published is circular, and is flagged as such. The manuscript computed $R = (3.3\text{ yr}/71\text{ d})^{11/4} \approx 2400$ from the observed times and then recovered 71 d from $\tau_{II} = \tau_I R^{-4/11}$ — algebraic inverses of one another. The channel-threshold ratio R must be derived from canonically normalized couplings and a specified production criterion *without* the GRB timing before 71 d counts as a prediction; until then it is an observed anchor. [flagged — open]

Gravitational revision (v8.2). For a circular binary,

$$t_{\rm merge}(a) = \frac{5}{256}\frac{c^5 a^4}{G^3 \mu M^2}.$$

For $30 + 30 M_\odot$, $R_S = 1.772 \times 10^5$ m, and direct evaluation gives 54.07 yr, 3.324 yr, and 71.82 d at $1466 R_S$, $730 R_S$, and $360 R_S$. The ratios 16.26 and 16.91 are the fourth powers of the near-halving separation ratios. **[reproduced]**

The provenance is: observation supplied 3.32 yr and 71 d; the STF window closure supplied $53.88 \simeq 54$ yr conditional on $\tau_- = 0.1$ yr; Peters supplied the translation. With an emission density $p_I(\tau) \propto \tau^{-11/8}$ on $[\tau_-, \tau_+]$, the centroid equation fixes τ_+ once τ_- and the observed centroid are declared. The mass-scaling theorem is more robust: if source and threshold carry the same chirp-mass power, the crossing time is chirp-mass independent. **[theorem/conditional]**

At $730 R_S$, a one-hole curvature proxy gives $q \sim 2.8 \times 10^{-19}\,\mathrm{m}^{-2}$ and $|Dq| \sim 2 \times 10^{-27}\,\mathrm{m}^{-2}\mathrm{s}^{-1}$. An external-tidal convention changes this by an order-unity factor. A binary midpoint enhances the leading tidal norm by a factor 16, moving the same local threshold to $1085 R_S$ and the time to approximately 16.2 yr. Thus the production world tube is load-bearing. **[reproduced]**

Appendix B — Clock Separation and Boundary Selection

Origin. The universal/local distinction this appendix proves is the two-clock ontology of *Theory of Time* §10.3 (universal time ontologically real from first activation; local temporal loops that create their own "now"; local loops that reference universal time). This appendix supplies the theorem that makes it necessary and the field-level consequences that V7.9's single-clock formalism missed. General Theory §1.4/§6.4 (State 1 "carried by universal time"; State 3 generating its own now) states the same distinction in the four-state ontology.

B.1 Gradient-clock obstruction (theorem). Let q have timelike, nonvanishing gradient on U and $n^\mu_q = s\nabla^\mu q/\sqrt{(-\nabla q\cdot\nabla q)}$, $s = \pm1$. Then $n_q\cdot\nabla q = -s\sqrt{(-\nabla q\cdot\nabla q)} \neq 0$ with definite sign; q is strictly monotone on every integral curve; a periodic q cannot define a continuous global clock this way. Applied to $\varphi = A\cos\Theta_I$: n^μ_φ is undefined at $\dot\varphi = 0$ ($X = \frac{1}{2}\dot\varphi^2 = 0$) and reverses chart orientation across it. On homogeneous FLRW the interaction reduces to $-a^3\gamma\varphi\,\mathrm{sgn}(\dot\varphi)\dot R$, non-differentiable at turning points; varying it produces $\delta(\dot\varphi)$ terms. [reproduced] V7.9's use of n^μ_φ is valid on monotonic patches only.

B.2 Corollary (STF clock separation). If universal ordering is represented by a scalar T_U with timelike gradient — as Theory of Time does — then $T_U \neq \varphi$, and with $\Theta_I \simeq m_s T_U + \delta \pmod{2\pi}$ the internal clock and universal time are distinct-but-related. A continuous time *orientation* alone gives a direction field, not a scalar function; within STF the scalar representation is by construction. [entailment]

B.3 Phase-lift completion (conditional). With winding integer w: $T_U = (2\pi w + \Theta_I - \delta)/m_s$, the lift of $\mathbb{R} \to S^1$, $T_U \mapsto e^{i m_s T_U}$. Universal time retains the continuous ordering including w; the wrapped phase erases w. A global lift exists only if the class in $H^1(U,\mathbb{Z})$ vanishes — nontrivial winding, which the topological sector invokes, is where a single-valued global unwrapped phase can be obstructed. Three lifts to keep apart: worldline (always), spacetime scalar (topologically conditional), boundary-defined ordering (different construction). [reproduced for the covering-space algebra; conjecture as an STF completion]

B.4 Turning points are diagnostic. $d\varphi/dT_U = -A m_s \sin\Theta_I = 0$ while $d\Theta_I/dT_U = m_s \neq 0$. In the fixed-amplitude limit $(\varphi, v_\varphi/m_s)$ with $v_\varphi = \dot\varphi$ satisfies $\varphi^2 + (v_\varphi/m_s)^2 = A^2$ and $\Theta_I = \mathrm{atan2}(-v_\varphi/(A m_s), \varphi/A)$ is well defined away from $A = 0$. With $A(t)$ redshifting, $\dot\varphi = \dot A\cos\Theta_I - A\dot\Theta_I\sin\Theta_I$: WKB regime $|\dot A|/(m_s A) \ll 1$, a slowly contracting spiral. atan2 gives an S^1 phase; the $\mathbb{R}$ lift is B.3. [reproduced]

B.5 Clock-Rate Invisibility (lemma). $T_U \to f(T_U)$, $f' > 0$: $\nabla f = f'\nabla T_U$, so $N^\mu = -f'\nabla^\mu T_U/(f'\sqrt{(-\nabla T_U\cdot\nabla T_U)}) = N^\mu$ unchanged. An action depending on T_U only through N^μ detects orientation and foliation, not the rate $J_O = dT_U/d\tau_O$. [reproduced]

B.5b Spatial Clock-Gradient Invariance (theorem). The refinement the invisibility lemma admits: although the absolute relative rate $J_C = dT_U/d\tau_C$ is invisible, its spatial logarithmic gradient on a universal slice is invariant under every allowed relabelling $T_U \mapsto f(T_U)$, because $\nabla_\nu \ln f'(T_U) \propto \nabla_\nu T_U \propto N_\nu$ and $h_\mu{}^\nu N_\nu = 0$: $D^\perp_\mu \ln J_C \equiv h_\mu{}^\nu\nabla_\nu \ln J_C$ is unchanged. A spatially uniform rescaling drops out of a gradient; only the spatially varying part of the rate is physical, and it is exactly reparameterization-invariant. This supplies an acceleration-dimensioned invariant, $\mathfrak{a}^{(C)}_\mu = c^2 D^\perp_\mu \ln J_C$, whose c^2 is the lapse↔potential normalization ($J_C \simeq 1 - \Phi/c^2 \Rightarrow c^2\nabla\ln J_C \simeq -\nabla\Phi$), not a fitted coefficient. Consistent with B.5: the lemma kills the absolute rate; the gradient survives it. [reproduced — August 2026 delegation, independently verified]

B.6 The 4π² firewall. $\mathscr{D}_{crit}$'s $4\pi^2$ is the cup product of the retarded and advanced Green-function sectors on the Hopf torus, $\int_{T^2_\gamma}\omega_R\wedge\omega_A = 4\pi^2$ (Topological Closure V6.3, Heegaard transgression) — not internal × universal periods. The clock theorem supports distinct temporal structures; the cup product is the separate derivation of the constant. [corpus-verified] One precision (August 2026): the coordinate-free content of the pairing is the primitive integer ⟨[ω_R/2πi] ⌣ [ω_A/(−2πi)], [T^2]⟩ = **1**; the raw $4\pi^2$ is that integer expressed in canonical unnormalized angular coordinates (∫dθ∧dθ̃ = $(2\pi)^2$). Canonical once e^{iθ} is adopted, not tunable — but not extra topological information beyond the integer one. [reproduced]

B.7 The repair is a new theory, not notation. Replacing n^μ_φ by N^μ inside the action changes the Euler–Lagrange equation, T_μν, the constraint algebra, the DHOST class, and the foliation/perturbation analysis. Candidate carriers: independent khronon/time scalar; constrained timelike vector or foliation; complex or rotating scalar with a phase dof; boundary-defined nonlocal ordering; or restriction of the EFT to X > 0. Each has its own dof count and stability conditions. The minimal Lagrange-multiplier form S_U = ∫√−g λ_U(∇T_U·∇T_U + 1) enforces ∇T_U·∇T_U = −1 and gives ∇_μ(λ_UN^μ) = 0; if varied it is a new constrained sector; if held fixed it is the fixed-clock theory. One obstruction is already proved: for a normalized-gradient clock N_μ = −α∇_μT_U with α = q^{-1}, q = √(−∇T_U·∇T_U), the flow acceleration is A^{(N)}_μ = D^⊥_μ ln α — not generically zero — but the minimal form's constraint q = 1 forces A^{(N)}_μ = 0, a geodesic universal flow with no lapse gradient. The minimal completion therefore forecloses every effect carried by a spatially varying clock rate (B.5b); a completion admitting a nontrivial lapse requires more structure than the unit-norm multiplier. [reproduced — August 2026] *Candidate-list update (August 2026):* the companion paper *The Universal Clock Carrier* resolves this appendix's five-way fork — amplitude closed by theorem; the unwrapped/axionic phase closed as a *global* carrier (shift-charge dilution θ̇ ∝ a^{-3}, ρ ∝ a^{-6}, plus KKLT periodicity; it survives as a finite-epoch local reference); the unit-eikonal route closed (this paragraph); a propagating khronon excluded absent a UV derivation — leaving the boundary-selected CMC construction as the conditional candidate, with its own named open items.

Gravitational revision (v8.2). If T is a scalar with everywhere nonzero timelike gradient and $N^\mu \propto \nabla^\mu T$, then T changes monotonically along every integral curve of N^μ. A periodic scalar returns to the same value and cannot be that global parameter. **[theorem]**

The internal phase may be reconstructed from $(\phi, \dot{\phi}/m_s)$ away from the zero-amplitude point, while T_U supplies the ordering. A phase lift $\mathbb{R} \to S^1$ can synchronize them locally but does not remove the global distinction.

The minimal unit-gradient action $\int \sqrt{-g}\,\lambda_U(\nabla T_U^2 + 1)$ enforces a geodesic congruence and eliminates a nontrivial lapse gradient. A propagating khronon adds modes and preferred-frame constraints. The retained candidate is boundary-selected CMC, not a new propagating clock. Its validity requires an invertible augmented CMC–volume operator and a domain admitting the foliation. **[conditional]**

Appendix C — Branches, Exact Memory, and the Doubled Parent

C.1 Dimensions. [φ] = 1, [I_4] = 4, [√I_4] = 2, [N] = 0, [∇] = 1. φN·∇I_4 has dimension 6 → coefficient M^{-2} ✓ for ζ/Λ; φN·∇√I_4 has dimension 4 → coefficient dimensionless. γφ𝒢 has dimension 5 → [γ] = M^{-1}; retarded matching ζ/Λ = γτ_eff has dimension M^{-2} and multiplies N·∇𝒢. g(ℛ) = 2ℛ gives 2ℛN·∇ℛ = N·∇I_4 (chain rule) — Branch B collapses to A. [reproduced] V7.9's boxed action attached ζ/Λ to N·∇√I_4; withdrawn.

C.2 The kernel. V7.9 App. O used the normalized L_R = ω_c e^{−ω_ct}Θ(t), ∫L_R = 1, whose expansion (L_R∗I) = I − İ/ω_c + … generates a rate only as a correction to a nonzero static response — contradicting K_R(0) = 0. Repair: zero-mode subtraction K^R_sel = δ(t) − ω_c e^{−ω_ct}Θ(t), ∫K = 0, (K∗I) = İ/ω_c − Ï/ω_c^2 + …, τ_eff = 1/ω_c, C_match = m_s/ω_c. Frequency response K(ω) = −iω/(ω_c − iω): ≈ −iω/ω_c (ω ≪ ω_c, the rate operator); O(1) at ω ~ ω_c; → 1 for ω ≫ ω_c. Since ω_c ~ m_s, phenomena on the 3.32-yr scale have ω/ω_c not small and the full memory kernel governs. [reproduced]

C.3 Scalings. Schwarzschild $\mathcal{R} = \sqrt{I_4} \propto M/r^3$: $\dot{\mathcal{R}} \propto Mv/r^4$, $\dot{I}_4 = 2\mathcal{R}\dot{\mathcal{R}} \propto M^2v/r^7$; at 10× radius Branch A is suppressed by ~10^{-3} relative to B. FLRW $\mathcal{G} = 24H^2(H^2 + \dot{H}) \sim H^4$: $\mathcal{G} \sim H^5$ vs $\sqrt{\mathcal{G}} \sim H^3$ — Branch A adds two powers of the small late-time H (dark-energy sourcing harder; early-universe response stronger). [reproduced]

C.4 The in-in form. A purely retarded kernel cannot be obtained by varying a single-copy real action (symmetric bilinear kernel); the minimal in-in form is $\Gamma_{STF} = S_{parent}[\Phi_+] - S_{parent}[\Phi_-] + \gamma\int\varphi_a K^R_{sel}(x,y;\mathfrak{o}_U)\,\mathscr{I}_r(y) + (i/2)\int\varphi_a N\varphi_a + \ldots$, with $\mathfrak{o}_U$ the universal causal orientation. Varying the difference field and taking the physical limit gives causal equations. This is the shape the Universal Embedding companion identifies with the T^2 doubling — proposed correspondence, not proof. [standard structure; correspondence stated]

Gravitational revision (v8.2). Dimensions distinguish the quadratic-rate and norm-rate levels:

$$[\phi D_U I_4] = 6, \qquad [\phi D_U \sqrt{I_4}] = 4.$$

The first accepts a coefficient of mass dimension -2; the second requires a dimensionless coefficient. The v8.2 norm-rate coefficient is $\kappa = (\zeta/\Lambda)M_*^2$.

The selector

$$K^R_{\mathrm{sel}}(t) = \delta(t) - \omega_c e^{-\omega_c t}\Theta(t)$$

has zero integral and cannot arise as a purely retarded equation from variation of a single-copy real bilinear action. The doubled form

$$\Gamma = S[+] - S[-] + \int \phi_a K^R_{\mathrm{sel}} Q_r + \frac{i}{2}\int \phi_a N \phi_a + \cdots$$

generates causal equations in the physical limit. The local memory pair is an exact realization, not a derivative truncation. **[standard/reproduced]**

Appendix D — Regulated Compact Alignment

D.1 Setup. Clock-resolved curvature components $\mathscr{C}^A$, positive clock-relative metric $h_{AB}(N)$, $q_N = \sqrt{h_{AB}\mathscr{C}^A\mathscr{C}^B}$ ($[q_N] = L^{-2}$). Response covector P_A.

D.2 Unsaturated (Branch A). $P_A = \alpha h_{AB}\mathscr{C}^B \Rightarrow P_A D_U \mathscr{C}^A = (\alpha/2) D_U(h_{AB}\mathscr{C}^A\mathscr{C}^B) = (\alpha/2) D_U I_4$. $\|P\| = \alpha q_N$ grows without bound. [reproduced]

D.3 Capacity-limited (Branch B). $\|P\| \le M^2$, $M = L^{-1}$. *Support function* $Q(\mathscr{C}) = \max_{\{\|P\|\le M^2\}} P_A\mathscr{C}^A \le \|P\|\|\mathscr{C}\| \le M^2 q_N$ *(Cauchy–Schwarz), equality at* $P_A = M^2 h_{AB}\mathscr{C}^B/q_N$. *Then* $D_U Q = P_A D_U \mathscr{C}^A = M^2 D_U q_N$ *— verified:* $P\cdot dC - M^2 dq = 0$ exactly, $\|P\|^2 = M^4$. Finite capacity + saturation ⇒ $M_*^2 D_U\sqrt{I_4}$. [reproduced]

D.4 The coefficient. $\kappa = \gamma\tau_{eff} M^2 = (\zeta/\Lambda)M^2 = (\zeta/\Lambda)/L_*^2 = 1.35\times10^{11}\ \mathrm{m}^2/(3.64\times10^{-30}\ \mathrm{m})^2 = 1.02\times10^{70}$, dimensionless — the conversion V7.9's cosmological calculation already used. No new scale. [reproduced]

D.5 Auxiliary-field action. $S_B \supset \int\sqrt{-g}[\kappa\varphi N^\mu\nabla_\mu\chi + \lambda(\chi^2 - \mathscr{I}_N)]$; $\delta\lambda \Rightarrow \chi = q_N$; integration by parts shows χ has no kinetic term — zero propagating dof. V7.9 used essentially this in vacuum with $\lambda(\chi^2 - \mathscr{G})$; what was missing was why $\chi = \sqrt{\mathscr{G}}$ is the channel variable — capacity saturation supplies it. [reproduced]

D.6 The transverse polarization. Decompose $\mathscr{C}^A = q\hat{\mathscr{C}}^A$: $D\mathscr{C}^A = \hat{\mathscr{C}}^A Dq + qD\hat{\mathscr{C}}^A$. Aligned $P \propto \hat{\mathscr{C}}$ projects out the angular term (Branch B, radial). A rotating source needs $P_A = M^{*2}(\cos\alpha\, \hat{\mathscr{C}}_A + \sin\alpha\, \mathscr{T}_A)$ with $\mathscr{T}$ tangent to the curvature-state orbit: $P\cdot D\mathscr{C} = M^{*2}[\cos\alpha\, Dq + \sin\alpha\, q\Omega_C]$. Radial polarization → Branch B; transverse → the spin-sensitive channel (Appendix G). [reproduced]

D.7 Named completions. *Curvature-Polarization Saturation Theorem*: compactification and causal closure produce a nonpropagating response polarization of fixed magnitude L^{-2}*, aligned with the curvature state selected by* N^μ*.* Capacity-Normalized Curvature Theorem*: the 10D internal-trace projector and one-winding closure induce an isotropic bounded dual response space of radius* L^{-2} whose support function is $L^{*-2}\sqrt{\mathscr{I}_N}$. If proved, they derive the square root, the normalization, alignment, Branch B over A, and the absence of a new parameter simultaneously. [stated — open]

D.8 One correction to Closure–Capacity. D_Nq_N is a curvature-amplitude production rate, not a Lyapunov exponent; the fractional/Lyapunov-like rate is $D_N \ln q_N = D_Nq_N/q_N$. [recorded]

Gravitational revision (v8.2). For

$$Q_{\rm aux} = M_*^2[p\cdot\mathcal{C} + \Delta\sqrt{1-p^2} - \Delta],$$

stationarity gives $p^* = \mathcal{C}/s$ and $Q_\Delta = M_*^2(s-\Delta)$. Expansions are

$$Q_\Delta = \frac{M_*^2q_N^2}{2\Delta} - \frac{M_*^2q_N^4}{8\Delta^3} + \cdots \quad (q_N \ll \Delta),$$

$$Q_\Delta = M_*^2q_N - M_*^2\Delta + \frac{M_*^2\Delta^2}{2q_N} + \cdots \quad (q_N \gg \Delta).$$

The Jacobian eigenvalues s and s^3/Δ^2 are positive for $\Delta > 0$; the one-leg readout rank is 44, the doubled rank 88, and zero physical phase-space dimensions are added. The exact unregulated limit is singular at $q_N = 0$. **[theorem]**

The capacity Hessian $M_*^2J^{-1}$ is finite at the apex, where it equals M_*^2I/Δ. Its condition number grows as $1 + q_N^2/\Delta^2$, so saturation can be numerically stiff without changing rank.

Appendix E — Positive Norm, Apex, and Selection

E.1 $\mathscr{G}$ is indefinite. With $S_{\mu\nu} = R_{\mu\nu} - \frac{1}{4}Rg_{\mu\nu}$, $\mathscr{G} = C^2 - 2S_{\mu\nu}S^{\mu\nu} + R^2/6$ (verified against $\mathscr{G} = R^2_{\mu\nu\rho\sigma} - 4R^2_{\mu\nu} + R^2$ and $C^2 = R^2_{\mu\nu\rho\sigma} - 2R^2_{\mu\nu} + R^2/3$). [reproduced]

E.2 FLRW sign table. Flat FLRW, constant w: $\dot{H} = -(3/2)(1+w)H^2$, $R = 3(1-3w)H^2$, $\mathscr{G} = -12(1+3w)H^4$. de Sitter: $R = 12H^2$, $\mathscr{G} = +24H^4$; matter: $3H^2$, $-12H^4$; radiation: 0, $-24H^4$. $\sqrt{\mathscr{G}}$ is imaginary through matter and radiation domination and cannot reproduce the real $\kappa\varphi\dot{R}$. Kerr's Kretschmann crosses zero (Semerák); VSI/type-N spacetimes have all polynomial invariants vanishing — the square-root problem is structural. [reproduced]

E.3 The clock supplies positivity. $E_{\mu\nu} = C_{\mu\alpha\nu\beta}N^{\alpha}N^{\beta}$, $B_{\mu\nu} = {}^*C_{\mu\alpha\nu\beta}N^{\alpha}N^{\beta}$; $\mathscr{W}_N = E^2 + B^2 \geq 0$ (spatial metric orthogonal to N positive definite) — the Bel–Robinson superenergy relative to N. Detects type-N waves where all polynomial invariants vanish. $C^2 = 8(E^2 - B^2)$ can vanish or flip while $\mathscr{W}_N > 0$. [standard; reproduced numerically]

E.4 $\mathcal{R}_{STF}(N) = \sqrt{R^2 + 8\mathscr{W}_N}$. Schwarzschild: $R = 0$, $B = 0 \Rightarrow \sqrt{8E^2} = \sqrt{C^2}$ — Schwarzschild/binary/flyby radial scaling preserved exactly. FLRW: $E = B = 0 \Rightarrow |R|$ — cosmological source preserved (sign at $R = 0$ to be treated). Kerr/radiative: $\sqrt{8(E^2 + B^2)}$ real and positive; sees type-N. Radiation FLRW: $R = 0$, $C = 0 \Rightarrow 0$ — traceless conformally-flat radiation invisible to the channel: a selection rule, stated as such. Not a full Riemann norm (no trace-free Ricci channel). [reproduced]

E.5 The price. $R^2 + 8\mathscr{W}_N \neq \mathscr{G}$. The map $\mathscr{G} \to R^2 + 8\mathscr{W}_N$ under universal-clock projection and saturation is the *Clock-Euclideanization Theorem*: the compactification supplies an indefinite curvature bilinear; closure relative to N^μ projects it onto the positive trace–tidal subspace accessible to the channel. Not proved; the internal-trace projector 6/9 used for L* does not by itself perform this projection. Once $\mathcal{R}$ depends on N^μ, the GB auxiliary-field argument no longer establishes ghost-freedom; the completed action needs its own ADM analysis. [stated — open]

E.6 Cosmology's residual question. The compactification reportedly gives $I_4 = aR^2 + bR_{\mu\nu}R^{\mu\nu}$; $q_{cos} = \sqrt{aR^2 + bR^2_{\mu\nu}}$; the replacement $q_{cos} \to |R|$ is justified only if $b = 0$, or FLRW makes the Ricci term $\propto R^2$, or the polarization selects the R direction, or the unwanted combination decouples. The most important possible source of change to cosmological numbers. [stated]

Gravitational revision (v8.2). The Gauss–Bonnet scalar

$$\mathcal{G} = C^2 - 2S_{\mu\nu}S^{\mu\nu} + \frac{1}{6}R^2$$

is indefinite. In flat FLRW with constant equation-of-state parameter w,

$$R = 3(1-3w)H^2, \qquad \mathcal{G} = -12(1+3w)H^4,$$

so $\sqrt{\mathcal{G}}$ is not a globally real response variable. The clock-relative quantity $E^2 + B^2$ is positive and detects radiative Weyl fields even when polynomial invariants vanish.

The unregulated Euclidean norm $q_N = \sqrt{\mathcal{C}^2}$ is continuous but not differentiable at $\mathcal{C} = 0$; its Hessian diverges as $1/q_N$. This cusp is why exact saturation cannot be used at the apex. The regulated Q_Δ is smooth. The projection from the compactification's indefinite bilinear to the selective positive trace–tidal state remains an open parent-level derivation.

Appendix F — The Four Flyby No-Gos

F.1 No-work (derived). Velocity-linear generalized potential $L_{int} = A_iv^i - A_0$; Euler–Lagrange $F_i = -\partial_iA_0 - \partial_tA_i + v^jF_{ij}$, $F_{ij} = \partial_iA_j - \partial_jA_i = -F_{ji}$. Stationary pure-vector part: $F_i = v^jF_{ij} \Rightarrow F_iv^i = v^iv^jF_{ij} = 0$. Coriolis/Lorentz-type: rotates the velocity, cannot change speed by work; open or closed trajectory. [reproduced] V7.9 B.10.4 treated the velocity-dependent potential as static; B.3 applied the fundamental theorem of line integrals to a non-gradient force; B.4/B.14 derived the factor of two as $\Delta V = (\zeta/\Lambda)[\dot{\mathcal{R}}_{out} - \dot{\mathcal{R}}_{in}]$ with "contributions add" — the endpoint difference of a non-gradient force. V7.9's

April-2026 note conceded $F\cdot v = 0$ but fenced off “the geometric derivation of $K = 2\omega R/c$ (B.4) is correct and stands”; that fence is false — B.4 rests on the invalidated step. **Withdrawn.**

F.2 Stationarity (theorem under hypotheses). Geodesics of a stationary asymptotically flat effective metric $\partial_t\tilde{g}_{\mu\nu} = 0$ with common asymptotic form: Killing energy $E = -\tilde{g}_{\mu\nu}\xi^{\mu}u^{\nu}$ conserved; asymptotic $E \leftrightarrow V_\infty$ relation the same at both ends $\Rightarrow V_{\infty,\mathrm{out}} = V_{\infty,\mathrm{in}}$. A local interval with $F\cdot v \neq 0$ does not evade this. Permanent change needs explicit nonstationarity, dissipation, different asymptotic structures, or a non-mechanical inference from the tracking observable. Real-transfer route: a co-rotating nonaxisymmetric $\varphi_0(r,\theta,\varphi - \omega t)$ with helical Killing vector $k = \partial_t + \omega\partial_\varphi$ conserves $E - \omega L_z$, so $\Delta E = \omega\Delta L_z$; Anderson would require $\Delta L_z/m = (2RV_\infty^2/c)(\cos\delta_{in} - \cos\delta_{out})$ — a concrete torque target; axisymmetric Kerr/Lense–Thirring cannot (E, L_z separately conserved). [reproduced]

F.3 Spin parity (theorem). Slow Kerr: $E_{ij} = E^{(0)}_{ij} + O(a^2)$, $B_{ij} = O(a)$. $C^2 = 8(E^2 - B^2) = C_0^2 + O(a^2)$; $\sqrt{8(E^2 + B^2)} = \sqrt{8E_0^2} + O(a^2)$; both even under $\omega \to -\omega$. Verified: coefficient of a^1 in C^2 and in $\mathscr{W}_N$ is zero; $I_2 \propto E\cdot B$ has a^1 coefficient $E_0 b_1 \neq 0$. Hence $D\sqrt{C^2}$ and $D\sqrt{8\mathscr{W}_N}$ contain no term linear in ω and cannot reverse for retrograde Venus, while $K = 2\omega R/c$ is linear in ω. No scalar magnitude channel produces it at first order; the signal must live in orientation (I_2/ϑ_C — Appendix G) or in the clocks (Appendices I–L). [reproduced] V7.9 acknowledged $\mathcal{R} = \sqrt{K}$ has no linear-spin correction and then assigned an $O(\omega)$ contribution to its “effective curvature rate”; incompatible. Also: the breathing-mode source $A(\sigma)C^2$ is spin-even $\Rightarrow \sigma(a) = \sigma(-a)$, $\nabla\sigma = \nabla\sigma^{(0)} + O(a^2)$, so the cross-disformal $H^{XD}_{\mu\nu} = \hat{B}(\nabla_\mu\sigma\nabla_\nu q + \dots)$ has no intrinsic $O(a)$ carrier — “$\nabla\varphi_0$ carries ω^1” is unsupported (Appendix O).

F.4 The stationary-source obstruction. For a stationary axisymmetric source with Killing vectors t^μ, ψ^μ, any invariant scalar has $\mathcal{L}_t\mathcal{R} = \mathcal{L}_\psi\mathcal{R} = 0$, so a rigidly corotating clock $k = t + \Omega\psi$ gives $k^\mu\nabla_\mu\mathcal{R} = 0$. Rotating a perfect sphere changes nothing. Under any stationary universal slicing, $N^\mu\nabla_\mu q = 0$ and the repaired universal-rate interaction vanishes on the Earth background; V7.9’s “quasi-static rotation-sensitive φ_0” cannot follow from $N\cdot\nabla q$. What survives is D_I: the spacecraft’s convective sampling $u\cdot\nabla q = \Gamma v\cdot\nabla q$, and its sampling of the $O(a)$ phase ϑ_C. Curvature evolution ≠ curvature sampling. [reproduced]

Gravitational revision (v8.2). F.1 No work. For $L_{\rm int} = A_i v^i - A_0$,

$$F_i = -\partial_i A_0 - \partial_t A_i + v^j F_{ij}, \qquad F_{ij} = -F_{ji}.$$

The stationary vector part satisfies $F_i v^i = v^i v^j F_{ij} = 0$. It rotates velocity and cannot change speed by work. **[derived]**

F.2 Stationarity. A stationary asymptotically flat effective metric with the same asymptotic form on both legs has a conserved Killing energy; the incoming and outgoing V_∞ are equal. A genuine energy change requires nonstationarity, dissipation, different asymptotic structures, or a non-mechanical observation map. **[theorem under stated hypotheses]**

F.3 Spin parity. In slow Kerr, $E_{ij} = E_{ij}^{(0)} + O(a^2)$ and $B_{ij} = O(a)$. Both $C^2 = 8(E^2 - B^2)$ and $8(E^2 + B^2)$ are even in $a \propto \omega$ through first order. A scalar magnitude cannot generate Anderson’s sign-odd $O(\omega)$ coefficient. The rotational information lives in the Pontryagin/phase sector or in the clocks. **[theorem/reproduced]**

F.4 Stationary source. If q is stationary and axisymmetric, $\mathcal{L}_t q = \mathcal{L}_\psi q = 0$; a rigidly corotating $k = t + \Omega\psi$ gives $k\cdot\nabla q = 0$. Curvature evolution and spacecraft sampling are distinct: $D_U q$ may vanish while $u_{\rm sc}\cdot\nabla q \neq 0$. **[derived]**

Appendix G — Kerr Curvature Phase and Exterior Information

G.1 The complex Weyl invariant. $m \equiv GM/c^2$, $a \equiv J/(Mc)$. Kerr $\Psi_2 = -m/(r - ia\cos\theta)^3$; the quadratic complex Weyl invariant $\mathfrak{I} = 48m^2/(r - ia\cos\theta)^6 = C^2 + iP$ (P the Pontryagin $C\cdot{}^*C$). Writing $z = r - ia\cos\theta = \rho e^{-i\chi}$, $\rho = \sqrt{r^2 + a^2\cos^2\theta}$, $\chi = \arctan(a\cos\theta/r)$: $\mathfrak{I} = q^2 e^{2i\vartheta_C}$ with $q = 4\sqrt{3}\, m/\rho^3$ and $\vartheta_C = 3\arctan(a\cos\theta/r)$. Verified: $|\mathfrak{I}| = q^2$, $\arg\mathfrak{I} = 2\vartheta_C$ at a random point. Slow rotation: $q = 4\sqrt{3}\, m/r^3 + O(a^2)$ (spin-even), $\vartheta_C = 3a\cos\theta/r + O(a^3)$ (spin-odd). $C^2 = 48m^2/r^6 + O(a^2)$; $P = 288m^2 a\cos\theta/r^7 + O(a^3)$; $P/C^2 \simeq 6a\cos\theta/r$. The first-order rotational information absent from $\sqrt{K}$ is entirely in ϑ_C. [reproduced, exact]

G.2 The curvature-phase connection. $\mathscr{A}_C = q\, d\vartheta_C$; $\mathcal{F}_C = d\mathscr{A}_C = dq \wedge d\vartheta_C = 36\sqrt{3}\, ma\sin\theta/\rho^5\, dr \wedge d\theta$ (verified exact); slow rotation $36\sqrt{3}\, ma\sin\theta/r^5$ — linear in a hence in ω; sign-reversing; maximal at the equator; zero on the axis; with $\theta = \pi/2 - \delta$, $\sin\theta = \cos\delta$, so $\mathcal{F}_C \propto \omega\cos\delta$. The specific differential-geometric object carrying the Anderson angular factor. [reproduced]

G.3 The two-clock normalized phase field. With $h_{\mu\nu} = g_{\mu\nu} + N_\mu N_\nu$ and $Y_N = h^{\mu\nu}\nabla_\mu q \nabla_\nu q$: Schwarzschild $q = 4\sqrt{3}m/r^3$, $\sqrt{Y_N} = 3q/r$, so the local curvature radius $r_\mathscr{C} = 3q/\sqrt{Y_N} = r$ — no explicit M, G, R or coordinate. $\Xi_\mu = r_\mathscr{C}\, h_\mu{}^\nu \nabla_\nu \vartheta_C$; slow Kerr $\Xi_{\hat r} \simeq -(3a/r)\cos\theta$, $\Xi_{\hat\theta} \simeq -(3a/r)\sin\theta = -(3a/r)\cos\delta$; $d\Xi = -(3a\sin\theta/r)\, dr \wedge d\theta \neq 0$ — cannot be removed by redefining one clock. [reproduced]

G.4 The surface scale. At $r = R$, $-\partial\vartheta_C/\partial\theta \simeq (3a/R)\cos\delta$ per leg; $a = J/(Mc) = I\omega/(Mc) = k_I R^2\omega/c \Rightarrow K_{phase} = 6k_I\, \omega R/c$; $K_{phase}/K_{Anderson} = 3k_I$. Earth $k_I = 0.3307 \Rightarrow 0.992$ ($K_{phase} = 3.075\times10^{-6}$ vs 3.099×10^{-6}); Venus $0.337 \pm 0.024 \Rightarrow 1.01$ (sign-reversing, $\omega < 0$); Jupiter $0.263 \Rightarrow 0.79$ ($K \approx 6.65\times10^{-5}$ vs 8.41×10^{-5}) — a genuine discriminator. **Status: local geometric scale, not a derived DSN coefficient** (Appendix H — the direction-odd coupling cancels on a retraced link). [reproduced]

G.5 Correction to V7.9's Kerr section. $a_\oplus = k_I R^2\omega/c = 3.27$ m (not ≈ 0.009 m); $a/R = 5.1 \times 10^{-7}$ (not $\sim10^{-9}$); $3a_\oplus/R_\oplus = 1.54 \times 10^{-6} \simeq \omega R/c$ because $3k_I \simeq 1$. [reproduced]

G.6 Exterior-information no-go. Two rotating bodies with the same exterior M and J but different R and k_I: identical local vacuum curvature to the relevant multipole order $\Rightarrow$ every local functional $F[C, \nabla C, N, \ldots]$ agrees; but $2\omega R/c = 2J/(k_I McR)$ differs. No purely local exterior-curvature theory derives $2\omega R/c$ universally; it must receive R, or ω, or k_I, or a nonlocal carrier of source-boundary data. $r_\mathscr{C}$ reconstructs the radius of the *event*, not the planet's surface. [reproduced]

G.7 ϑ_C is not the internal clock. Inserting $\delta\Theta_I = \vartheta_C$ into $T_U = (2\pi w + \Theta_I - \delta)/m_s$ gives $\delta T_U = \vartheta_C/m_s$; near Earth $|\vartheta_C| \lesssim 1.5\times10^{-6}$ and $\hbar/(m_s c^2) = 1.67\times10^{7}$ s $\Rightarrow \delta T_U \sim 26$ s, enormously larger than any flyby residual. And $\Theta = m_s T_U + \vartheta_C$ has timelike gradient only if $\mu^2 > h^{\mu\nu}\nabla_\mu\vartheta_C \nabla_\nu\vartheta_C$, $\mu = m_s c/\hbar \simeq 2.0\times10^{-16}\ \mathrm{m}^{-1}$, while $|\nabla\vartheta_C| \sim 3a_\oplus/R_\oplus^2 \simeq 2.4\times10^{-13}\ \mathrm{m}^{-1}$ — ratio 10^3, spacelike. Three irreducible roles: T_U (ordering), Θ_I (Compton phase), ϑ_C (spatial curvature orientation). [reproduced]

Gravitational revision (v8.2). For Kerr,

$$\mathfrak{I} = C^2 + iC^*C = \frac{48m^2}{(r - ia\cos\theta)^6} = q^2 e^{2i\vartheta_C},$$

$$q = \frac{4\sqrt{3}m}{(r^2 + a^2\cos^2\theta)^{3/2}}, \qquad \vartheta_C = 3\arctan\frac{a\cos\theta}{r}.$$

The magnitude is spin-even at first order; the phase is spin-odd. The curvature-phase connection $\mathcal{A}_C = q\, d\vartheta_C$ has

$$d\mathcal{A}_C = dq \wedge d\vartheta_C = \frac{36\sqrt{3}ma\sin\theta}{(r^2 + a^2\cos^2\theta)^{5/2}}\,dr \wedge d\theta,$$

which is linear in a, sign reversing, and proportional to $\cos\delta$ near the equator. It supplies the right geometric symmetry but not the DSN normalization.

No local exterior-curvature functional can universally recover $2\omega R/c$ from bodies with identical exterior (M, J) but different R or inertia coefficient. Source-boundary information or an observational carrier is required. **[exterior-information no-go]**

Appendix H — Reciprocity Selection

H.1 The theorem. Decompose a small optical-metric perturbation relative to N^μ: $h^{(\gamma)}_{\mu\nu} = 2\Phi N_\mu N_\nu + 2N_{(\mu}A_{\nu)} + H_{\mu\nu}$ (A, H spatial). For a ray of spatial direction ℓ^μ, $c\,\delta t = \int(\Phi - A_\mu\ell^\mu + \tfrac{1}{2}H_{\mu\nu}\ell^\mu\ell^\nu)d\ell$. Under exact retrace $\ell \to -\ell$: Φ even (adds), $A\cdot\ell$ odd (cancels), $H_{\ell\ell}$ even (adds). The clock-shift coupling $N_{(\mu}\Xi_{\nu)}$ is in the cancelling vector sector; on a retraced link $\delta\rho = 0$, and for moving endpoints only the loop holonomy $\oint\Xi = \int d\Xi$ remains — a Sagnac-like area observable, not twice an endpoint value. Toy rectangular loop: $\oint\Xi = -3a\ln(r_2/r_1)(\cos\theta_1 - \cos\theta_2) \propto (\sin\delta_1 - \sin\delta_2)$, *not* Anderson's $\cos\delta_{in} - \cos\delta_{out}$, and containing $\ln(r_2/r_1)$ — tracking-distance, station and arc dependence Anderson lacks. [reproduced]

H.2 The magnetic-Weyl candidate. $\tilde{g}^{(\gamma)}_{\mu\nu} = g_{\mu\nu} + \lambda_B\chi\mathscr{G}(W)B_{\mu\nu}/\sqrt{W}$, $W = E^2 + B^2$, $\mathscr{G}(W)$ the closure gate (0 flat, → 1 saturated), χ a pseudoscalar for parity. Quadratic in $\ell \Rightarrow$ uplink and downlink add. Weak Kerr: $E_{ij} = (m/r^3)(\delta_{ij} - 3n_in_j)$, $B_{ij} = -(3m/r^4)[a_in_j + a_jn_i + (\delta_{ij} - 5n_in_j)(a\cdot n)]$, $\sqrt{E_{ij}E^{ij}} = \sqrt{6}\,m/r^3 \Rightarrow \hat{B}_{\ell\ell} = -\sqrt{3/2}(1/r)[2(a\cdot\ell)(n\cdot\ell) + (a\cdot n)(1 - 5(n\cdot\ell)^2)] + O(a^2)$ — *mass cancelled, O(a/r); the closure gate is essential or* $M \to 0$ *leaves a finite effect. Straight ray* $x = b + s\ell$, $b \perp \ell$: $\int_{-\infty}^{\infty}\hat{B}_{\ell\ell}\,ds = \pm(3\pi/2)\sqrt{3/2}\,a\cdot\hat{b} = 5.771\,a\cdot\hat{b}$ (verified numerically for $a \parallel \hat{b}$; zero for $a \perp \hat{b},\ell$ and for $a \parallel \ell$). Earth $2\omega R/c = (2/\alpha_E)(a/R) = 6.046\,a/R$ ($\alpha_E = 0.3308$) — 4.5% from the rank-2 Kerr integral, not inserted. Not yet a prediction: units of length (~5.771a); DSN ray finite; λ_B underived; even in ℓ *and* in v ⇒ no $\cos\delta_{in} - \cos\delta_{out}$ from it alone. [reproduced]

H.3 The three "twos". Uplink + downlink: real in raw phase, removed by DSN's c/2 conversion (round-trip light time to one-way range). Incoming vs outgoing branches: could remain, needs a derived sign reversal. $K = 2\omega R/c$: Anderson's coefficient, not derived by the optical tensor. [reproduced]

Gravitational revision (v8.2). Decompose a weak optical perturbation relative to N^μ:

$$h^{(\gamma)}_{\mu\nu} = 2\Phi N_\mu N_\nu + 2N_{(\mu}A_{\nu)} + H_{\mu\nu}.$$

For a ray direction ℓ^μ, the scalar and tensor pieces are even under $\ell \to -\ell$, while $A\cdot\ell$ is odd and cancels on an exact retrace. A vector clock shift therefore survives a coherent two-way link only through a non-retraced contour or nonzero holonomy.

A local real quadratic electromagnetic action has a reciprocal constitutive tensor. Dilaton, axion, and nonbirefringent metric sectors do not by themselves produce a universal direction-odd Anderson bridge in an ideal stationary coherent transponder. Escapes require birefringence, dissipation/nonreciprocity, nonlocality, active device physics, or a real force, each with additional signatures. **[local reciprocal-EFT no-go]**

Appendix I — Vorticity, Transponder, and Carrier

I.1 The factor of two. Earth-fixed internal-clock congruence U^μ_E = Γ_E(N^μ + β^μ_E), weak rigid rotation β_E = (ω×r)/c. Spatial curl relative to N: ∇×(ω×r) = 2ω exactly (verified) ⇒ ℋ_C = 2ω/c; with r_𝒞 = R at Earth's clock boundary, 𝒦_C = r_𝒞|ℋ_C| = 2ωR/c — Anderson's K. Kerr normalization used a = J/(Mc) and k_I; clock-flow vorticity uses ω directly, no GM/(c^2R), no artificial cancellation. The same factor appears in congruence-adapted gravitoelectromagnetic decompositions (twice the vorticity). [reproduced]

I.2 Coherent Transponder Cancellation. A direction-independent conversion ν_I = 𝒞ν_U cancels exactly through a fixed turnaround ratio q. Direction-odd conversion ν_I(k) = [1 + ε(x,u,ℓ)]ν_U(k), ε(−ℓ) = −ε(ℓ): ν_U,↓/(qν_U,↑) = (1+ε)/(1−ε) ≃ 1 + 2ε survives. y_STF = 2ε; conventional y_Doppler ≃ −2δV_LOS/c ⇒ δV_arc = −𝒦_C V∞ cos δ — the transponder's 2 is removed by the c/2 conversion; ΔV∞ = δV_out − δV_in = 𝒦_C V∞(cos δ_in − cos δ_out) = (2ωR/c)V∞(cos δ_in − cos δ_out). [reproduced]

I.3 The angular structure. ν_⊥ = √(v·v − (v·ŝ)²) = V∞ cos δ — the *norm* of the equatorial component; a linear contraction ŝ·v gives V sin δ (wrong function). [reproduced]

I.4 The carrier is a connection, not T_U. Hypersurface-orthogonal N_μ = −∇_μT_U/|∇T_U|: Frobenius ⇒ ω^(N) = 0 — the universal clock has no vorticity, appropriately. Rotation lives in U_E. Synchronization one-form 𝒜_μ = h^(N)*μνβ^ν_E = (ω×r)/c; ℱ = 2D*[μ𝒜_ν], spatial dual ℋ_C = ∇_N×𝒜 = 2ω/c; R|ℋ_C| = 2ωR/c. Phase-bundle form: D_μΘ_I = ∇*μΘ_I − q_C𝒜_μ, transport W_γ = exp(iq_C∫γ𝒜), W{γ⁻¹} = W_γ⁻¹. Retraced two-way: W*{γ⁻¹}W_γ = 1 — a universal clock connection produces no residual on a reciprocal path; non-retraced legs close to ∮𝒜 = ∫ℱ — Sagnac, already in relativistic time transfer and JPL light-time models. Clock connection + ordinary transport = standard Sagnac, not a new anomaly. [reproduced]

I.5 The direction-odd conversion is new physics. ν_I = −(1/2π)k_μu^μ is standard; its direction dependence is ordinary Doppler. ε_req = λ_C𝒢_closure r_𝒞Ω_C(ν_⊥/c)σ_γ, σ_γ = sgn(k_μr^μ), Ω_C = √(½ℱ_μνℱ^μν): at Earth's boundary ε_req = λ_C(2ωR/c)(V∞/c)cos δ σ_γ; Anderson iff λ_C = 1 acting in the coherent readout chain. Nonanalytic (norm, sign), observer- and ray-dependent, not generated by the scalar action, generally preferred-frame detector physics. Closure topology gates but cannot normalize: λ_C → λ_C + δλ leaves the winding number unchanged (One Bit of Destiny's lemma turned on the flyby); a unit coefficient must come from canonical normalization, quantized clock charge, 10D reduction of a matter/photon operator, or a derived constitutive principle. [reproduced]

Gravitational revision (v8.2). For rigid rotation,

$$\boldsymbol{\beta}_E = \frac{\boldsymbol{\omega} \times \mathbf{r}}{c}, \qquad \nabla \times \boldsymbol{\beta}_E = \frac{2\boldsymbol{\omega}}{c}.$$

At a carrier boundary of radius R, the dimensionless rotational capacity is $2\omega R/c$. The universal normal remains hypersurface-orthogonal; rotation lives in the Earth-fixed material congruence.

A direction-independent clock conversion cancels through an ideal coherent transponder. A direction-odd conversion $\epsilon(-\ell) = -\epsilon(\ell)$ survives as a doubled frequency ratio, after which the conventional Doppler $c/2$ conversion removes the transponder factor two. The remaining bridge requires a covariant physical coupling and cannot be normalized by topology alone.

Appendix J — Coherent-Link Cancellation

J.1 Cancellation theorem. $J\_A \equiv dT\_U/d\tau\_A$; $\nu\_A = J\_A(1/2\pi)d\Phi/dT\_U$. Two-way: Earth emits $\nu_0 \Rightarrow \nu\text{^}(U)\uparrow =$ *ν_0/J_E(1); spacecraft receives J_S(2)P*$\uparrow\nu_0$/J_E(1), emits q× that; back to universal ÷J_S(2): $\nu\text{^}(U)\downarrow =$ *qP*$\uparrow\nu_0$/J_E(1) — spacecraft clock cancels identically; Earth receives $\nu_3 = q\nu_0[J\_E(3)/J\_E(1)]P\_\uparrow P\_\downarrow$. Same station, stationary map: J_E(3) = J_E(1) ⇒ ordinary rate difference disappears; slowly varying: J_E(3)/J_E(1) ≃ 1 + Δ_RT d ln J_E/dT_U — a round-trip derivative, not K(cos δ_in − cos δ_out). Three-way (A→B): J_B(3)/J_A(1) survives; one-way onboard: J_E/J_S survives. Hierarchy: 2-way same-station — only temporal change or path holonomy; 3-way — receiver/transmitter ratio; 1-way — Earth/spacecraft ratio; VLBI — inter-station. Two-way minus three-way exposes ln[J_B/J_A] + ΔΠ_BA. [reproduced]

J.2 Clock-Holonomy Requirement. The two-way measurement is a closed contour Γ = γ_↑ + γ_↓ − γ_E; $\delta\Phi = \oint\_\Gamma\mathscr{A} = \int\_\Sigma\mathcal{F}$; an exact scalar rescaling $\mathscr{A} = d\chi$ gives $\oint d\chi = 0$. A two-clock effect survives coherent closure only if $\mathcal{F} \neq 0$ or the observational contour is not closed (independently normalized inbound/outbound arcs). [reproduced]

J.3 Operator audit. Most general local quadratic photon action $S\_\gamma = -\tfrac{1}{8}\int\chi\text{^}\mu\nu\rho\sigma F\_\mu\nu F\_\rho\sigma$; real action ⇒ pair-exchange symmetry (reciprocity); premetric decomposition: principal (20, optical cone, generically birefringent), axion (1, polarization/phase rotation), skewon (15, nonreciprocity, absent from a real quadratic action). $\mathcal{F}^{C\_\mu\nu F}\mu\rho F\text{^}\nu\_\rho = 0$ (antisym × sym); $\mathcal{F}^{C\_\mu\nu F}\mu\rho\tilde{F}\text{^}\nu\_\rho = 0$ ($F^{\mu\rho\tilde{F}}\nu\_\rho = \tfrac{1}{4}g\text{^}\mu\nu F\tilde{F}$). Dilaton $Z\_C F^2$: reciprocal, direction-even. Axion $\vartheta\_C F\tilde{F}$: polarization, wrong observable. Kinetic mixing $\varepsilon\_C\mathcal{F}\text{^}CF$: source/diagonalization, no direction-odd cone. Nonbirefringent principal $K^{\mu\nu(F\_\mu\rho F\_\nu}\rho - \tfrac{1}{4}g\_\mu\nu F^2) \equiv$ effective metric — the only viable polarization-independent sector; the required K^μν_req ~ $N^{(\mu R}\nu)$ is an optical shift one-form ⇒ δt_↑ + δt_↓ = 0 on retrace — back to H.1. A stationary passive medium in the transponder conserves frequency (changes wavelength/phase velocity/delay/impedance only); slowly varying parameters give δν ~ ν d(L_dev ε/c)/dt, suppressed by L_dev/c ~ ns–μs against flyby minutes–hours. **Local Reciprocal-EFT No-Go:** under local action + gauge invariance + real quadratic F + stationary clock background + polarization-independent propagation + ideal coherent transponder, the constitutive tensor reduces to effective metric + dilaton + axion, and none produces the Anderson clock bridge. Escapes: birefringence, dissipation/nonreciprocity (skewon; hardware/temperature/power dependent), nonlocality, active matter/transponder physics (matter–photon operators $B^{\mu\_C\bar{\psi}\gamma}\nu\psi F\_\mu\nu$ — composition/design dependent, no universality theorem), or a real force. [reproduced]

Gravitational revision (v8.2). Let $J_A = dT_U/d\tau_A$. In a same-station coherent two-way link, the spacecraft clock cancels and a stationary Earth conversion cancels between transmission and reception. A scalar clock rescaling survives only through temporal change; a connection survives only through a nonzero contour integral. Three-way and one-way modes retain different clock ratios. Therefore a universal clock effect must predict link-mode dependence rather than merely attach a local scalar to the spacecraft.

The orbit-observation hierarchy is:

- two-way same-station: temporal change or path holonomy only;
- three-way: transmitter/receiver clock ratio;
- one-way: Earth/onboard clock ratio;
- VLBI: inter-station closure.

This hierarchy supplies a direct discriminator for the observation-map branch.

Appendix K — No-Work Holonomy and Projection

K.1 The correspondence (derived). Pull the curvature-rate interaction back to a worldline: $L_{int} = \gamma\varphi u^\mu\nabla_\mu\mathcal{R} = \mathscr{A}_\mu u^\mu$ with $\mathscr{A}_\mu = \gamma\varphi\nabla\mu\mathcal{R}$. $\mathcal{F}_{\mu\nu} = 2\nabla[\mu\mathscr{A}_\nu] = \gamma(\nabla_\mu\varphi\nabla_\nu\mathscr{R} - \nabla_\nu\varphi\nabla_\mu\mathscr{R}) = \gamma(d\varphi\wedge d\mathcal{R})_{\mu\nu}$ (verified). Euler–Lagrange $a^\mu = \mathcal{F}^{\mu\_\nu u}\nu \Rightarrow u_\mu a^\mu = \mathcal{F}_{\mu\nu}u^{\mu u}\nu = 0$ (no work). Same connection: $\oint_\Gamma\mathscr{A} = \int_\Sigma\gamma\, d\varphi\wedge d\mathcal{R} \neq 0$ wherever $\nabla\varphi \nparallel \nabla\mathcal{R}$. **Antisymmetric STF force ⟺ zero mechanical work ⟺ potentially nonzero phase holonomy.** V7.9 obtained the first half and treated it as a failure; the two-clock reading says no work was the prediction. Doppler-space target: $\delta y_{Anderson} = -(4\Omega RV_\infty/c^2)(\cos\delta_{in} - \cos\delta_{out})$; the derivation must show $(1/2\pi\nu_0)(d/d\tau_E)\oint_\Gamma\mathscr{A}$ equals it. Three bridges open: $\mathscr{A}$ couples to the operational radio/clock phase with fixed normalization; its rotating-Earth flux gives $2\Omega R/c$ without inserting Anderson; when the contour closes/stays open and why later Earth flybys are null. [reproduced]

K.2 The closure norm (geometric correspondence, demoted). Rotating carrier $r_O(\theta) = R(\cos\theta, \sin\theta, 0)$, $v_O = \Omega R(-\sin\theta, \cos\theta, 0)$; $\hat{s}(\alpha,\delta) = (\cos\delta\cos\alpha, \cos\delta\sin\alpha, \sin\delta)$; $p(\theta) = v_O\cdot\hat{s} = \Omega R\cos\delta\sin(\alpha - \theta)$ exact. Linear average $(1/2\pi)\int p = 0$. Retarded/advanced closure norm $Q = [(1/\pi)\int p_R p_A]^{1/2}$ with $p_A = p_R^* \Rightarrow Q = \Omega R|\cos\delta|$ — right ascension gone, declination retained; $\varepsilon_O = (2/c)Q \Rightarrow$ Anderson with separate arc closure and 2-way doubling; kernel $D_{ij} = (1/\pi)\int p_i p_j$ has diagonals $\Omega^2R^2\cos^2\delta_i$ and off-diagonal $\Omega^2R^2\cos\delta_{in}\cos\delta_{out}\cos(\alpha_{in} - \alpha_{out})$: separated arcs keep the diagonal difference (Anderson), joint closure keeps the cross-coherence. **But** orbit determination is linear to first order: $\Delta V = h^{T\_VWP\_\perp s/(h}T\_VWP\_\perp h\_V)$ is a linear functional of s; a positive nonlinear Q cannot arise in the estimator from a zero-mean p ($\int p = 0 \Rightarrow$ zero projection onto a constant step). The quadratic operation must occur in the physics before measurement or not at all; importing the retarded/advanced adjoint here assumes the missing gluing theorem. **Status: geometric correspondence** — it identifies Anderson's $\cos\delta$ as the phase-independent amplitude of ordinary diurnal rotational Doppler geometry (declination → amplitude, right ascension → phase), and station-local projections carry $\cos\lambda$ and $\sin(\alpha - \theta)$ that a global positive quantity does not (cf. Mbelek's special-relativistic term with $\cos\varphi_S/\cos\alpha$). [reproduced]

K.3 The No-Work Projection Theorem (derived, linear). $F\cdot u = 0 \Rightarrow V\cdot\delta V = 0 \Rightarrow \delta|V| = 0$ to first order while $\delta\hat{v} = \delta V/V_\infty \neq 0$. Two-way Doppler $\delta y = -(2/c)\hat{n}\cdot\delta V \neq 0$ generically (verified: transverse δV gives $\delta|V| \sim 10^{-10}$ m/s but $\hat{n}\cdot\delta V = O(\delta V)$). If Doppler dominates and angular rank is weak, $h_V \approx a\, h_{RA} + b\, h_{Dec}$, direction and speed are partially degenerate, and the estimator represents a transverse deflection as $\Delta V_\infty \neq 0$ with $\Delta V_{\infty,physical} = 0$. With continuous multi-observable tracking, rank(H) increases, the degeneracy breaks, and the same signal is reconstructed as a tiny deflection, absorbed, or rejected — $\Delta V \to 0$ without the field vanishing. Later nulls become evidence of greater observational closure. Two sub-branches: **B1** kinematic projection (original no-work force → real transverse deflection → Doppler/range residual → apparent ΔV; no new coupling; investigate first); **B2** clock holonomy (connection → direct signal/clock phase → apparent ΔV; needs the clock–connection coupling theorem, substantive after photon sequestering). Exact next calculation: $\delta v(T) = \int a_{STF}\, dT'$; verify $v\cdot\delta v = 0$; propagate $\delta y_{2w} = -(2/c)\hat{n}\cdot\delta v + \delta y_{lt}$, $\delta\rho = \hat{n}\cdot\delta r + \delta\rho_{prop}$; pass through the actual estimator. [reproduced]

Gravitational revision (v8.2). Pull the response interaction to a worldline:

$$L_{\rm int} = \gamma\phi u^\mu\nabla_\mu q = \mathcal{A}_\mu u^\mu, \qquad \mathcal{A} = \gamma\phi\, dq.$$

Then

$$\mathcal{F} = d\mathcal{A} = \gamma\, d\phi\wedge dq, \qquad u_\mu\mathcal{F}^\mu{}_\nu u^\nu = 0,$$

while

$$\oint_\Gamma \mathcal{A} = \int_\Sigma \gamma\, d\phi \wedge dq$$

may be nonzero. **No-work holonomy correspondence:** antisymmetric response implies zero mechanical work and permits a phase holonomy. **[derived]**

For a first-order perturbation with $\mathbf{V}\cdot\delta\mathbf{V} = 0$, $\delta|\mathbf{V}| = 0$, two-way Doppler can nevertheless contain a nonzero $\widehat{\mathbf{n}}\cdot\delta\mathbf{V}$. A Doppler-dominated estimator with weak angular rank may represent a transverse deflection as $\Delta\widehat{V}_\infty$. Continuous range and angular data lift the degeneracy. **[no-work projection theorem]**

Appendix L — Clock-Carrier Capacity and Utilization

L.1 The global carrier. Closed rotating system C with universal normal N^μ, internal phase $\theta \in S^1$, axial generator $\psi^\mu = \partial_\theta$, rate Ω_C; spatial metric $h_{\mu\nu}$; cylindrical radius $\rho(x) = \sqrt{h_{\mu\nu}\psi^\mu\psi^\nu}$; boundary radius $R_C = \sup_{\partial C}\rho = R_\oplus$ at the equator; carrier velocity $v^\mu_C = \Omega_C\psi^\mu$. [definition]

L.2 The operator norm (theorem). $\ell_s(x) = v_{C\mu}s^\mu/c$; rotating sphere $\ell_s(\theta,\lambda) = (\Omega R\cos\lambda/c)\cos\delta\sin(\alpha - \theta)$. $\|\ell_s\|_{\infty,C} = \sup_{\partial C}|\ell_s| = (|\Omega|R/c)\cos\delta$ — attained at the equator ($\lambda = 0$), $\alpha - \theta = \pi/2$ (verified on a 2001×2001 grid). Restoring orientation: $\kappa_C(s) = \mathrm{sgn}(\Omega)\|\ell_s\| = (\Omega R/c)\cos\delta$. Explains simultaneously: equatorial R not station $R\cos\lambda$; declination not right ascension; linear sign-sensitive rotation; no G or M. Two-way capacity $C_{2w} = 2\kappa_C = (2\Omega R/c)\cos\delta$; if inbound and outbound records each saturate it, $\Delta V/V_\infty = (2\Omega R/c)(\cos\delta_{in} - \cos\delta_{out})$ exactly. [reproduced]

L.3 Capacity is not saturation. Closure–Capacity says capacity gates whether a loop can close ($C \geq H$), not that every closed loop runs at capacity. Using capacity as the anomaly would require "every completed STF measurement transaction saturates the directional clock capacity of its carrier" — too strong; fully closed later flybys would then show the effect. [recorded]

L.4 Capacity × utilization. $\varepsilon_a = \eta_a(2\Omega_C R_C/c)\cos\delta_a$, $\eta_a \in [-1,1]$; $\Delta V/V_\infty = (2\Omega_O R_O/c)[\eta_{in}\cos\delta_{in} - \eta_{out}\cos\delta_{out}]$; Anderson is $\eta_{in} = \eta_{out} = 1$; nulls at $\eta \simeq 0$ or $\eta_{in}\cos\delta_{in} \simeq \eta_{out}\cos\delta_{out}$. η_a *must not be fitted*: $\eta_a = h^T W P_\perp s_{STF,a}/(C_a h^T W P_\perp h_V)$, $C_a = V_\infty(2\Omega_C R_C/c)\cos\delta_a$ — computed from station identities, tracking windows, link mode, phase continuity, range/VLBI coverage, clock resets, solve-for parameters, and the design-matrix projection of the STF template. Capacity supplies the scale; the waveform $s_{STF}(t)$, derived from the action or clock/link coupling, supplies the utilization. [reproduced]

L.5 The bound. $|\varepsilon_a| \leq (2|\Omega_O|R_O/c)\cos\delta_a$; $|\Delta V/V_\infty| \leq (2|\Omega_O|R_O/c)(\cos\delta_{in} + \cos\delta_{out})$. Any reliable anomaly exceeding it rules out the observer-clock mechanism. Anderson lies inside, at a saturated orientation. [reproduced]

L.6 Carrier discrimination. Encountered-body source: $\Omega_P R_P$, changes planet to planet. Global Earth carrier: $\Omega_\oplus R_\oplus$, persists for Earth-tracked encounters elsewhere. Local station: $\Omega_\oplus R_\oplus\cos\lambda_A$, station-latitude and sidereal structure. Link holonomy: oriented path functional, changes with routing. No-work deflection: not a carrier rate; stations reconstruct one common deflected trajectory. Distinct predictions; the same encounter can yield different fitted anomaly capacities depending on which closed clock system completes the transaction. [reproduced]

L.7 The Clock-Carrier Capacity–Observability Theorem (stated). For a measurement transaction embedded in universal time and closed by a rotating internal clock carrier, the maximum apparent first-order velocity fraction is the operator norm 2|Ω|R cos δ/c, and the realized fraction is its projection through the transaction's actual observation operator. Accommodates in one equation: Anderson's Earth coefficient, source–observer degeneracy, early detections, later nulls, non-Earth failures, no physical energy change, the two-clock architecture. Empirical step: compute η_a for every early detection and later null. [stated; components L.2, L.4 reproduced]

Gravitational revision (v8.2). For a closed rotating carrier with axial generator ψ^μ, angular rate Ω_C, and boundary radius R_C, define $v_C^\mu = \Omega_C \psi^\mu$. For asymptotic direction s^μ,

$$\left\| \frac{v_C \cdot s}{c} \right\|_{\infty, C} = \frac{|\Omega_C| R_C}{c} \cos\delta.$$

This operator norm explains the equatorial radius, declination-only dependence, spin sign, and absence of G, M. It is a capacity, not an assertion of saturation. The realized observable is

$$\epsilon_a = \eta_a \frac{2\Omega_C R_C}{c} \cos\delta_a, \qquad -1 \le \eta_a \le 1,$$

where η_a is the normalized projection of an STF template through the actual orbit-determination design matrix. The historical test must compute all η_a before comparison with reported anomalies.

Appendix M — Source–Observer Degeneracy and Interchange

M.1 The degeneracy (theorem). Every original Anderson event was a flyby *of* rotating Earth observed *through* rotating Earth's tracking and clock infrastructure: source = observer = ⊕. K_source = 2Ω_sR_s/c and K_observer = 2Ω_oR_o/c coincide identically. When the rotating gravitational source and the rotating observational clock carrier are the same body, a source-local dynamical correction and an observer-local temporal correction share the same first-order rotational coefficient; Earth-only data cannot identify its causal location. [reproduced]

M.2 What non-Earth flybys decide. Source = B, observer = ⊕: the dynamical branch predicts K_B = 2Ω_BR_B/c with projections on the planet's axis; the observer branch predicts K_obs = 2Ω_⊕R_⊕/c with projections on the terrestrial network. Failure of planet-local scaling falsifies the source-force interpretation while leaving — and favoring — the observer-clock interpretation. Confirmation requires an observer-based law predicting tracking-mode and closure dependence *before* reanalysis; non-Earth data are not yet clean (planetary gravity fields, bound-orbit reconstruction, Jovian normal modes). This is what “observational relativity” means in a rigorous inverse-problem sense: the inferred parameter depends on the physical history and the observation operator. [reproduced]

M.3 The symmetry verdict. Anderson's K: linear in Ω; odd under Ω → −Ω; independent of G and M; no periapsis-curvature dependence; scale ΩR/c. Source-curvature force: obstructed for parity-even invariants; needs an odd invariant or added structure; needs cancellation/amplification of the compactness $GM/(c^2R) \approx 7\times10^{-10}$ (a source-local effect ~ compactness × ΩR/c ~ 10^{-15} vs Anderson 3×10^{-6} — nine orders); the natural gravitational scale is not ΩR/c. Observer-clock map: linear, sign-reversing, G- and M-free, and ΩR/c is the bare rotational rapidity — all automatic; no work expected. Branch B is the structurally economical branch. [reproduced]

M.4 The covariant two-clock observable. N^μ = Γ(u^μ_O + v^μ_O), Γ = −u_O·N; ν_O = −k·u_O, ν_U = −k·N; ν_O/ν_U ≃ 1 − v_O·ŝ/c; two-way δy_O ≃ −(2/c)v_O·ŝ; Earth v_O = Ω_⊕×r_O. Right symmetry; but a station gives ΩR cos λ cos δ sin(α − θ), so the Universal Clock Carrier must specify whether u_O belongs to a station, the closed Earth system, the ECI congruence, or the STF phase restricted to Earth closure — this is Appendix L's answer (the closed carrier's operator norm). [reproduced]

M.5 Clock–Carrier Interchange (derived). r = H_xδx + r_link + r_clock; ΔV = h$^{\mathrm{T_VWP_\perp r/(h}}$T_VWP_⊥h_V) ⇒ ΔV ≠ 0 ⇏ ΔE∞ ≠ 0. Three branches: energy-changing force (v·δv ≠ 0; Doppler, range, angular all change; ordinary geometry); no-work deflection (v·δv = 0, δv_⊥ ≠ 0; direction changes; different stations project one trajectory); clock/link holonomy (δx = δv = 0, δΦ_Γ ≠ 0; no optical trajectory change; intrinsic link dependence). Observable decomposition: δy_2 ≃ −(2/c)(n̂·δv + n̂·δr) + δy_link + δy_clock; δρ ≃ n̂·δr + cδt_link; δθ ≃ P_⊥n̂δr/ρ; δE∞ = v∞·δv∞. Link test: 𝒟_AA = ln[J_A(T$_3$)/J_A(T$_1$)] + Π_A↑ + Π_A↓; 𝒟_AB − 𝒟_AA = ln[J_B/J_A] + ΔΠ_BA; 𝒟_S→A = ln[J_A/J_S] + Π. **The decisive experiment:** during one encounter, coherent two-way from one station + simultaneous three-way from another + one-way from a stable onboard oscillator + range + calibrated angular tracking. A common energy change → work-producing branch; a common deflection with δE∞ = 0 → original no-work interaction; a station/link-dependent residual with no optical change → carrier/holonomy; disappearance under full joint estimation → observational projection; disappearance without structure → weakens the identification. [reproduced]

M.6 The one-bit channel cannot carry ωR/c. The advanced closure certificate carries one topological bit (closed/open); ωR/c is a continuously varying real number differing between planets. It cannot be transmitted by the one-bit advanced arc; it must reside in an ordinary retarded field sourced by matter, a boundary condition, or a conventional exterior multipole. And closure normalization ≠ dynamical amplitude: (1/4π^2)∫ω_R∧ω_A = 1 normalizes a completed transaction and does not fix K_R^{-1}J_rot; 4π^2 cannot legitimately set the flyby coupling to unity. Zero-capacity corollary for the "One Bit Is Not No Signal" program: if the certificate is topologically fixed for every admissible completed transaction and its distribution is invariant under all local instrument choices, P(w|a,b) = P(w) and the advanced sector has zero controllable signaling capacity. [reproduced; corollary stated]

Gravitational revision (v8.2). Every original Anderson event was both a flyby of Earth and an observation through Earth's rotating clock infrastructure. Hence

$$K_{\mathrm{source}} = \frac{2\Omega_\oplus R_\oplus}{c} = K_{\mathrm{observer}}$$

identically. Earth-only data cannot locate the coefficient causally. A non-Earth encounter observed from Earth separates the predictions: a source theory scales with the encountered body; an observer theory scales with the terrestrial carrier and link architecture.

Orbit residuals decompose as

$$r = H_x\delta x + r_{\mathrm{link}} + r_{\mathrm{clock}}, \qquad \Delta\widehat{V} = \frac{h_V^T W P_\perp r}{h_V^T W P_\perp h_V}.$$

Therefore $\Delta\widehat{V} \neq 0$ does not imply $\Delta E_\infty \neq 0$. A work-producing force, no-work deflection, link holonomy, and estimator projection remain distinct branches with different multi-observable signatures.

Appendix N — Tensor Speed on the Scalar–Gauss–Bonnet Route

N.1 Method. For $f(\varphi)\mathcal{G}$, $\mathcal{G}$ is topological in 4D: a static coupling leaves c_T untouched; the correction enters through the coupling's time-variation. Horndeski tensor sector (Kobayashi–Yamaguchi–Yokoyama 2011; Bellini–Sawicki α-basis): $c_T^2 - 1 = \alpha_T \simeq 8(\ddot{f} - H\dot{f})/M_{Pl}^2$, cross-checked against the exact ratio $F_T/Q_T = (1 - 8\ddot{f}/M^2)/(1 - 8H\dot{f}/M^2)$. $f = \kappa(\zeta/\Lambda)(\varphi/M_{Pl})M_{Pl}^2$, $\kappa = O(1)$ the C.5b auxiliary factor; $(\zeta/\Lambda)/c^2 = 1.5\times10^{-6}$ s²; $H_0 = 2.43\times10^{-18}$ s⁻¹; $m_s = 3.94\times10^{-23}$ eV. [standard; reproduced]

N.2 Tracking regime. $\dot{\varphi} \sim H_0\varphi$, $\ddot{\varphi} \sim H_0^2\varphi$, Planck-order stabilized modulus $x_0 = \varphi/M_{Pl} \le 1$: $|c_T/c - 1| \lesssim 8\kappa(\zeta/\Lambda)H_0^2x_0/c^2 \approx 7\times10^{-41}$ — 25 orders below GW170817's 10^{-15}. [reproduced]

N.3 Oscillating regime. *[Post-v8.1 note: the response-matched recalculation confirms this appendix's instantaneous envelope 3.6×10^{-30} and adds the conditional cross-messenger residual $|\mathcal{R}\_2C|\_\{z=1\} \sim 2.6\times10^{-37}$ s⁻¹; the recorded realization is effectively a null prediction observationally. The corrected benchmark and its dependency grade are stated in §IV.E and §VII.A; nothing in this appendix is withdrawn.]* $\varphi = A\cos m_st$, $m_s/H_0 = 2.5\times10^{10}$ — the potentially dangerous case. Amplitude from the framework's own $\rho_{DE} = \tfrac{1}{2}m_s^2A^2$: with $\rho_{DE} = 0.7\times3H_0^2M_{Pl}^2 = 3.2\times10^{-47}$ GeV⁴ and $m_s = 3.94\times10^{-32}$ GeV, $A = 2.0\times10^8$ GeV, $A/M_{Pl} = 8.3\times10^{-11}$. $|c_T/c - 1| \lesssim 8\kappa(\zeta/\Lambda)m_s^2A/(M_{Pl}c^2) \approx 1.8\times10^{-30}$ at $\kappa = 1$ cycle-averaged (the instantaneous envelope $|\ddot{\varphi}|_{max} = m_s^2A$ gives twice this, 3.6×10^{-30} — 14 orders inside the bound either way); 1.8×10^{-26} at $\kappa = 10^4$ (still 10 orders). Saturating amplitude $\varphi/M_{Pl} \approx 4.7\times10^4$ — super-Planckian. [reproduced] *Process note:* a first pass mis-read the dark-matter paper's "A ~ 780 SI units" as $\varphi/M_{Pl} = 780$, placing a spurious worst case within 60× of the bound; caught by re-deriving the amplitude from ρ_{DE}. Recorded because a single-pass calculation would have shipped it.

N.4 Status. $c_T = c$ holds by calculation on the sGB parent in both regimes, robust to κ and H_0. Open only for the completed two-clock action if its carrier brings its own dynamics.

Gravitational revision (v8.2). For $f(\phi)\mathcal{G}$, the four-dimensional Gauss–Bonnet density is topological at constant f. The tensor correction is

$$c_T^2 - 1 \simeq \alpha_T = \frac{8(\ddot{f} - H\dot{f})}{M_{\rm Pl}^2}.$$

Using the retained scalar–Gauss–Bonnet normalization, the tracking regime gives $|c_T/c - 1| \lesssim 7\times10^{-41}$. For $\phi = A\cos(m_st)$, taking A from $\rho = \frac{1}{2}m_s^2A^2$ gives $A/M_{\rm Pl} \simeq 8.3\times10^{-11}$ and an envelope of order 10^{-30}. Both are far below the multimessenger bound. **[reproduced]**

This appendix is not the tensor action of the complete split-leg parent. Its status is exactly: tensor speed passed on the scalar–Gauss–Bonnet route; open for any completed carrier/environment theory whose additional terms modify the tensor principal symbol.

Appendix O — Ten-Dimensional Parent and Carrier Audit

O.1 Reduction. ds²₁₀ = e^{−6σ}g_μνdx^μdx^ν + e^{2σ}ĝ_mndy^mdy^n, block-diagonal ($G_{\mu m} = 0$); 4D massless sector $g_{\mu\nu}$ and σ, no vector; the curvature-squared descendant $A(\sigma)\mathcal{G}$ with $[y] = M^{-1}$; $L^* = 3.64\times10^{-30}$ m from the internal-trace projector; the Kähler potential with Re T ≡ e^{4σ}, $-3\ln(T+\bar{T}) = -12\sigma - 3\ln 2$ (σ the log-breathing coordinate; the exponent is fixed by canonical normalization against the reduction's φ_c =

$\sqrt{24}\, M_{Pl}\, \sigma$ — §II.D. Two prior errors on this line, both corrected: V7.9's -6σ read as $-3\ln(2\sigma)$, a notational collision; and an interim repair wrote $\mathrm{Re}\, T \equiv e^{2\sigma}$, whose $n = 2$ gives $\varphi_c = \sqrt{6}\, M_{Pl}\, \sigma$ against the reduction's $\sqrt{24}$ — a factor-2 normalization error, August 2026). [reproduced; V7.9 record for the full reduction]

O.2 The visible photon sector. $L_\gamma = -\frac{1}{4}\mathrm{Re}\, f_\gamma(\varphi)F^2$; $f_\gamma = f_0 + f_1\delta\varphi$; canonical $F^{(c)} = \sqrt{f_0}F \Rightarrow g_{\varphi\gamma} = \partial_\varphi \ln \mathrm{Re}\, f_\gamma|_{\varphi_0}$ — not ζ/Λ (different dimension and origin). Sequestering: $f_{SM} \sim T_s$ depends on the local cycle, $\partial\tau_s/\partial\tau_b \approx 0 \Rightarrow g^{tree}_{\varphi\gamma} = 0$; residual mixing $K_{b\bar{s}} \sim 1/\mathcal{V}$: $g^{eff}_{\varphi\gamma} = c_\gamma/(\mathcal{V} M_{Pl})$, $|c_\gamma| \lesssim 0.612$ by analogy with $\alpha_{eff} \sim 0.612/\mathcal{V}$ (assumption, not theorem); $\mathcal{V} > 175 \Rightarrow g^{eff} \lesssim 1.4\times10^{-21}$ GeV^{-1}; virtual $\gamma\gamma \to \varphi^* \to \gamma\gamma$ at 1.6 eV: $|\mathcal{M}| \lesssim 5\times10^{-60}$; $\Gamma = g^2 m_s^3/(64\pi) \lesssim 6\times10^{-139}$ GeV, $\tau_\varphi \gtrsim 10^{114}$ s. Photon-coupling cancellation: $L = -\frac{1}{4}Z(\varphi)F^2$, $Z = 1 + g_{\varphi\gamma}\delta\varphi$, $\nabla_\mu[ZF^{\mu\nu}] = j^\nu$; geometric optics: both polarizations on one null cone, common transport $\nabla_\mu[Z|a|^2k^\mu] = 0$; $K_\varphi = c_\varphi\mathbb{1}$ on the polarization space $\Rightarrow$ $(K_A\otimes K_B)\rho(K^\dagger_A\otimes K^\dagger_B) = |c_A c_B|^2\rho \Rightarrow \rho' = \rho$ after normalization; efficiency cancels under fair sampling; free wave $F^2 = 0$. On-shell $\varphi \to \gamma\gamma$ gives 2×10^{-23} eV photons ($\lambda \approx 6.7$ ly), $10^{23}\times$ below optical. $S_{STF} = S_{QM} + O(E^2/\mathcal{V}^2M^2_{Pl})$; the visible-sector coupling is unnormalized-Z-free: V7.9's $(\alpha/\Lambda)\varphi F^2$ lacked the ¼ and overloaded α; corrected in the boxed action and the LOD-appendix width. [reproduced]

O.3 The carrier audit — no field carries both O(ω) and boundary data. Breathing mode σ: sourced by parity-even $C^2 \Rightarrow \sigma(a) = \sigma(-a)$, $O(a^0, a^2)$, carries no R; produced by the reduction. Universal clock T_U: no vorticity (Frobenius), no R, ω, k_I; shift-symmetric $T_U \to T_U + C \Rightarrow$ orientation, foliation, ordering — not absolute winding, not planetary boundary data; completion open. Ordinary Kerr $g_{t\varphi}$: O(a), carries J not R; GR. Curvature phase ϑ_C: O(a), local r not source R; geometric, not dynamical. Axion ϑP: O(a) via $P = 288m^2a\cos\theta/r^7$ (dynamical Chern–Simons mechanism, Yunes–Pretorius) — the natural pseudoscalar is STF's own imaginary modulus partner ϑ in $T = \sigma + i\vartheta$; but a conventional analytic $\vartheta \propto (\alpha_{CS}/f^2)P$ retains m^2a/R^5 (mass and compactness), and ϑP couples to stationary orientation, not its universal rate ($\vartheta N\cdot\nabla P$ again vanishes in stationary Kerr); the mass cancels only in the *normalized* ratio $P/C^2 \simeq 6a\cos\theta/r$ — which loops back to Branch B (a regularized $\mathcal{O}_{odd} = P/\sqrt{(C^2)^2 + P^2 + \mathcal{S}^2}$ *with* $\mathcal{S}$ a derived closure scale). Matter-vorticity carrier B_μ: could carry R via the boundary ($\chi^\mu_\Sigma = R_\Sigma\varpi^\mu$, $|\chi_\Sigma| \simeq \omega R/c$) but is not in the reduction; would need $\mathcal{K}^\mu{}_\nu B^\nu = J^\mu_{rot}$, a source coupling, and a photon coupling — three underived quantities. **The present 10D theory contains no field carrying both O(ω) and source-boundary information; the cross-disformal metric is not generated by the compactification performed ($\hat{B}_{KK} = 0$).** [reproduced]

O.4 Circularity ledger. $L^* = 3.64\times10^{-30}$ m vs dark-energy-required 3.55×10^{-30}: conditional consistency check. Coupling near the historical flyby value: not validation (flyby derivation withdrawn). $\Omega_{STF} \sim 0.65$ vs observed: matched downstream benchmark. Flux integer ~ few million: consistent with the chosen stabilization ratio. No inconsistency in using these as calibration; they must not be counted again as predictions. [recorded]

O.5 The static-response problem. $A(\sigma)\mathcal{G}$ responds to *static* curvature; STF's selectivity must come from the response kernel (K(0) = 0, Appendix C), making STF a nonlocal response theory rather than the minimal local scalar-tensor theory V7.9 branded. The retarded map from the compactified parent to the local rate operator is a constitutive completion target, not a proven reduction. [recorded]

Gravitational revision (v8.2). The block-diagonal compactification produces a four-dimensional metric and breathing scalar but no vector carrying both source rotation and boundary radius. With $\mathrm{Re}\, T = e^{4\sigma}$, the canonical normalization is $\phi_c = \sqrt{24}M_{\mathrm{Pl}}\sigma$. The curvature-squared descendant supplies a scalar–Gauss–Bonnet ancestor and the scale L_*.

The visible gauge kinetic function is sequestered from the bulk volume modulus at tree level in the declared construction. The reduction does not generate the formerly proposed cross-disformal matter metric, a boundary-CMC selection term, the compact-alignment regulator, or the $Q_\Delta X_\alpha$ environment vertex. The retarded map from the compactified parent to the high-pass response remains a constitutive completion target.

The parent is therefore evidence for a curvature-squared scalar ancestor and its normalization, not a derivation of the full infrared gravitational bridge.

Appendix P — Gravitational Supersession Ledger

P.1 Former Horndeski/DHOST argument

Integrating the local interaction by parts does not turn it into a standard one-field Horndeski term. The divergence of a normalized scalar gradient contains second derivatives and inverse powers of its kinetic scalar, and the Weyl-based q_N is not a Ricci scalar term. The companion degeneracy operators required by a nonzero G_{4X} were absent. The former class claim is withdrawn.

P.2 Direct local norm obstruction

For $u_A = \mathcal{C}_A$, $q = \sqrt{u^2}$,

$$\frac{\partial^2 q}{\partial u_A \partial u_B} = \frac{1}{q}\big(\delta_{AB} - \widehat{u}_A \widehat{u}_B\big).$$

If u_A depends linearly on a metric acceleration a_I through $J_{AI} = \partial u_A / \partial a_I$, the acceleration Hessian of the integrated-by-parts interaction contains

$$H^{(a)}_{IJ} = -\frac{\kappa A}{q} J^T (I - \widehat{u}\widehat{u}^T) J, \qquad A = D_U \phi + \theta \phi.$$

It is generically nonzero. On FLRW with $R_0 \neq 0$, transverse-traceless perturbations give

$$S^{(2)}_{\mathrm{rate}} \supset -\frac{\kappa A_0}{4|R_0|} \int d^4x\, a^3 \ddot{\gamma}_{ij} \ddot{\gamma}^{ij}.$$

Together with the Einstein term, the schematic propagator is

$$\frac{1}{\omega^2 (A_2 + C_4 \omega^2)} = \frac{1}{A_2}\left(\frac{1}{\omega^2} - \frac{1}{\omega^2 + A_2/C_4}\right),$$

which has opposite residues. At $A_0 = 0$ the rank changes rather than becoming structurally degenerate. At the flat apex the unregulated norm is nondifferentiable. **[closed generically]**

P.3 Closed same-content repairs

ROUTE	RESULT	REASON
ordinary off-shell ADM map	no-go	six normal-curvature jets are independent off-shell data
torsion-constrained connection	failed	torsion fixes the connection; reduced response restores 0/1/5/6 jet ranks and extra pairs

ROUTE	RESULT	REASON
regular compact/square-root auxiliary	no-go	Schur congruence preserves reduced curvature Hessian
regular BF/Legendre	no-go	dualizes rather than removes the Hessian
singular BF without gauge identity	failed as cure	constrains curvature histories
same-metric Plebański	failed	simplicity tangents do not span six physical channels; metricity deformed
six spectator/Stückelberg nulls	no-go	nulls remove added fields; invariant rank-six block survives
Abelian BF source	failed generically	STF source is not off-shell closed
shifted metric, regular	no cure	rank preserved by congruence
shifted metric, singular	failed	rank-bifurcating shells, folding, derivative stacking

These are scoped results. They close the tested exact same-content repairs, not every conceivable independent-carrier or nonlocal UV theory.

P.4 Surviving route

The surviving local EFT architecture retains the jets independently, varies the full parent, and reduces only on an analytic weak-backreaction branch. Its status is conditional because $\mathsf{A}(k)$, the CMC deformation, and all secondary brackets must remain regular.

Appendix Q — Threshold Scaling, Apex No-Go, and World-Tube Dependence

Q.1 Distinct claims not to be merged. (i) The $4\pi^2$ Hopf/anti-Hopf cup product — a topological theorem. (ii) The threshold ansatz $\mathscr{D}$_crit(m_s) = m_sM_Pl$H_0/(4\pi^2)$ — a natural-unit parametric expression. (iii) Its SI value $\mathscr{D}$_crit ≡ $\mathscr{D}$_GR(730 R_S) ≈ 10^{-27} $m^{-2}s^{-1}$ — an assignment. [record]

Q.2 The audit. $\hbar H_0 = 1.60\times10^{-33}$ eV; unreduced M_Pl = 1.2209×10^{28} eV: $\mathscr{D}$_crit = 1.95×10^{-29} eV^3; 1 eV^3 = $1/((\hbar c)^2\hbar)$ $m^{-2}s^{-1}$ = 3.90×10^{28} $m^{-2}s^{-1}$ ⇒ $\mathscr{D}$_crit ≃ 0.76 $m^{-2}s^{-1}$; reduced M_Pl ⇒ 0.15. Neither is 10^{-27}; the discrepancy is 26–27 orders (10^{-27} $m^{-2}s^{-1}$ = 2.56×10^{-56} eV^3). The 10^{-27} is $\mathscr{D}$_GR at 730 R_S (Appendix A.5: ≈ 2×10^{-27}). The former evaluation was not a unit conversion; it introduced an unreported normalization by matching to $\mathscr{D}$_GR. This does not refute the cup product; it refutes the naive identification of the cup-product-normalized *mass scale* with the SI curvature-rate *observable*. [reproduced]

Q.3 What the bridge must contain. A map from the topological/natural-unit threshold to the geometrical SI curvature-rate normalization — an additional STF conversion scale (the capacity radius L^{*-2} is the natural candidate, Appendix D) or an honest restatement that 730 R_S is observationally selected and m_s is a phase conversion (this paper's current position). Until then Path 1 has a written normalization gap; the Peters timing calculation remains valid; the threshold cannot be counted as an independent derivation of 730 R_S. [stated — open] A second provenance question rides with the bridge (August 2026, declared, not resolved here): the threshold divides by $4\pi^2$, whose coordinate-free invariant value is the primitive integer 1 (B.6); whether the physical normalization should carry the angular representative $4\pi^2$ or the normalized integer is part of what the bridge must decide, since the choice moves the natural-unit value by ~39.5 — small against the 27 orders, but not free. [stated — open, rides with the SI bridge]

Q.4 The Framework Guide. It presents the natural-unit expression as directly yielding 1.07×10^{-27} $m^{-2}s^{-1}$; that page must be aligned with Q.2. [housekeeping]

Q.5 A concrete bridge candidate — recorded at its audited strength (August 2026). The August threshold audit supplies numbers for the bridge Q.3 asks for. With the external-tidal functional $\mathscr{D}_{ext}(x) = (3\sqrt{3}/20)c^7/(G^3M^3)x^{-7}$ (companion of mass M/2 at separation a; all values below independently re-derived): $\mathscr{D}_{ext}(730\ R_S) = 1.0137\times10^{-27}$ $m^{-2}s^{-1}$, so the required constitutive suppression against $\mathscr{D}_{crit} = 0.7606$ $m^{-2}s^{-1}$ is **$Z_{\mathscr{D}} = 1.333\times10^{-27}$**. The compactification supplies ***$(\ell_{Pl}/L)^5 = 1.726\times10^{-27}$* — *within a factor 1.30 of the requirement; with unit coefficient the crossing sits at 703.5 R_S against the framework's 730, and an O(1) coefficient $C_5 = 0.772$ recovers it. The exponent fitted to the requirement is p = 5.02, so the fifth power is singled out among neighbouring integers ($(\ell_{Pl}/L)^4 = 3.9\times10^{-22}$, $(\ell_{Pl}/L)^6 = 7.7\times10^{-33}$). Three cautions prevent promotion to a derivation, and they are the audit's own: (i) six compact dimensions naturally produce six volume powers — 5 = d_int − 1 suggests a codimension-one boundary, flux or kernel-moment origin, which is a clue, not a proof; (ii) the best numerical agreement uses mixed Planck conventions (the declared L* carries the reduced-Planck ratio while the threshold uses the unreduced mass; consistent conventions move the required coefficient to 1.97 or 4.04 and the crossing to 804 or 891 R_S); (iii) the match is not unique — $\sqrt{(m_s/M_{Pl})/(4\pi^2)} = 1.439\times10^{-27}$ fits better (coefficient 0.926), and many monomials live in the available hierarchy. Two unrelated constructions within a factor 1.4 of the target is not evidence. Status: a sharp target for the retarded-kernel derivation — determine whether the doubled influence functional or a compactification boundary calculation produces $Z_{\mathscr{D}} = C_5(\ell_{Pl}/L)^5$* with C_5 fixed independently and one consistent Planck convention — not a completed bridge.** Also from the audit, two closures and one correction: the unsuppressed threshold crosses the tidal functional only at x ≈ 0.11 (inside merged horizons — it selects no physical separation); a universal threshold implies $x(M,z) \propto M^{-3/7}H^{-1/7}$*, so 730 R_S cannot be a universal activation radius for all masses and is retained as the reference value for the reference binary; and the "Pretorius & Lehner 2002" citation formerly attached to the binary cross-term suppression is withdrawn (that identifier is a cosmological-perturbation paper). The audit's verdict is this appendix's closing sentence:* STF retains an empirical/theoretical convergence at the supplied 730 R_S reference separation, but the closure threshold does not yet independently select that separation.* [recorded at audit strength; numbers reproduced]

Q.6 The production location is load-bearing (world-tube result, August 2026). The proxy $\sqrt{K} = \sqrt{48}\, Gm/(c^2a^3)$ never specified *which surface* it represents, and the choice is not a coefficient: at the equal-mass binary midpoint the two leading electric-Weyl tensors add (each hole at distance a/2), giving $\mathcal{R}_{mid} =$ **16** $\mathcal{R}_{proxy}$ exactly at leading order [reproduced analytically]. Imposing the same threshold there moves the anchor by $a \to 16^{1/7}a = 1.486a$ and $t \to 16^{4/7}t = 4.876t$ — i.e. 730 R_S / 3.324 yr → **1085 R_S / 16.2 yr**. This is not a proposed replacement; it proves the **Binary World-Tube Sensitivity result**: a threshold on a local binary curvature scalar selects no unique separation until the spacetime support of the response is specified. Related non-commutations, all verified in the audit: a body-centred world-tube point responds at a^{-3}; the sphere-averaged tube cancels the first-order tidal quadrupole and responds at a^{-6}; a far-zone radiative point responds at a^{-4}/D — so norm-taking, angular averaging, filtering and spatial integration do not commute physically. (The far-zone kernel's rungs, 16.26/16.91, sit closest to the observed 16.36/16.98.) The exact kernel also selects nothing by resonance: at all three anchors $\Omega_{GW}/\omega_c \sim 10^6$ — deeply saturated — and time-remaining-to-merger is not a local oscillation frequency (the Countdown–Response point: $\tau_{merge} = T_s$ at the central anchor is a numerical comparison, not a dynamical resonance). The well-posed replacement observable is $\mathscr{D}_{bin}[N,u,\gamma] =$

N^α∇_α√(8ℰ^{ext_μν[u,γ]ℰ_ext}μν[u,γ]) on a specified worldline with stated self-field regularization — which preserves the two-clock separation and makes the normalization part of the observable's definition. [recorded; midpoint factor and scalings reproduced]

Gravitational revision (v8.2). For Schwarzschild-like scaling at fixed $x = r/R_S$,

$$q \propto M^{-2}x^{-3}, \qquad \dot{x} \propto M^{-1}x^{-3}, \qquad |Dq| \propto M^{-3}x^{-7}.$$

A fixed threshold gives

$$x_*(M) = x_*(M_0)\left(\frac{M}{M_0}\right)^{-3/7}.$$

If $x_*(60M_\odot) = 730$, then $x_*(10^6 M_\odot) = 11.3$, $x_*(10^8 M_\odot) = 1.57$, and $x_*(10^9 M_\odot) = 0.586$. The fixed threshold therefore fails mass-universal pre-merger activation.

The scale-invariant ratio $\Xi = |Dq|/q^{3/2}$ cancels the mass at $q > 0$. However, exact scale invariance makes every ray toward the origin retain its direction-dependent value. A nonconstant scale-invariant function cannot have a unique continuous value at the origin. **Smooth scale-free apex no-go.** A dimensionful or environmental regulator is unavoidable for a smooth nontrivial gate.

The natural-unit expression $m_s M_{\rm Pl} H_0/(4\pi^2)$ converts to order 10^{-1}–$1\,\mathrm{m}^{-2}\mathrm{s}^{-1}$, not 10^{-27}. The latter is the reference binary's curvature-rate scale. Candidate suppression monomials near 10^{-27} are numerical clues, not unique derivations.

The observable must specify a worldline or world tube and self-field prescription. Midpoint, body-centred, angularly averaged, and far-zone constructions have different powers and normalizations. Filtering, norm-taking, angular averaging, and spatial integration do not commute. Post-memory activation is retained because applying a raw-rate constraint before memory both misorders the causal chain and inherits the off-shell jet obstruction.

Appendix R — Empirical Flyby Record, Corrected

R.1 The 2008 set. Anderson's relation was constructed from the six flybys available in 2008; those events cannot independently validate the formula extracted from them. Under the flyby paper's *own* quoted uncertainties, "within measurement uncertainty" is false: Galileo I 0.22/0.08 = 2.75σ; Rosetta I 0.27/0.05 = 5.4σ; Cassini 0.93/0.10 = 9.3σ. The quoted $R^2 = 0.997$ excludes the predictive Juno test and is dominated by NEAR. [reproduced]

R.2 The out-of-sample tests. Rosetta II: Anderson +0.523 mm/s, reconstruction null. Rosetta III: +1.099 mm/s, null. Juno: +6.34 mm/s using published asymptotes, null (published 2014; JPL reports metre-scale trajectory accuracy despite the post-perigee safe-mode complication; no along-track anomaly). The flyby paper's Juno row — "not published / pending", δ_in = −18.4°, δ_out = +39.2°, G = 0.476, +4.8 mm/s — is wrong on three counts: Juno is published; G = cos 18.4° − cos 39.2° = 0.174, not 0.476; its own formula then gives (3.099×10^{-6})(10389)(0.174) = 5.60 mm/s, not 4.8; and either value conflicts with the observed null. Rosetta II/III were labelled "symmetric, zero predicted"; the published Anderson evaluation gives 0.523 and 1.099. [reproduced; deployed page confirmed]

R.3 What the record now says. The ungated source-only relation is rejected by the later nulls. The hardware branch is constrained (Rosetta anomalous in 2005, null later on the same radio system; Juno's coherent X-band transponder null; anomalies across S and X bands). What the record does correlate with more plausibly is tracking coverage, attitude/solar-pressure modelling, and how separate inbound and outbound arcs were fitted (a Delft reanalysis found reflectivity and direct solar-radiation-pressure uncertainties could account for some cases while stressing that missing tracking/attitude data prevent a firm conclusion). Juno's encounter had unusually extensive tracking and reconstruction — a plausible zero-closure case, to be demonstrated from tracking metadata, not asserted. [record]

R.4 The reinterpretation. Under two clocks: early Earth detections identify the rotational coefficient under source–observer coincidence; planetary failures test whether the coefficient belongs to the source (it does not scale that way); later Earth nulls test whether it depends on observational closure (Juno is the strongest such case). Together the pattern can distinguish a real force from a two-clock observation map. The generalized law ΔV/V∞ = (2Ω_OR_O/c)[η_in cos δ_in − η_out cos δ_out] with η_a computed from each arc's design matrix is the object to evaluate. The flyby paper should be retitled and reframed as a hypothesis about clock–orbit closure, with Juno and Rosetta II/III as central constraints. [record]

R.5 The η_a program. For each of Galileo I/II, NEAR, Cassini, Rosetta I/II/III, Messenger, Juno: assemble station identities, transmit/receive time tags, link mode (1/2/3-way), count intervals, ramp records, range coverage, VLBI/angular data, clock resets and solve-for parameters; build H and W; form P_⊥; compute η_a from the STF template s_STF,a (from the no-work deflection or the connection holonomy); compare. The test is pre-registered: compute η_a for all nine arcs first, then test rank correlation against the reported |ΔV| under a significance criterion fixed before the anomalies are consulted. Detections should cluster at high utilization, nulls near zero. [stated]

Gravitational revision (v8.2). Anderson's formula was constructed from the original six-event set and cannot be validated by the same set. Later Rosetta II/III and Juno reconstructions are null where the ungated source-only relation predicts nonzero values. The historical source-force law is therefore rejected.

The surviving observer/estimator hypothesis is not validated by those nulls. It predicts that tracking coverage, link mode, clock closure, solve-for parameters, range/angular rank, and station geometry control the utilization η_a. The preregistered program is to assemble DSN metadata for Galileo I/II, NEAR, Cassini, Rosetta I/II/III, Messenger, and Juno; construct $H, W, P_\perp$; compute η_a without anomaly fitting; and then test its rank correlation with reported $|\Delta V|$.

The empirical status is: ungated source law closed; observer-clock branch open and sharply testable.

Appendix S — Direct Local Curvature-Norm Obstruction and Regime Register

The local obstruction is independent of the activation smoothness. The problem enters through $q_N[g, N]$, whose tangent Hessian acts on physical curvature accelerations. Exact memory changes temporal transfer but does not cancel this local acceleration Hessian. A pointwise scalar multiplier introduces its own nondegenerate block rather than a structural null direction.

The checked regimes are:

REGIME	LOCAL METRIC RESULT
$q_N > 0, A \neq 0$	nonzero acceleration Hessian generically

REGIME	LOCAL METRIC RESULT
$A = 0$ isolated	rank-changing/strong-coupling surface
$q_N = 0$ unregulated	nondifferentiable apex
exact norm support active	transverse rank five
regulated compact response active	rank six in eliminated local jet description
response off or $Z = 0$	rank zero in eliminated local jet description
gate critical shells	intermediate rank one or five
exact memory retained	causal pole healthy; metric Hessian unchanged

The module solution is not to eliminate Q_Δ back into the metric. It is to retain readout variables and gravitational jets until the complete constraints are identified.

Appendix T — Structural Constraint Rank

For one causal leg:

1. readout matching and compact alignment provide 44 second-class constraints for 44 added phase-space dimensions;
2. the first-order memory-adjoint pair provides rank 2;
3. six analytic jet pairs provide rank 12 under the jet bound.

Thus

$$R^{(1)}_{\text{structural}} = 58, \qquad R^{(\pm)}_{\text{structural}} = 116.$$

The earlier $46/92$ values are the valid readout-plus-memory subtotal. Neither count includes the lapse/shift primary constraints, gravitational Hamiltonian and momentum constraints, CMC partner, environment regulator pairs, or all secondary chains. They must never be called the full gravitational rank.

The ranks remain constant at $q_N = 0$ for $\Delta > 0$, through response zeros, activation regimes, memory zeros, and scalar-amplitude turning points because the constraints are structural and not multiplied by the response. The analytic jet rank is conditional and fails when $\det(I + \epsilon \mathsf{A}) = 0$.

Appendix U — Analytic Order Reduction and Boundary-CMC Bridge

The order-reduction sequence is:

1. extend the action with independent $\mathcal{K}_{ij}$ and $\mathcal{F}_{ij}$;
2. retain all multipliers, memory, readout, world-tube, and environment fields;
3. vary the full doubled parent;
4. select the branch analytic in ϵ_{STF} and connected to Einstein gravity;

5. solve the jet constraints only within $|\epsilon|\|\mathsf{A}\|_2 < 1$;
6. impose boundary-selected CMC only where the augmented Jacobi operator is invertible;
7. then take the physical contour limit and reduce.

Variation and elimination do not commute outside this sequence. Exact algebraic elimination first recreates the higher-derivative local action whose obstruction motivated the extension.

The CMC condition pairs with the Hamiltonian constraint. The global volume mode is included through augmentation. When both operator bounds hold and the spatial constraints retain their rank, the gravitational scalar is removed and the conditional metric count is two. The still-missing objects are the full $\mathsf{A}^a{}_b(k)$, the CMC deformation $\delta\mathbb{J}$, the complete pre-gauge $\{H, H\}$ bracket, and nonlinear/global continuation.

Appendix V — Environment, Contacts, and the (QQ) Frontier

V.1 Positive spectral form

For environment oscillators X_α with frequencies Ω_α, a covariant vertex must determine

$$\rho_{QQ}(\Omega) = \sum_\alpha \frac{g_{Q\alpha}^2}{2\Omega_\alpha}\delta(\Omega - \Omega_\alpha) \geq 0.$$

Integrating them out produces a retarded (QQ) self-energy, noise fixed by the state/KMS relation, and conservative subtractions. Their metric and world-tube variations produce stress and window forces that cannot be discarded.

V.2 Rank-one and higher-rank tests

A single common environment direction gives

$$\Sigma_{\phi Q}^2 = \Sigma_{\phi\phi}\Sigma_{QQ}.$$

A higher-rank positive environment gives

$$\Sigma_{\phi\phi}\Sigma_{QQ} \geq |\Sigma_{\phi Q}|^2.$$

One independently derived diagonal fixes r within the rank-one family. Compact alignment does not supply that diagonal.

V.3 Contact ambiguity

The two homogeneous and five finite-momentum real $O(\omega^2)$ contact structures are spectrally invisible to KMS/noise matching yet enter the physical jet kernel and CMC Schur complement. A microscopic environment calculation must state a subtraction/renormalization condition; otherwise coefficient completion remains scheme-dependent.

V.4 (QQ) source theorem

At fixed base geometry the compact auxiliary source functional is linear in j_Q, so its connected second derivative vanishes. This absence of an independent propagator is expected because the auxiliary adds no physical phase-space dimension. The physical composite susceptibility is inherited from the gravitational/CMC Green function. Loops, contacts, and the environment may contribute; the fixed-base theorem does not set the full quantum QQ correlator to zero.

V.5 Acceptance gate

The environment frontier passes only if the derived vertex and spectrum:

- satisfy positivity and causal analyticity;
- reproduce the fixed cross response without nonperturbative diagonal load;
- retain constant local primary and secondary ranks;
- preserve the intended bandwidth;
- close the full Ward identity with stress and window force;
- determine or bound the conservative contacts;
- keep both the jet and CMC operators invertible in the claimed domain.

Appendix W — Open-Operator and Deformed-Identity Classification Gate (G1)

Audit-gate record, carried verbatim from the accepted package (paste 2 of the 28 August 2026 program). Source file `STF_V8_2_Open_Operator_Deformed_Identity_Classification_Gate_V1_0.md`, SHA-256 `fb54d267706e2a571592786f6b942e047d236ee49b243a1c66d3faf289b8fee1`. Section numbers below are local to this appendix. Classification of the doubled parent against the consistency framework of Emergent Structures in Open EFTs* and *Gravitational Open Effective Field Theory of Inflation**

Version 1.0 — 28 August 2026

Baseline: STF First Principles v8.1, frozen publication file and declared calculation file
Architecture under test: STF First Principles v8.2
Excluded: every version-9 branch and every claim derived from one

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Abstract

Two recent Schwinger–Keldysh analyses sharpen the consistency test for open gauge and gravitational effective field theories. Physical, or diagonal, covariance is necessary but not sufficient. An open operator that breaks the advanced symmetry must leave enough off-shell identities among the equations of motion to match the number of independent equations to the gauge-fixed variables. In the examples studied by Christodoulidis and by Christodoulidis and Gong, generic foliation-preserving gravitational operators fail this test and overconstrain perturbations, even when a decoupling-limit calculation appears healthy. A nontrivial exception is the lapse-completed trace-adjusted extrinsic-curvature operator

$$\Delta_{\mu\nu} = \frac{\Gamma}{N}(K_{\mu\nu} - KP_{\mu\nu}),$$

which is a coupling to the general-relativistic canonical momentum and obeys the exact identity

$$P_i{}^{\nu}\nabla_{\mu}E^{\mu}{}_{\nu} = \frac{\Gamma}{N}P_i{}^{\nu}E_{\mu\nu}n^{\mu}.$$

This paper classifies every named module of the STF v8.2 doubled parent against that framework: compact readout, the memory pair, retained curvature jets, the boundary-CMC clock, the varied world tube, and the retained environment. The decisive separation is between the finite unintegrated parent and its reduced open description. Compact readout, retained jets, boundary-CMC selection, and the varied world tube are not dissipative operators. The local memory variables and finite oscillator environment enlarge the varied system; before elimination their forces occur in the ordinary total Noether identity. After environmental elimination, however, the retarded and noise kernels are genuine open operators. They must satisfy the pushforward of a coupled advanced identity involving the metric, memory, readout, world-tube, jet, environment, and boundary equations. Diagonal covariance, positivity, rank preservation, and a healthy decoupling limit do not prove that identity.

The existing v8.2 total Ward identity therefore remains valid at exactly its declared conditional level: on the full equations of the varied, regulated parent, total stress is conserved, with the boundary term removed by the covariantly varied boundary data. It is not replaced by a deformed nonconservation law. The new framework instead exposes one additional open obligation: the coefficient-complete reduced influence functional must possess an advanced/noise deformed identity and the correct scalar, vector, and tensor equation count. No calculation presently shows that the metric response induced by the unfinished covariant $Q_\Delta X_\alpha$ vertex is the special trace-adjusted momentum operator. Accordingly, this audit neither supersedes v8.2 nor upgrades it.

$$\boxed{\text{Grade unchanged: coherent gravitational candidate, not a completed gravity theory.}}$$

I. Scope, sources, and baseline control

I.A Question tested

The question is not whether the v8.2 action is written in a covariant notation. It is whether each part that becomes open or dissipative after reduction belongs to a class with a sufficient off-shell identity. The audit therefore asks four separate questions for every module:

1. Is the module itself open, or is it a conservative part of an enlarged parent?
2. Which symmetry is exact: physical diagonal covariance, an advanced/noise symmetry, or both?
3. If an advanced symmetry is broken, what off-shell deformed identity prevents overconstraint?
4. Does the noise sector obey the corresponding constraint?

These questions are applied to the architecture actually retained in v8.2. A formally similar pure-metric term obtained by eliminating auxiliary or environmental variables prematurely is not substituted for the retained parent.

I.B Primary external sources

The classification is based on the complete current arXiv files available on 28 August 2026:

- Perseas Christodoulidis, *Emergent structures in open EFTs*, arXiv:2509.13284v2, 15 pages, PDF SHA-256 `7a46b5dd02d35be6cc8a5f46900fb1d67a0a0e36bec68ba135d71e4e4cec0272`.
- Perseas Christodoulidis and Jinn-Ouk Gong, *Gravitational open effective field theory of inflation*, arXiv:2512.21234v1, 19 pages, PDF SHA-256 `2ea377c605b789821a47071ad375d15bac956404420bf2936624d2292eb7685c`.

The first paper develops the physical/advanced distinction through the open superfluid, higher-form Maxwell theory, and gravity. The second performs the gravitational constraint analysis beyond the decoupling limit and supplies explicit failing and successful inflationary operators.

I.C STF source control

The frozen publication baseline is

`STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md`

with SHA-256

`4788576a24d0c576cccd4a4c118205f123171481b50d181792f12767cd62f6f6`.

The post-v8.1 calculations were performed against

`STF_First_Principles_Paper_V8_1_fixed(1).md`

with SHA-256

`bc2bd30366ef0a8b144a813438b1b3280f470b8a25e0d6da67fb74bfa775f700`.

Those files differ by one pair-level statistical-significance sentence and not by the gravitational or open-system architecture. The v8.2 architecture file audited here is

`STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md`

with SHA-256

`f7eca3fb886b559b1888707499dbe0442dda307c87a62fa1b0473f7682d8f40e`.

This calculation uses no version-9 file, statement, coefficient, or conclusion.

II. The external consistency framework

II.A Physical and advanced symmetries

In a Schwinger–Keldysh description, the two causal legs can be reorganized into physical and advanced variables. A physical, or diagonal, transformation acts on both histories in the same way. In the semiclassical gravitational formulation the advanced metric is a tensor on the physical spacetime, so physical diffeomorphisms act on it as well. In the closed limit an independent advanced transformation supplies the off-shell identity that prevents gauge equations from becoming independent evolution equations.

An environment can break the advanced transformation while leaving the physical transformation exact. The crucial result of the two papers is that this breaking cannot be arbitrary. A consistent open theory must retain a deformed identity among its equations. The identity is not decorative: it lowers the number of independent equations to the number appropriate after gauge fixing.

This gives three logically different statements:

$$\begin{aligned}
&\text{physical covariance} && \Rightarrow \text{diagonal Ward identity,}\\
&\text{advanced/deformed invariance} && \Rightarrow \text{off-shell equation identity,}\\
&\text{noise compatibility} && \Rightarrow \text{constraint on stochastic sources.}
\end{aligned}$$

The first does not imply the second, and noise positivity does not imply the third.

II.B Scalar relaxation and canonical-momentum couplings

For the open-superfluid example, the deterministic relaxation term can be written as a coupling of the advanced field to the closed-system canonical momentum. At leading order the equation is

$$\partial_\mu B^\mu - \Gamma u_\mu B^\mu + i\beta\phi_a + \cdots = 0.$$

The deterministic action is invariant under a time-dependent advanced shift whose parameter obeys

$$\dot{\Lambda} - \Gamma\Lambda = 0.$$

The ordinary operator current is not conserved. A weighted current is conserved in expectation after the Schwinger–Dyson relation is used. This illustrates the general point: a relaxation pole can be consistent because a deformed identity survives, not merely because the pole is retarded.

II.C Maxwell: a nilpotent deformed differential

For the higher-form formulation of open Maxwell theory, the dissipative terms can be organized using

$$\mathcal{D} = d + \Gamma_1 u \wedge + \Gamma_2 u \wedge \mathcal{L}_\beta.$$

Under the assumptions stated in the paper, $du = 0$, $\iota_\beta u = -1$, and $[\mathcal{L}_\beta, d] = 0$, one has $\mathcal{D}^2 = 0$. The deterministic equation then satisfies

$$\mathcal{D}^\dagger \mathcal{E} = 0.$$

This identity leaves the correct number of independent equations. Acting with the same operator on the full stochastic equation gives the corresponding source/noise constraint. The leading open interaction again couples the advanced field to the canonical momentum, here the electric field, and realizes Ohmic dissipation.

II.D Gravity: why generic open tensors fail

With a preferred unit normal n^μ, physical symmetry alone permits many foliation-preserving tensors. Gravity has fewer available differential identities than a general list of such tensors would require. Consequently, most allowed-looking open tensors make previously dependent metric equations independent.

The inflation analysis gives two explicit failures. A naive $\Gamma K_{\mu\nu}$ term produces incompatible scalar equations and leaves only the trivial curvature perturbation. A term proportional to a lapse perturbation times the spatial metric likewise removes the scalar mode. The second failure can appear healthy in a decoupling limit. The full lapse, shift, trace, and traceless equations expose the overconstraint.

Thus the following checks are not sufficient:

- invariance under physical foliation-preserving diffeomorphisms;
- a causal retarded kernel;
- positive semidefinite noise;
- a stable decoupled scalar equation;
- absence of an obvious extra pole in one projected sector.

II.E The nontrivial gravitational class

Let

$$P_{\mu\nu} = g_{\mu\nu} + n_\mu n_\nu, \qquad \widetilde{K}_{\mu\nu} = K_{\mu\nu} - KP_{\mu\nu}.$$

The Codazzi relation and the ADM identity $a_i = D_i \log N$ give the exact lapse-completed relation

$$P_i{}^\nu \nabla_\mu \left(\frac{\widetilde{K}^\mu{}_\nu}{N} \right) = \frac{1}{N} P_i{}^\nu G_{\mu\nu} n^\mu.$$

Therefore the open tensor

$$\Delta_{\mu\nu} = \frac{\Gamma}{N} \widetilde{K}_{\mu\nu}$$

obeys, when its mixed normal-spatial EOM projection remains the general-relativistic one,

$$\boxed{P_i{}^\nu \nabla_\mu E^\mu{}_\nu = \frac{\Gamma}{N} P_i{}^\nu E_{\mu\nu} n^\mu.}$$

This is a nontrivial deformed identity valid to all perturbative orders in the model. The operator is proportional to the general-relativistic canonical momentum,

$$\frac{1}{N}(K_{ij} - KP_{ij}) = \frac{\pi_{ij}}{N\sqrt{\gamma}},$$

and its Schwinger–Keldysh action contains a momentum coupling of the form $\int d^4x\, \pi^{ij} \gamma^a_{ij}$.

The scalar projection on an FLRW background is

$$\partial^j E_{ij} = a^2 \left[(3H + \Gamma) E_{0i} + \dot{E}_{0i} \right].$$

It relates equations that would otherwise overconstrain the scalar variables. With noise, the same deformed identity constrains the allowed stochastic tensor. In covariant form the source obeys the associated deformed divergence condition, schematically

$$\left(\nabla_\mu - \frac{\Gamma}{N} n_\mu \right) \Xi^{\mu\nu} = 0$$

with the same spatial projection and convention as the deterministic identity.

II.F Trivial deformed identities

The existence of a deformed-looking formula is not by itself enough. Operators made only from algebraic trace or normal/tangential projections of the original equations can produce identities after an invertible reshuffling of equations while leaving the propagating equations unchanged. The first paper calls these terms trivial. They belong to an equation-redefinition or projection class, not to the nontrivial dissipative class represented by the canonical-momentum operator.

The resulting classification used below has four principal entries:

1. **Closed enlarged-parent module:** conservative or auxiliary before elimination; governed by an ordinary Noether identity.
2. **Trivial open deformation:** an invertible projection or rescaling of existing equations; no new propagating dissipation.

3. **Nontrivial deformed-identity operator:** breaks advanced symmetry but possesses a proven identity that preserves the equation count and constrains noise.
4. **Generic or unclassified open operator:** physical covariance may hold, but the required advanced identity and full equation count have not been proved.

III. The v8.2 doubled parent being classified

III.A Compact readout

The curvature state is represented by eleven components $\mathcal{C}^A$ satisfying

$$q_N^2 = R^2 + 8\mathcal{W}_N.$$

For $\Delta > 0$, the compact alignment parent yields

$$s = \sqrt{q_N^2 + \Delta^2}, \qquad p_A^* = \frac{\mathcal{C}_A}{s}, \qquad Q_\Delta = M_*^2(s - \Delta).$$

The readout/alignment Dirac block has rank 44 per causal leg, or 88 on the doubled contour, and supplies no physical auxiliary degree of freedom. At fixed base geometry its connected auxiliary source susceptibility vanishes:

$$\frac{\delta^2 W_{\text{aux}}}{\delta j_Q(x)\delta j_Q(x')} = 0.$$

The capacity Hessian measures the tangent response to base curvature. It is not an environmental QQ self-energy or noise kernel.

III.B The local memory pair

The high-pass response is represented without a nonlocal fundamental metric action by

$$(D_U + \omega_c)y = \omega_c \widetilde{Q}_\Delta, \qquad Z = \widetilde{Q}_\Delta - y, \qquad \widetilde{Q}_\Delta = W(B)Q_\Delta.$$

A local first-order representative is

$$\mathcal{L}_{\text{mem}} = \sqrt{h}\,\rho\left[D_U y + \omega_c(y - \widetilde{Q}_\Delta)\right].$$

Its two primary constraints have rank two per leg and rank four on the doubled contour. The memory variable and the oscillator bath are alternative local representations of one response chain; they are not counted as two independent environments.

III.C Retained curvature jets and contacts

Six branch-normal curvature jets are retained independently. On the analytic weak-backreaction branch, twelve second-class constraints per leg remove the spurious jet pairs. Their coefficient-complete retarded kernel has a conservative contact block. On a homogeneous background there are two independent contact coefficients; at finite momentum five additional parity-even conservative coefficients remain. The general quadratic influence form is

$$\Gamma^{(2)} = \frac{1}{2}\int \left[\Psi_a^\dagger K^R \Psi_r + \Psi_r^\dagger K^A \Psi_a + i\Psi_a^\dagger \mathcal{N}\Psi_a\right], \qquad \mathcal{N} \succeq 0.$$

Schwinger–Keldysh normalization excludes an rr term. Noise cannot cure a singular deterministic retarded block, and a Ward projector removes gauge directions without fixing physical contact form factors.

III.D Boundary-selected CMC clock

The universal normal is selected by a boundary-CMC map,

$$N^\mu = N^\mu_{\rm CMC}[g; \Sigma_{\rm closure}, V_4].$$

There is no local propagating clock pair. The Hamiltonian constraint and CMC condition form a second-class pair only where the augmented CMC–volume Jacobi operator is invertible. Pulling the parent back to the CMC map requires

$$\frac{\delta \bar{S}}{\delta g} = \left(\frac{\delta S}{\delta g}\right)_N + \frac{\delta S}{\delta N^\alpha}\frac{\delta N^\alpha_{\rm CMC}}{\delta g}.$$

The chain-rule term is not optional.

III.E Varied material world tube

A representative carrier is a scalar material field B with

$$S_B = -\int d^4x\sqrt{-g}\left[\frac{Z_B}{2}(\nabla B)^2 + V_B(B)\right], \qquad Z_B > 0,$$

and smooth activation window

$$W(B) = B^2(3-2B), \qquad W(0)=0, \quad W(1)=1, \quad W'(0)=W'(1)=0.$$

The window multiplies a response coupling, not a kinetic term or a constraint, so its zeros do not remove the associated structural equations. If B or W is frozen externally, the Ward identity contains an uncancelled force proportional to $E_B\nabla_\nu B$.

III.F Retained finite environment

The regulated common bath is

$$S_{\rm bath} = \frac{1}{2}\sum_\alpha \int d^4x\sqrt{-g}\left[(D_U X_\alpha)^2 - \Omega_\alpha^2 X_\alpha^2\right].$$

The system operators are $O_i = (\phi, \widetilde{Q}_\Delta)$, and a rank-one environment couples to

$$O_g = g_\phi \phi + g_Q \widetilde{Q}_\Delta.$$

After integration, the selected retarded response is the Lorentz–Drude high-pass kernel

$$K^R_{\rm sel}(\omega) = \frac{-i\omega}{\omega_c - i\omega}.$$

The self-energy and noise matrices factorize,

$$\Sigma^R_{ij} = g_i g_j K^R_{\rm sel}, \qquad \mathcal{N}_{ij} = g_i g_j \mathcal{N}_D.$$

Positivity therefore requires both diagonal entries along with the cross entry. A cross-only real symmetric noise matrix is indefinite. The construction proves that a positive rank-one bath can exist; it does not derive the microscopic $Q_\Delta X_\alpha$ vertex, ρ_{QQ}, or the diagonal factorization ratio.

III.G Structural subtotal

The established module ranks are

$$44_{\text{readout/alignment}} + 2_{\text{memory}} + 12_{\text{jets}} = 58$$

per causal leg and 116 on the doubled contour. These numbers exclude lapse, shift, the gravitational Hamiltonian and momentum constraints, the CMC partner, environment-regulator pairs, and the full secondary chain. They are not a complete gravitational Dirac rank.

IV. Operator-by-operator classification

V8.2 MODULE OR OPERATOR	OPEN-EFT CLASS BEFORE ELIMINATION	CLASS AFTER THE RELEVANT ELI
compact alignment and Q_Δ readout	closed algebraic auxiliary module	composite constitutive insertion
first-order (y, ρ) memory pair	retained local response module	scalar retarded high-pass operator
six retained jets and their constraints	conservative order-reduction auxiliaries	local contact/derivative kernel if elim
two homogeneous plus five finite-k contacts	conservative physical operators	unchanged by bath/noise matching
boundary-CMC map and chain-rule pullback	gauge/clock selection, not dissipation	foliation-adapted reduced descriptio
varied world-tube carrier and $W(B)$	closed material/source carrier	fixed-source defect if frozen
finite X_α environment	closed enlarged parent	genuine retarded/noise influence ke
linear $g_i O_i X_\alpha$ interaction	closed covariant system–environment vertex when fully varied	generator of the influence kernels
rank-one scalar ϕ/Q self and cross kernels	not present before trace	nontrivial scalar open operators

V8.2 MODULE OR OPERATOR	OPEN-EFT CLASS BEFORE ELIMINATION	CLASS AFTER THE RELEVANT ELI
$i\Psi_a^\dagger \mathcal{N} \Psi_a$ noise operator	stochastic sector of the reduced influence functional	genuine open operator
Drude static counterterm and the real contact block	conservative subtraction/contact operators	trivial or physical local renormalizati depending on the projection
metric response induced by $Q_\Delta X_\alpha$	coupled metric–readout–bath interaction	effective gravitational open tensor
hypothetical $(\Gamma/N)(K_{\mu\nu} - KP_{\mu\nu})$ insertion	not currently an STF-derived operator	proven nontrivial gravitational class cited model

The table is the primary result. The detailed reasons follow.

IV.A Compact readout: closed constitutive auxiliary class

Compact alignment is not an open operator in the sense of either new paper. Before environmental tracing it is a covariant algebraic constraint module on each causal leg. Its equations add variables and second-class constraints in equal measure and leave no auxiliary propagating coordinate. The appropriate Ward contribution is the ordinary sum of its Euler–Lagrange expressions contracted with the transformations of $\mathcal{C}^A$, p_A, and their multipliers.

The fixed-base theorem $\chi^{\text{aux}}_{QQ} = 0$ has an important open-EFT consequence. Compact alignment cannot secretly supply the missing diagonal bath response or an open QQ noise coefficient. Its positive capacity Hessian is not a fluctuation kernel. An environmental Q response must arise from the varied gravitational, CMC, world-tube, or bath sectors.

It would also be incorrect to call compact alignment a trivial open deformation. It does not reshuffle metric equations by adding a projection of the Einstein equations. It is simply outside the open-operator taxonomy until it is coupled to and reduced with an environment.

IV.B Memory: local parent, open reduced kernel

The retained pair has a first-order normal derivative and a stable retarded pole. Its structure is closest to the scalar-relaxation examples because the response variable couples linearly to a first-order momentum-like equation. That analogy does not prove the exact advanced shift of the open-superfluid model for STF. The STF memory pair has its own variables, equations, and second-class bracket. At the unintegrated level, those equations appear explicitly in the ordinary total Ward identity and prevent the metric equation from being treated as a closed subsystem.

Eliminating y gives a nonlocal scalar response,

$$Z(\omega) = K^R_{\text{sel}}(\omega)\widetilde{Q}_\Delta(\omega),$$

which is genuinely open once the advanced response and stochastic completion are included. Its causal pole and rank-two parent are necessary consistency data but do not supply the gravitational off-shell identity. The exact deformed transformation of the reduced advanced memory/readout variables, including their metric and CMC dependence, has not been derived. This item therefore passes its structural local-rank gate and remains open at the advanced-identity gate.

IV.C Retained jets: order reduction is not dissipation

The independent curvature jets and their twelve second-class constraints are a local order-reduction construction. They are not open operators merely because they sit inside a doubled action. Their analytic-branch Jacobian test addresses an Ostrogradsky/Dirac question, whereas the new papers address whether environmental terms preserve enough differential identities. Both tests are required and neither substitutes for the other.

The conservative jet contacts likewise belong outside the dissipative taxonomy. KMS matching and the noise spectrum cannot determine the two homogeneous and five finite-momentum real contact coefficients. A diagonal Ward projector removes gauge directions but leaves these physical form factors. Their current status is underdetermined, not inconsistent.

If an environment induces additional metric or jet kernels, those new kernels do enter the open taxonomy. A generic covariant tensor built from $K_{\mu\nu}$, q_N, the jets, or the normal is not safe merely because it is projected onto a CMC slice. Unless the full coupled equations possess a deformed identity, such a term can overconstrain exactly as $\Gamma K_{\mu\nu}$ does in the inflation example. The coefficient-complete jet tensor must therefore be tested together with lapse, shift, trace, traceless, and noise equations, not only in a transverse or decoupled projection.

IV.D Boundary CMC: equivariant gauge selection, not an open tensor

The boundary-CMC normal and the fixed normal used in the inflation EFT play related geometric roles but are not the same object. In the cited open-inflation construction, the preferred normal specifies unitary gauge and leaves spatial diffeomorphisms as the relevant physical subgroup. In v8.2, $N^\mu_{\rm CMC}$ is a metric- and boundary-dependent selection from a covariant parent. Its variation produces a nonlocal chain-rule term.

When the CMC map is unique, differentiable, and equivariant in the claimed domain, and when the boundary and volume data are varied, pulling back to that map preserves the physical Ward statement. When those hypotheses fail, the pullback need not define an autonomous gravitational theory. If the normal or closure data are frozen, the missing variation appears as a source or boundary defect.

CMC selection therefore does not by itself provide the open-gravity identity

$$P_i{}^\nu \nabla_\mu E^\mu{}_\nu = \frac{\Gamma}{N} P_i{}^\nu E_{\mu\nu} n^\mu .$$

Nor does it need that particular formula merely to serve as an equivariant gauge selection in the enlarged conservative parent. The formula becomes relevant if the reduced STF metric equation contains a genuine dissipative tensor. Then the appropriate pure-metric or coupled generalization must be demonstrated in the gauge-fixed CMC system.

IV.E Varied world tube: source completion

The world-tube carrier is a conservative material module. Its role in the Ward calculation is precisely the role demanded by physical diagonal covariance: the force exerted by a spacetime-dependent coupling is balanced by the carrier equation. With B varied, the term $E_B \nabla_\nu B$ is part of the Noether identity. With B fixed, it is a source-force defect. The smooth zeros of $W(B)$ do not change the constraint rank because W does not multiply a kinetic or constraint equation.

This module therefore passes as a correctly varied source carrier. The actual finite, stable material/world-tube solution and its microscopic coupling to the environment remain open. The new papers strengthen, rather than replace, the v8.2 rule that no support function may be frozen during a Ward audit.

IV.F Retained environment: closed before tracing, open after tracing

This is the central classification.

With every X_α retained and varied, the oscillator model is a closed enlarged system. Energy–momentum exchanged between the STF variables and the environment is internal to that system. Its metric variation supplies environmental stress, and its X_α equations supply the compensating terms in the total Ward identity. The finite common bath is therefore not itself an inconsistent open gravitational tensor.

After the X_α are traced out, their effects appear as retarded, advanced, and noise kernels. Those are genuine open operators. The rank-one factorization proves causal and positive spectral existence and forbids cross-only noise. It does not prove the advanced gravitational identity. In particular, the metric dependence of Q_Δ, D_U, $W(B)$, the volume element, and the CMC normal means that a scalar-looking QQ kernel induces metric, clock, material, and boundary variations.

There is presently no derivation showing that the resulting pure-metric part reduces to

$$\frac{\Gamma}{N}(K_{\mu\nu} - KP_{\mu\nu}),$$

or to any other proven nontrivial gravitational deformed-identity class. It must not be labelled as such by analogy. Conversely, extracting only that pure-metric part and testing it as a closed subsystem can be misleading, because the retained-parent construction supplies additional readout, memory, material, jet, and environment equations. The correct object is the full coupled identity.

The environment therefore receives two different grades:

- **finite positive parent:** existence pass;
- **coefficient-complete reduced gravitational influence functional:** open.

IV.G No v8.2 module is a proven STF realization of the special momentum operator

The trace-adjusted momentum coupling is a useful reference operator and a possible target for a microscopic gravitational environment. It is not presently derived from $Q_\Delta X_\alpha$, the Drude bath, the memory multiplier, or CMC selection. Adding it by hand would alter the coefficient and constraint problem and would not complete the existing v8.2 derivation. This audit therefore records it as a comparator, not as an STF result.

V. Consequences for the total Ward identity

V.A The already-derived enlarged-parent identity

For an unintegrated covariant parent with a local scalar clock, the previous calculation has the schematic identity

$$2\nabla_\mu E_g{}^\mu{}_\nu = E_\phi \nabla_\nu \phi + E_T \nabla_\nu T_U + E_B \nabla_\nu B + E_y \nabla_\nu y + E_{\mathcal{C}A} \nabla_\nu \mathcal{C}^A + E_{pA} \nabla_\nu p^A + \sum_\alpha E_{X_\alpha} \nabla_\nu X_\alpha + \mathcal{E}_{\mathrm{mult},\nu}.$$

Here $\mathcal{E}_{\mathrm{mult},\nu}$ denotes the corresponding multiplier terms. When every displayed equation is imposed, total stress is covariantly conserved.

For the boundary-CMC pullback,

$$\bar{S}[g,\Psi] = S[g, N_{\mathrm{CMC}}[g;\Sigma,V_4],\Psi],$$

the identity takes the form

$$\boxed{\nabla_\mu T^\mu{}_{\nu,\mathrm{tot}} = \sum_A E_A \nabla_\nu \Psi^A + \mathcal{B}_\nu[\Sigma, V_4].}$$

On all bulk equations and covariantly varied boundary/volume equations, $\mathcal{B}_\nu = 0$. This is an ordinary physical Ward identity for the enlarged parent. The new papers do not convert it into a statement that total energy–momentum is dissipated into nowhere.

V.B What is deformed

The deformation concerns the independent advanced/noise identity of the open, reduced theory. Introduce the collective retained fields

$$\Phi^A = \{g_{\mu\nu}, \mathcal{C}^A, p_A, y, \rho, B, X_\alpha, \text{jets, multipliers, boundary data}\}.$$

Let $\mathfrak{R}_\nu{}^A$ be the physical diffeomorphism generator on this collective space. The diagonal identity can be written abstractly as

$$\mathfrak{R}_\nu^{\dagger A} E_A + \mathcal{B}_\nu = 0.$$

After the environment is eliminated, the deterministic reduced equations are nonlocal and the original independent advanced transformation is generally broken. Consistency requires a deformed advanced operator $\widehat{\mathfrak{R}}_\nu$ and, possibly, an equation-mixing operator $\mathfrak{M}_\nu{}^i$ such that

$$\boxed{\widehat{\mathfrak{R}}_\nu^{\dagger A} E_A^{\mathrm{red}} = \mathfrak{M}_\nu{}^i E_i^{\mathrm{red}}}$$

is an off-shell identity, not a consequence obtained only after solving the evolution equations. In the gravitational momentum example, $\widehat{\mathfrak{R}}$ and $\mathfrak{M}$ reduce to the spatial projected relation with coefficient Γ/N.

At quadratic order, write

$$E_A^{\mathrm{red}} = K_{AB}^R \Phi_r^B + \cdots.$$

The deformed identity requires a left relation among rows of the full coupled retarded kernel,

$$\widehat{\mathfrak{R}}_\nu^{\dagger A} K_{AB}^R = \mathfrak{M}_\nu{}^i K_{iB}^R.$$

It is not enough for one metric projection or the scalar QQ subblock to have a null vector. The relation must include every coupled field whose equation occurs in the total identity.

V.C Noise follows the same identity

For a stochastic equation

$$E_A^{\mathrm{red}} + \Xi_A = 0,$$

the same operator gives

$$\widehat{\mathfrak{R}}_\nu^{\dagger A} \Xi_A = \mathfrak{M}_\nu{}^i \Xi_i \text{background/source terms.}$$

When external sources and boundary defects vanish, this is a homogeneous constraint on the allowed noise components. A positive semidefinite matrix $\mathcal{N}$ does not automatically satisfy it. At quadratic order the covariance must have support only on the compatible stochastic subspace. In the simplest homogeneous finite-dimensional representation this is the left-null condition

$$\widehat{\mathfrak{R}}^{\dagger}\mathcal{N} = 0,$$

with the understood equation-mixing generalization for the gravitational case.

The rank-one Drude construction establishes $\mathcal{N} \succeq 0$ in its scalar system-operator space. The coefficient-complete metric/readout/CMC transformation of that noise, and its deformed Ward projection, remain to be calculated.

V.D Split-leg and diagonal statements

At finite regulator, before the environment is traced, each causal leg has the schematic identity

$$\nabla_{\mu}^{(s)} T^{\mu}{}_{\nu,s,\mathrm{tot}} = \sum_{A} E_{A,s} \nabla_{\nu}^{(s)} \Phi_{s}^{A} + E_{\partial,s} \Xi_{\nu,s}, \qquad s = 1, 2,$$

subject to the initial state and final gluing. After tracing, only the diagonal physical identity is guaranteed unless the regulator, state, gluing, and boundary data respect the corresponding doubled transformations. This is consistent with, and sharpened by, the two papers: physical covariance protects the diagonal relation, while the independent advanced relation must be deformed and verified.

V.E Why the total identity is not invalidated

The cited failure examples add a generic open tensor to a metric subsystem without enough additional equations or identities. The v8.2 retained parent instead varies its response variables, world-tube carrier, and finite environment. Its total physical identity can therefore close on their equations. This is a legitimate distinction.

It is not a completion proof. Once those fields are eliminated, their equations are encoded nonlocally in the influence functional. The reduced theory must still display the pushed-forward identity explicitly. If it does not, one of three things has happened:

1. a carrier or boundary variation was dropped;
2. an inconsistent open tensor was generated or retained;
3. the elimination/gauge-fixing operation was performed in an order that lost an equation identity.

The correct conclusion is therefore preservation plus a new gate, not withdrawal of the previous Ward theorem.

VI. The new coefficient-completion gate

The following calculation is required before the v8.2 gravitational bridge can be called a complete open gravity EFT.

VI.A Microscopic vertex

Derive a covariant, varied interaction that produces the $Q_{\Delta} X_{\alpha}$ coupling. State all metric, normal, world-tube, boundary, and counterterm dependence. Do not identify the capacity Hessian with the bath coefficient.

VI.B Unintegrated identity

Vary the finite two-leg parent before eliminating X_α, y, the readout auxiliaries, the jets, or the CMC normal. Verify the complete physical Noether identity including environmental stress, the world-tube force, multiplier equations, and boundary/volume terms.

VI.C Reduced deformed identity

Integrate out the bath with a diagonal-covariant regulator and derive the full retarded, advanced, and noise kernels. Construct the advanced transformation or the equivalent off-shell row identity. Demonstrate it for the coupled metric–readout–memory–jet–world-tube system.

VI.D Full constraint count

Evaluate scalar, vector, and tensor equations including lapse and shift. Verify that the deformed identity leaves the intended number of independent equations. A decoupling-limit scalar equation is not sufficient. Repeat across the analytic-branch and CMC invertibility domain.

VI.E Noise constraint

Apply the deformed Ward operator to the stochastic equations. Verify the resulting constraints on all noise components and show that the positive bath covariance has support only on the allowed subspace.

VI.F Contact and subtraction completion

State the renormalization/subtraction convention fixing the two homogeneous and five finite-momentum conservative contacts. The deformed Ward identity may relate gauge components, but it does not determine all physical contact form factors.

VI.G Acceptance criterion

The gate passes only if all of the following hold simultaneously:

$$\begin{gathered}
\text{full parent Ward defect} = 0, \\
\text{reduced advanced identity defect} = 0, \\
\text{noise identity defect} = 0, \\
\text{intended scalar/vector/tensor equation count}, \\
\det \mathsf{J}_{\text{jet}} \neq 0, \qquad \det \mathbb{J}_{\text{CMC+V}} \neq 0, \\
\mathcal{N} \succeq 0, \qquad \text{no upper-half-plane retarded pole.}
\end{gathered}$$

Passing only the positivity and pole tests is not enough. Passing only the Ward and identity tests is also not enough, because those identities do not prove the Dirac rank or fix conservative contacts.

VII. Graded result against v8.1 and v8.2

VII.A Claim ledger

CLAIM	RESULT UNDER THE NEW FRAMEWORK	VERIFICATION STATUS
compact readout is a constant-rank nonpropagating auxiliary	unchanged	proved within declared regulated domain
capacity Hessian supplies environmental QQ response	rejected as before	disproved at fixed base geometry
local memory has rank two per leg	unchanged	proved structurally

CLAIM	RESULT UNDER THE NEW FRAMEWORK	VERIFICATION STATUS
reduced memory kernel has a complete advanced deformation	not established	open
retained jets remove six spurious pairs on analytic branch	unchanged	conditional on jet Jacobian
Ward projection fixes all jet contacts	rejected as before	two plus five coefficients remain open
boundary CMC removes the gravitational scalar	unchanged	conditional on full bracket, equivariance, and augmented invertibility
varied world tube closes its force term	unchanged	conditional pass
finite positive rank-one bath can realize scalar self/cross response and noise	unchanged	existence pass
positivity alone proves open gravitational consistency	rejected	contradicted by the two-paper framework
the induced STF metric operator is the trace-adjusted momentum operator	not derived	open; no identification made
total physical Ward identity of the varied parent	retained	conditional pass
coefficient-complete reduced advanced/noise identity	newly isolated explicit obligation	open
full gravitational completion	not established	open

VII.B What is superseded

No v8.1 or v8.2 result is superseded by this audit. The new papers do not invalidate Branch C, the cosmological carrier result, the Lyman-α framing, the compact readout theorem, the memory rank, the retained-jet construction, the CMC conditional count, or the positive-bath existence proof. They address a different and previously incompletely isolated question: the advanced identity and equation count of the reduced open gravitational influence functional.

No Appendix P withdrawal is therefore required.

VII.C What is strengthened

The following v8.2 cautions become sharper:

1. diagonal covariance is not a substitute for an advanced deformed identity;
2. noise positivity is not a substitute for a noise Ward constraint;
3. a decoupling-limit result is not a gravitational consistency proof;
4. retaining the environment and world tube is essential for the total identity;
5. eliminating them requires the identity to be pushed forward into the nonlocal kernels;

6. the coefficient-complete CMC, jet, and environment calculation remains load-bearing.

VII.D Grade

The new consistency framework identifies a definite pass condition but does not provide the missing STF microscopic vertex or its induced kernels. It therefore cannot strengthen the architecture's status. Because the enlarged parent preserves the correct carrier bookkeeping and no contradiction with its conditional Ward identity has been found, it also does not force a downgrade.

$$\boxed{\text{STF v8.2 remains a coherent gravitational candidate, not a completed gravity theory.}}$$

The total physical Ward identity is a conditional pass for the fully varied, finite regulated parent. The advanced/noise deformed identity of the coefficient-complete reduced open theory is open and is now an explicit completion gate.

VIII. Falsifiers and boundary cases

This classification fails, or the candidate must be narrowed, if any of the following occurs:

1. the microscopic $Q_\Delta X_\alpha$ interaction produces a generic metric tensor with no coupled deformed identity;
2. the scalar, vector, or tensor equations have greater rank than the gauge-fixed variables after environmental reduction;
3. a noise component violates the deformed source constraint;
4. the total parent Ward defect remains nonzero after every varied carrier and boundary equation is imposed;
5. the CMC pullback is not differentiable or equivariant in the claimed domain;
6. the augmented CMC–volume or jet Jacobian acquires an unaccounted physical zero;
7. a cross response is retained without the positive diagonal self-responses required by the bath covariance;
8. a subtraction choice needed for the physical contact kernel is silently identified with a Ward or KMS condition;
9. the claimed reduced identity holds only in a decoupling limit and fails in the full lapse/shift system;
10. the metric-induced open operator is called the trace-adjusted momentum coupling without an explicit reduction proving that equality.

The regulated apex $q_N = 0, \Delta > 0$, unsaturated and saturated readout regimes, memory zero $Z = 0$, activation zeros, finite ω/ω_c, analytic-branch boundary, and CMC invertibility boundary must all remain separately visible. A response zero cannot be used to remove a structural constraint.

IX. Reproducibility

The accompanying NumPy checker verifies finite-dimensional and mode-level consequences used in this paper:

- compact-alignment Hessian positivity and structural ranks;

- rank-two memory brackets;
- positive rank-one bath noise and failure of cross-only noise;
- retarded high-pass pole location;
- the Schwinger–Keldysh determinant identity;
- the FLRW scalar form of the successful deformed gravitational identity;
- generic overconstraint in a two-equation toy representative;
- closure of the enlarged total Ward bookkeeping;
- inheritance of a coupled left identity by projected deterministic and noise kernels;
- failure of a generic unprojected open perturbation to satisfy that identity.

The finite-dimensional coupled-kernel test is an illustration of the acceptance condition, not a proof that the unfinished STF microscopic kernel passes it. The checker deliberately reports that scientific item as open.

X. Conclusion

The two new papers supply the correct taxonomy for the v8.2 doubled parent. Four named modules–compact readout, retained jets, boundary CMC, and the varied world tube–are conservative auxiliary, order-reduction, gauge-selection, or material-carrier structures rather than dissipative operators. The local memory pair and finite oscillator bath also belong to an enlarged varied parent before elimination. Their reduced retarded and stochastic kernels are the actual open operators.

The enlarged-parent distinction is scientifically useful because it explains how the existing total Ward identity can remain ordinary: energy–momentum transferred to the retained environment is still part of the total system. It is not an exemption from the new consistency test. After environmental reduction, the metric, readout, memory, jet, material, CMC, and boundary kernels must obey a coupled advanced deformed identity, and the noise must obey its companion constraint. No present v8.2 calculation proves that the induced gravitational tensor is the known nontrivial trace-adjusted canonical-momentum operator.

The result is a finite new gate, not a new completion claim. The frozen v8.1 baseline remains the baseline, v8.2 remains the architecture under test, no version-9 input enters, and the grade remains unchanged.

References

1. P. Christodoulidis, *Emergent structures in open EFTs*, arXiv:2509.13284v2; JHEP **05** (2026) 145.
2. P. Christodoulidis and J.-O. Gong, *Gravitational open effective field theory of inflation*, arXiv:2512.21234v1.
3. Z. Paz, *The Selective Transient Field from First Principles: The Two-Clock Theory and Its Conditional Gravitational Completion*, v8.2 (28 August 2026).
4. Z. Paz, *The Selective Transient Field from First Principles*, frozen v8.1 baseline (26 August 2026).
5. Z. Paz, *Covariant Clock, World Tube, Gaussian Bath and Ward Completion*, post-v8.1 calculation archive.

6. Z. Paz, *Boundary-CMC Hamiltonian, Dirac and Coefficient-Identifiability Gate*, post-v8.1 calculation archive.
7. Z. Paz, *Boundary-CMC Quadratic SK Influence Parent and Contact-Kernel Audit*, post-v8.1 calculation archive.
8. Z. Paz, *Boundary-CMC Rank-One Drude-Bath Reconciliation and Local Dirac Gate*, post-v8.1 calculation archive.
9. Z. Paz, *Compact Alignment, QQ Susceptibility and Environment-Normalization Gate*, post-v8.1 calculation archive.

Appendix X — Covariant Q_Δ-Environment Vertex and Horizon Spectral Gate (G2)

Audit-gate record, carried verbatim from the accepted package (paste 6 of the 28 August 2026 program). Source file `STF_V8_2_Covariant_QDelta_Environment_Vertex_and_Horizon_Spectral_Gate_V1_0.md`*, SHA-256* `6164626560f1becbd33f958876967c99ec097d88a1a158a4b89dd866c19525c9`*. Section numbers below are local to this appendix. Finite-bath derivation, Lorentz–Drude spectral theorem, and the conditional status of warm-horizon matching*

Version 1.0 — 28 August 2026

Frozen baseline: STF First Principles v8.1
Architecture tested: STF First Principles v8.2
Excluded: STF v9.0 and every result derived from a version-9 branch

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Abstract

STF First Principles v8.2 declared one immediate environmental calculation: choose covariant world-tube fields X_α, derive an uneliminated $Q_\Delta X_\alpha$ vertex, compute the positive spectral density ρ_{QQ}, and retain its retarded self-energy, conservative subtraction, noise, stress, and window force before the boundary-CMC Dirac and Ward audit. This paper performs that calculation for the minimal finite Gaussian scalar environment compatible with the retained v8.2 parent. It then tests whether the horizon environment described in three recent papers can supply or bound the resulting spectral density.

Let

$$Q_\Delta = M_*^2\left(\sqrt{q_N^2+\Delta^2}-\Delta\right), \qquad \widetilde{Q}_\Delta = W(B)Q_\Delta,$$

where B is the varied world-tube phase field and $W(B)=B^2(3-2B)$. The leading Gaussian scalar interaction on the doubled contour is

$$S_{QX} = -\sum_{s=\pm} s\int_{\mathcal{M}_s} d^4x\sqrt{-g_s}\,\widetilde{Q}_{\Delta,s}\,\mathcal{F}_{Q,s}, \qquad \mathcal{F}_Q=\sum_\alpha c_\alpha(\mathcal{I})X_\alpha.$$

Here the c_α are scalar Wilson coefficients constructed from varied material and clock invariants $\mathcal{I}$. The bath kinetic block is not multiplied by W. For constant c_α on a stationary tube, integrating out the retained oscillators gives

$$\rho_{QQ}(\Omega) = \sum_\alpha \frac{c_\alpha^2}{2\Omega_\alpha}\delta(\Omega - \Omega_\alpha) \geq 0$$

and the once-subtracted retarded self-energy

$$\Sigma^R_{QQ}(z) = \int_0^\infty d\Omega\, 2\Omega \rho_{QQ}(\Omega)\left[\frac{1}{z^2-\Omega^2} + \frac{1}{\Omega^2}\right], \qquad \operatorname{Im} z > 0.$$

Requiring the exact v8.2 selected response

$$\Sigma^R_{QQ}(z) = g_Q^2 \frac{-iz}{\omega_c - iz}$$

fixes its positive ideal continuum uniquely through the retarded discontinuity:

$$\boxed{\rho^{\mathrm{D}}_{QQ}(\Omega) = \frac{g_Q^2}{\pi}\frac{\Omega\omega_c}{\Omega^2+\omega_c^2}.}$$

It obeys

$$g_Q^2 = 2\int_0^\infty \frac{\rho^{\mathrm{D}}_{QQ}(\Omega)}{\Omega}\, d\Omega, \qquad \mathcal{N}_{QQ}(\omega) = 2\pi \rho^{\mathrm{D}}_{QQ}(|\omega|)\coth\left(\frac{\beta|\omega|}{2}\right),$$

and therefore

$$\mathcal{N}_{QQ}(0) = \frac{4g_Q^2}{\beta\omega_c}.$$

This is a derivation of the covariant vertex class and of the spectral shape required by the selected v8.2 kernel. It is not a microscopic determination of the Wilson coefficient g_Q^2, the factorization ratio r, or a unique ultraviolet completion.

The linked horizon papers establish a physically relevant but narrower result. Warm Killing-horizon sectors produce an Ohmic absorptive response and a nonzero low-frequency symmetrized field spectrum. A horizon can therefore supply an additive infrared Q-channel only after a covariant projection from electromagnetic or tidal horizon observables into the scalar force $\mathcal{F}_Q$ has been specified. If

$$\mathcal{F}_H = \lambda_H P_A\, \delta\mathcal{C}^A_H, \qquad P_A = \frac{\partial Q_\Delta}{\partial \mathcal{C}^A} = M_*^2 \frac{\mathcal{C}_A}{\sqrt{q_N^2+\Delta^2}},$$

then conditionally

$$\rho^H_{QQ}(\omega; x) = \lambda_H^2 P_A(x)\rho_H^{AB}(\omega; x, x)P_B(x).$$

In a local KMS regime with finite projected symmetrized noise $S_H(0)$,

$$\rho^H_{QQ}(\omega) = \frac{\beta_{\mathrm{loc}}\lambda_H^2}{4\pi} P_A S_H^{AB}(0) P_B\, \omega + O(\omega^3).$$

Thus the horizon supplies a candidate Ohmic slope, not the universal normalization or full Ω-dependence of the STF bath. The Schwarzschild results give geometry- and state-dependent infrared scaling, while the optimal-purification paper changes the coherent source protocol and realized decoherence, not the commutator spectral density. No model-independent numerical bound on g_Q^2 or ρ_{QQ} follows without a world-tube projection, a near/far matching prescription, and an observational limit in that same channel.

The unintegrated vertex is a diagonal-covariant scalar and preserves the established $58/116$ structural subtotal because it changes no primary kinetic Hessian. Its metric, readout, clock, material, environment, and boundary variations must nevertheless be kept. The previously derived total physical Ward identity therefore remains a conditional pass. The coefficient-complete reduced advanced/noise identity and boundary-CMC Schur complement remain open.

$$\boxed{\text{Grade unchanged: coherent gravitational candidate, not a completed gravity theory.}}$$

I. Scope and source control

I.A The declared calculation

Appendix V and §VIII.G of v8.2 distinguish three objects that must not be merged:

1. the compact-alignment capacity Hessian;
2. the physical composite QQ susceptibility inherited from the varied gravitational and CMC Green function;
3. the one-particle-irreducible environmental force spectrum generated by a $Q_\Delta X_\alpha$ vertex.

At fixed base geometry the compact auxiliary source functional is linear in its source, so its connected auxiliary QQ susceptibility is zero. That theorem rules out using the positive capacity Hessian as a hidden environmental propagator. It does not set the full composite correlator to zero. The present calculation concerns item 3.

The exact v8.2 frontier was:

- choose covariant world-tube/environment fields;
- derive the uneliminated $Q_\Delta X_\alpha$ vertex;
- compute ρ_{QQ};
- derive its retarded self-energy, conservative subtraction, noise, stress, and window force;
- test the rank-one equality or the higher-rank positivity inequality;
- insert the result into the boundary-CMC Schur complement;
- run the complete Dirac, Ward, positivity, and pole audit.

This paper completes the first four steps for a declared minimal Gaussian scalar environment, verifies the rank-one equality when the same environment direction couples to both system operators, and identifies precisely what is still needed before the last two steps can be claimed.

I.B Frozen STF files

The publication baseline is:

STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md

with SHA-256

4788576a24d0c576cccd4a4c118205f123171481b50d181792f12767cd62f6f6.

The post-v8.1 calculations were actually performed against:

STF_First_Principles_Paper_V8_1_fixed(1).md

with SHA-256

bc2bd30366ef0a8b144a813438b1b3280f470b8a25e0d6da67fb74bfa775f700.

Those two files differ by one pair-level statistical-significance sentence and not by the gravitational or environment architecture. The v8.2 file graded here is:

STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md

with SHA-256

f7eca3fb886b559b1888707499dbe0442dda307c87a62fa1b0473f7682d8f40e.

The preceding open-operator audit is:

STF_V8_2_Open_Operator_Deformed_Identity_Classification_Gate_V1_0.md

with SHA-256

fb54d267706e2a571592786f6b942e047d236ee49b243a1c66d3faf289b8fee1.

No version-9 manuscript, coefficient, field definition, or conclusion was opened or used.

I.C External papers read in full

The current arXiv versions available for this audit were downloaded, text-extracted, rendered page by page, and read through their appendices and references:

1. Jordan Wilson-Gerow, Annika Dugad, and Yanbei Chen, *Decoherence by warm horizons*, arXiv:2405.00804v2, 19 pages, PDF SHA-256 **9d335fe351c8b1f56b4aa46ed2a735d56ad2b748b1d6062e93516cba23031065**.
2. Daine L. Danielson, Gautam Satishchandran, and Robert M. Wald, *Local Description of Decoherence of Quantum Superpositions by Black Holes and Other Bodies*, arXiv:2407.02567v4, 16 pages, PDF SHA-256 **daf5dca695c33c9278922544e45d9f57346822530c43380680371bfe31673396**.
3. Daine L. Danielson, Jonah Kudler-Flam, Gautam Satishchandran, and Robert M. Wald, *How to Minimize the Decoherence Caused by Black Holes*, arXiv:2501.04773v2, 11 pages, PDF SHA-256 **642804b42b607c4d9e8cd80d347a88d2daa7c03c19835fdaaca13db2dc55fd83**.

The papers use several normalizations for commutators, symmetrized two-point functions, power spectra, and decoherence exponents. The matching below therefore states its Fourier convention. Order-unity tensor-projector factors are not silently promoted to exact coefficients.

II. What the horizon papers establish

II.A Warm horizons: response, state, and decoherence are distinct

Wilson-Gerow, Dugad, and Chen give a local open-system description of the steady decoherence previously associated with soft radiation through a Killing horizon. Their Rindler example is a charge q held in a spatial superposition of separation ϵ in a laboratory with proper acceleration a. The steady electromagnetic rate is

$$\Gamma^{\mathrm{EM}}_{\mathrm{DSW}} = \frac{q^2 a^3 \epsilon^2}{12\pi^2}$$

in their units and conventions.

The useful general statement for the STF calculation is not the particular charge formula. It is the fluctuation–dissipation relation between an Ohmic absorptive response and the low-frequency noise of a warm environment. For a bilinear coupling and an absorptive expansion

$$\operatorname{Im}\chi(\omega) = \gamma_1\omega + \gamma_3\omega^3 + \cdots,$$

the leading classical dissipative force is

$$F_{\mathrm{diss}} = -\gamma_1\dot{q} + \cdots$$

and the long-hold decoherence rate is

$$\Gamma_\beta = \frac{\epsilon^2}{\beta}\gamma_1.$$

For the uniformly accelerated electromagnetic dipole they find

$$\gamma_1 = \frac{q^2a^2}{6\pi}, \qquad \beta_{\mathrm{Unruh}} = \frac{2\pi}{a},$$

which reproduces the steady horizon rate.

The origin of the Ohmic term is visible directly in their accelerated-frame electric spectrum:

$$S_E^{IJ}(\Omega) = \delta^{IJ}\frac{a^2\Omega + \Omega^3}{6\pi}\left[\frac{1}{2} + \frac{1}{e^{\beta\Omega}-1}\right].$$

The $a^2\Omega$ factor times the Bose occupation has a finite $\Omega \to 0$ limit. By contrast, the inertial Planck electric spectrum begins with Ω^3, so its zero-frequency limit vanishes.

Two distinctions are load-bearing.

First, the retarded commutator spectrum is a property of the chosen environment operator and background. The symmetrized noise also depends on the state. A warm KMS occupation converts an Ohmic absorptive term into a nonzero zero-frequency noise plateau. The temperature does not by itself manufacture the retarded operator.

Second, “thermal radiation” is not a sufficient classification. A finite-temperature inertial electromagnetic bath does not automatically give the same steady dipole decoherence. The low-frequency answer depends on which environmental observable couples to the system and on the corresponding spectral power. The horizon result cannot therefore be imported into STF by equating “warm” with a universal scalar bath.

II.B Local black-hole description: the actual environmental observables

Danielson, Satishchandran, and Wald rewrite the horizon calculation in terms of local two-point functions in the laboratory. For electromagnetic sources, the decoherence measure can be written as a quadratic expectation value of the incoming vector potential smeared with the current difference. In a radially separated charge experiment this reduces to the local electric-field correlator:

$$\langle N\rangle = q^2 \int dt\, dt'\, d(t)d(t')\, s^a s^{a'} \langle E_a(t)E_{a'}(t')\rangle.$$

The linearized gravitational analog uses the electric part of the Weyl tensor,

$$\mathcal{E}_{ab} = C_{acbd}t^c t^d,$$

and a quadrupolar source constructed from the mass and branch separation. This matters for STF because the black-hole environment is not presented as a fundamental scalar X_α. It appears as electromagnetic field strength or tidal curvature, with tensor structure, greybody propagation, state dependence, and a location-dependent projection into the apparatus.

For a Schwarzschild black hole of mass M, with a laboratory at proper distance D in the regime specified in that paper, their long-hold scalings are

$$\langle N\rangle_{\rm EM} \sim \frac{M^3 q^2 d^2}{D^6} T,$$

and

$$\langle N\rangle_{\rm GR} \sim \frac{M^5 m^2 d^4}{D^{10}} T.$$

These equations show constant low-frequency local power in the relevant projected field observable. Schematically,

$$S_{EE}(0) \sim \frac{M^3}{D^6}, \qquad S_{\mathcal{E}\mathcal{E}}(0) \sim \frac{M^5}{D^{10}},$$

with charge, mass, branch-separation, tensor, and normalization factors supplied by the source smearing.

The state comparison is equally important:

- in the Unruh state, the low-frequency horizon-originating modes give the linear-in-T effect;
- in the Hartle–Hawking state, both relevant mode families are thermally populated;
- in the Boulware state, spontaneous soft emission remains, but the growth is logarithmic rather than a steady warm-noise rate;
- for a static star with no suitable internal degrees of freedom, the horizon-originating modes are absent and the analogous linear-in-T effect does not occur;
- a material body can mimic the black-hole channel only if it has appropriate dissipative dipole or quadrupole degrees of freedom.

The paper also gives effective stochastic multipole estimates. In restored units, the Unruh-state black hole behaves in the electromagnetic channel as if it had a fluctuating dipole amplitude spectral density scaling as

$$\Delta|P_U|(\omega) \sim \frac{\sqrt{\hbar}\, G^{3/2} M^{3/2}}{c^3},$$

and in the gravitational channel as if it had a fluctuating quadrupole amplitude spectral density

$$\Delta|Q_U|(\omega) \sim \frac{\sqrt{\hbar}\,G^2 M^{5/2}}{c^5}.$$

These are useful candidate environmental spectra. They are not yet ρ_{QQ}: a coupling, a covariant scalar projection, and a subtraction convention are still required.

II.C Optimal purification changes the source history

Danielson, Kudler-Flam, Satishchandran, and Wald ask how much horizon-induced decoherence can still be reduced after part of the entangling radiation has crossed a horizon. Given an earlier free datum f, the optimal continuation is a filtered, reflected field. In Rindler frequency,

$$\hat{g}(\omega, y) = \operatorname{sech}\left(\frac{\pi\omega}{\kappa}\right)\widehat{\tilde{f}}(\omega, y),$$

or equivalently,

$$g(t, y) = \frac{\kappa}{2\pi}\int_{-\infty}^{\infty} dt' \operatorname{sech}\left[\frac{\kappa(t-t')}{2}\right]\tilde{f}(t', y).$$

The unrecovered positive-affine-frequency norm contains

$$\frac{1}{\pi}\int d^{d-2}y\int_0^{\infty} d\omega\,\omega \coth\left(\frac{\pi\omega}{\kappa}\right)|\widehat{f}(\omega, y)|^2,$$

whereas the optimal continuation replaces the low-frequency weight by the corresponding $\tanh$ expression. The optimal action decays on a timescale κ^{-1}. For a superposition held open for $T \gg \kappa^{-1}$, the improvement does not change the leading long-hold decoherence estimate.

For the examples evaluated in that paper, acting just before the original ramp-down reduced $\langle N\rangle$ by 4.6%; acting immediately after closing reduced it by 1.3%; delaying by κ^{-1} reduced it by only 0.07%. Each percentage tends to zero as the long hold time increases.

This result constrains a protocol-dependent influence exponent. It does not change the environmental commutator. The filter changes the classical mean history coupled into the environment; it does not renormalize the retarded spectral density of the environment itself. It can therefore bound the irrecoverable decoherence for a specified horizon channel and specified prior history, but it cannot determine or bound an unprojected STF ρ_{QQ}.

III. STF variables and the environmental object

III.A Regulated compact capacity

On the v8.2 analytic branch, the eleven-component clock-relative curvature state is denoted $\mathcal{C}^A$, with norm q_N. For $\Delta > 0$,

$$s = \sqrt{q_N^2 + \Delta^2}, \qquad Q_\Delta = M_*^2(s - \Delta).$$

The gradient in curvature-state space is

$$\boxed{P_A^{\text{eff}} \equiv \frac{\partial Q_\Delta}{\partial \mathcal{C}^A} = M_*^2\frac{\mathcal{C}_A}{s}.}$$

The compact-alignment Hessian is positive for $\Delta > 0$, but it is a response of the composite to base curvature. It is not a bath correlator.

The world-tube field B supplies the smooth coupling window

$$W(B) = B^2(3 - 2B),$$

with

$$W(0) = 0, \qquad W(1) = 1, \qquad W'(0) = W'(1) = 0.$$

The windowed system operator is

$$\widetilde{Q}_\Delta = W(B)Q_\Delta.$$

The window multiplies the interaction, not the bath kinetic term. Therefore $W = 0$ turns off the coupling without deleting the environmental equation or changing its primary kinetic rank.

III.B Definition of ρ_{QQ}

The environmental quantity called ρ_{QQ} is most cleanly defined as the positive spectral density of the bath force that couples linearly to $\widetilde{Q}_\Delta$. Let that force be $\mathcal{F}_Q$. With the retarded convention used in this paper,

$$G^R_{FF}(z) = \sum_\alpha \frac{c_\alpha^2}{z^2 - \Omega_\alpha^2}, \qquad \operatorname{Im} z > 0,$$

and

$$\boxed{\rho_{QQ}(\Omega) = -\frac{1}{\pi}\operatorname{Im} G^R_{FF}(\Omega + i0) = \sum_\alpha \frac{c_\alpha^2}{2\Omega_\alpha}\delta(\Omega - \Omega_\alpha).}$$

The subscript QQ labels the system channel. It does not mean that this is the fixed-base two-point function of the compact auxiliary. This convention is the one required to compare directly with the v8.2 frontier formula.

III.C Minimal assumptions

The derivation below makes the following explicit choices:

1. X_α are real scalar environmental fields on the varied world tube.
2. The finite regulator has positive oscillator frequencies $\Omega_\alpha > 0$.
3. The bath kinetic operator is independent of $W(B)$.
4. The leading interaction is Gaussian and bilinear in the system coordinate and bath force.
5. The coefficients $c_\alpha(\mathcal{I})$ are diagonal-covariant scalars constructed from varied material, clock, and boundary data.
6. A stationary local patch is used to define frequency and KMS relations.
7. The zero-frequency conservative term is removed by an explicit local matching counterterm.

These assumptions define a completion class. They do not assert that a unique microscopic material or horizon model realizes it.

IV. Covariant uneliminated vertex

IV.A Finite doubled parent

On each causal leg $s=\pm$, take

$$S_{\mathrm{bath},s}=\frac{1}{2}\sum_{\alpha}\int_{\mathcal{M}_s}d^4x\sqrt{-g_s}\left[(D_{U_s}X_{\alpha,s})^2-\Omega_\alpha^2X_{\alpha,s}^2\right].$$

The doubled bath action is

$$S_{\mathrm{bath}}^{\mathrm{CTP}}=\sum_{s=\pm}s\,S_{\mathrm{bath},s}.$$

The leading interaction is

$$\boxed{S_{QX}^{\mathrm{CTP}}=-\sum_{s=\pm}s\int_{\mathcal{M}_s}d^4x\sqrt{-g_s}\,W(B_s)Q_{\Delta,s}\sum_{\alpha}c_\alpha(\mathcal{I}_s)X_{\alpha,s}.}$$

Every quantity appearing in this equation is varied before the bath is eliminated. In particular:

- $g_{\mu\nu}$ enters the measure, the clock derivative, the curvature state, and any scalar coefficient $\mathcal{I}$;
- Q_Δ enters through the compact readout and retained curvature jets;
- B enters through $W(B)$ and its own material action;
- X_α obey finite environmental equations;
- the clock normal U^μ, the world-tube variables, and boundary data are retained;
- any dependence $c_\alpha(\mathcal{I})$ contributes its own material and metric force.

At leading bilinear order this is the minimal scalar vertex. A tensor horizon observable must first be contracted with varied world-tube data to become $\mathcal{F}_Q$. Inserting a fixed external projector would recreate the source-force defect that v8.2 excludes.

IV.B Equations before elimination

For constant c_α on a stationary local tube, the oscillator equation is schematically

$$\left(D_U^2+\Omega_\alpha^2\right)X_\alpha=-c_\alpha\widetilde{Q}_\Delta,$$

with the precise sign determined by the action and metric convention. The system equation receives the force

$$\frac{\delta S_{QX}}{\delta Q_\Delta}\propto-W(B)\mathcal{F}_Q.$$

The world-tube equation receives

$$\frac{\delta S_{QX}}{\delta B}\propto-W'(B)Q_\Delta\mathcal{F}_Q,$$

and variations of $c_\alpha(\mathcal{I})$ add the corresponding material forces. These terms are not optional bookkeeping. They are how energy–momentum exchange between the STF variables and the retained environment remains internal in the enlarged parent.

IV.C Counterterm and matching convention

The bare static oscillator response is

$$G^R_{FF}(0) = -\sum_\alpha \frac{c_\alpha^2}{\Omega_\alpha^2}.$$

The v8.2 selected high-pass response has zero DC. A local counterterm is therefore fixed by the matching condition

$$\Sigma^R_{QQ}(0) = 0.$$

In the present sign convention this means

$$\boxed{\Sigma^R_{QQ}(z) = G^R_{FF}(z) - G^R_{FF}(0).}$$

At finite regulator the corresponding doubled local contact may be written

$$S^{\rm CTP}_{{\rm ct},Q} = -\frac{1}{2}\sum_{s=\pm} s \int_{\mathcal{M}_s} d^4x\sqrt{-g_s}\, G^R_{FF}(0)\, \widetilde{Q}^{\,2}_{\Delta,s},$$

where the sign is defined so that its quadratic kernel shifts the bare response by $-G^R_{FF}(0)$. Because $\widetilde{Q}_\Delta = WQ_\Delta$, this contact contributes its own metric, readout, and B-equation terms.

Equivalently,

$$\Sigma^R_{QQ}(z) = \int_0^\infty d\Omega\, 2\Omega \rho_{QQ}(\Omega) \left[\frac{1}{z^2-\Omega^2} + \frac{1}{\Omega^2}\right].$$

The subtraction is local and conservative. It does not affect the positive discontinuity or the KMS noise. It does contribute to the real coefficient set that enters the jet kernel and the boundary-CMC Schur complement. Its existence is derived; radiative protection of the chosen zero-DC matching condition is not.

After the Gaussian bath is eliminated, the quadratic Q-sector of the influence action has the standard physical/advanced form

$$S^{(2)}_{\rm IF} = \int d^4x\, d^4x'\, \widetilde{Q}_{\Delta,a}(x)\Sigma^R_{QQ}(x,x')\widetilde{Q}_{\Delta,r}(x') + \frac{i}{2}\int d^4x\, d^4x'\, \widetilde{Q}_{\Delta,a}(x)\mathcal{N}_{QQ}(x,x')\widetilde{Q}_{\Delta,a}(x'),$$

with r and a denoting the physical and advanced combinations. This equation displays why retarded response, conservative subtraction, and noise must be matched separately.

V. Spectral calculation

V.A Finite positive bath

For finitely many oscillators,

$$\rho_{QQ}(\Omega) = \sum_\alpha \frac{c_\alpha^2}{2\Omega_\alpha}\delta(\Omega-\Omega_\alpha)$$

is manifestly nonnegative. The retarded function is analytic in the upper half-plane. The once-subtracted representation satisfies

$$\Sigma^R_{QQ}(0) = 0$$

and its imaginary part on the positive real axis is

$$-\operatorname{Im}\Sigma^R_{QQ}(\omega+i0)=\pi\rho_{QQ}(\omega)\geq 0.$$

This is the diagonal positivity that the fixed cross response did not determine.

V.B Exact Lorentz–Drude continuum

The selected v8.2 kernel is

$$K^R_{\rm sel}(z)=\frac{-iz}{\omega_c-iz}.$$

If the Q channel has coefficient g_Q^2, then

$$\Sigma^R_{QQ}(z)=g_Q^2K^R_{\rm sel}(z).$$

Taking the retarded discontinuity gives

$$-\frac{1}{\pi}\operatorname{Im}\Sigma^R_{QQ}(\Omega+i0)=\frac{g_Q^2}{\pi}\frac{\Omega\omega_c}{\Omega^2+\omega_c^2}.$$

Therefore

$$\boxed{\rho^{\rm D}_{QQ}(\Omega)=\frac{g_Q^2}{\pi}\frac{\Omega\omega_c}{\Omega^2+\omega_c^2}.}$$

Substitution into the once-subtracted dispersion relation gives exactly

$$\int_0^\infty d\Omega\,2\Omega\rho^{\rm D}_{QQ}(\Omega)\left[\frac{1}{z^2-\Omega^2}+\frac{1}{\Omega^2}\right]=g_Q^2\frac{-iz}{\omega_c-iz}.$$

The companion NumPy checker evaluates this identity at several complex frequencies in the upper half-plane using mapped Gauss–Legendre quadrature. The maximum error is below 4×10^{-15} for the test parameters.

The exact normalization moment is

$$\boxed{g_Q^2=2\int_0^\infty\frac{\rho^{\rm D}_{QQ}(\Omega)}{\Omega}\,d\Omega.}$$

The ideal Lorentz–Drude form is an EFT continuation. A microscopic ultraviolet model can multiply it by a higher cutoff and add local counterterms while preserving the low-frequency kernel over the declared band. Such a change would have to be rematched; it is not uniquely fixed by the infrared response.

V.C KMS noise

For the convention

$$\mathcal{N}_{QQ}(\omega)=2\pi\rho_{QQ}(|\omega|)\coth\left(\frac{\beta|\omega|}{2}\right),$$

the Drude noise is

$$\boxed{\mathcal{N}^{\rm D}_{QQ}(\omega)=2g_Q^2\frac{|\omega|\omega_c}{\omega^2+\omega_c^2}\coth\left(\frac{\beta|\omega|}{2}\right).}$$

It is nonnegative and has the finite low-frequency limit

$$\boxed{\mathcal{N}^{\mathrm{D}}_{QQ}(0)=\frac{4g_Q^2}{\beta\omega_c}.}$$

The division of labor is now explicit:

- the retarded discontinuity fixes ρ_{QQ};
- the state and KMS relation fix the occupation-dependent noise;
- the subtraction fixes the conservative DC convention;
- microscopic matching fixes g_Q^2 and any ultraviolet completion.

Temperature cannot determine the normalization if the underlying coupling has not been specified.

V.D Rank-one common environment

For the v8.2 system-operator vector

$$O_i=(\phi,\widetilde{Q}_\Delta)$$

and a common bath direction

$$O_g=g_\phi\phi+g_Q\widetilde{Q}_\Delta,$$

the response matrix factorizes:

$$\Sigma^R_{ij}=g_ig_jK^R_{\mathrm{sel}}.$$

Hence

$$\boxed{\left(\Sigma^R_{\phi Q}\right)^2=\Sigma^R_{\phi\phi}\Sigma^R_{QQ}.}$$

The noise matrix has the same outer-product structure and is positive semidefinite of rank one. If the measured or derived cross coefficient is $\gamma_\times$, then

$$g_\phi^2=|\gamma_\times|r,\qquad g_Q^2=\frac{|\gamma_\times|}{r},\qquad r>0.$$

The spectral calculation fixes the Q-channel shape conditional on g_Q^2. It does not fix r. One independently matched diagonal or a microscopic common-bath vertex is still required.

VI. Stress, rank, and Ward consequences

VI.A Environmental stress and world-tube force

The interaction stress is defined by

$$T^{QX}_{\mu\nu}=-\frac{2}{\sqrt{-g}}\frac{\delta S_{QX}}{\delta g^{\mu\nu}}.$$

It includes more than the variation of $\sqrt{-g}$. The composite Q_Δ depends on the clock-relative curvature state; the projector and normal enter that state; the coefficients $c_\alpha(\mathcal{I})$ can depend on material invariants; and the counterterm is a metric-dependent local composite contact.

For the full collective field set

$$\Psi^A = \{g_{\mu\nu}, \mathcal{C}^A, p_A, y, \rho, B, X_\alpha, \mathrm{jets}, \mathrm{multipliers}, \mathrm{boundary\ data}\},$$

diagonal covariance gives the ordinary enlarged-parent identity

$$\boxed{\nabla_\mu T^\mu{}_{\nu,\mathrm{tot}} = \sum_A E_A \nabla_\nu \Psi^A + \mathcal{B}_\nu[\partial\mathcal{M}, V_4],}$$

with the standard tensor-index terms understood. The interaction contributions cancel only when the B, X_α, readout, clock, material, and boundary equations are included.

Freezing B leaves a defect proportional to

$$W'(B) Q_\Delta \mathcal{F}_Q \nabla_\nu B.$$

Freezing an environment mode leaves a defect proportional to

$$W(B) Q_\Delta c_\alpha \nabla_\nu X_\alpha.$$

Freezing a coefficient-carrying material invariant leaves its corresponding $\nabla_\nu \mathcal{I}$ force. The checker verifies this chain-rule bookkeeping in a finite scalar representative.

VI.B Primary structural ranks

The vertex $W Q_\Delta c_\alpha X_\alpha$ is algebraic in the retained readout, world-tube field, and bath coordinates. It does not multiply $(D_U X_\alpha)^2$ and does not add bath velocities. On the first-order split-leg parent it therefore leaves the primary kinetic Hessian unchanged.

The established structural subtotal remains

$$44_{\mathrm{readout/alignment}} + 2_{\mathrm{memory}} + 12_{\mathrm{jets}} = 58$$

per causal leg and

$$116$$

on the doubled contour.

These numbers still exclude lapse and shift primary constraints, the gravitational Hamiltonian and momentum constraints, the CMC partner, environment-regulator pairs, and the complete secondary chain. The counterterm and environmental self-energy can change the secondary coefficient matrix and the CMC Schur complement. Preserving the primary subtotal is not a proof of complete gravitational rank.

VI.C Total physical identity versus reduced advanced identity

Before the bath is traced, the finite parent is closed and its energy exchange is internal. After the bath is integrated out, the reduced influence functional contains a retarded kernel and a noise kernel. The physical diagonal Ward identity is the pushforward of the enlarged-parent Noether identity if the regulator, initial state, gluing, counterterms, and boundary treatment are covariant.

The independent advanced/noise identity is a separate requirement. At quadratic order the full coupled reduced kernel must possess an off-shell row relation of the form

$$\widehat{\mathfrak{R}}_\nu^{\dagger A} K^R_{AB} = \mathfrak{M}_\nu{}^i K^R_{iB},$$

and the stochastic covariance must live on the compatible source subspace. The scalar spectral theorem derived here proves analyticity, positivity, zero DC, and rank-one factorization in the (ϕ, Q) block. It does not prove the coefficient-complete row identity for the metric–readout–memory–jet–world-tube–CMC system.

Accordingly, the already derived total physical Ward identity is neither withdrawn nor upgraded:

- **unintegrated diagonal identity:** conditional pass, with all fields varied;
- **reduced diagonal identity:** conditional pass under covariant elimination and matching;
- **full advanced/noise deformed identity:** open;
- **coefficient-complete boundary-CMC closure:** open.

VII. Does a horizon supply ρ_{QQ}?

VII.A A projection is mandatory

The horizon papers provide spectra of electromagnetic and gravitational observables. The STF bath force is a scalar world-tube operator. A matching map is therefore required.

At linear order a covariant candidate is

$$\mathcal{F}_H(x) = \lambda_H(\mathcal{I})P_A(x)\delta\mathcal{C}_H^A(x),$$

where

$$P_A = M_*^2 \frac{\mathcal{C}_A}{s}.$$

Equivalently, in a gravitational tidal basis one may write

$$\mathcal{F}_H = \lambda_H e_H^{ab}\mathcal{E}_{ab}^H,$$

where e_H^{ab} is constructed from varied apparatus/world-tube data. It cannot be an unexplained fixed tensor.

The projected retarded spectral density is then

$$\boxed{\rho_{QQ}^H(\omega; x) = \lambda_H^2 P_A(x)\rho_H^{AB}(\omega; x, x)P_B(x)}$$

or the corresponding tidal contraction. This is an additive bath sector only if the horizon modes have been separated from the gravitational variables retained in the STF system.

VII.B Warm-horizon infrared matching

Let the projected symmetrized local horizon spectrum in the chosen convention be

$$S_H^{\text{proj}}(\omega) = \lambda_H^2 P_A S_H^{AB}(\omega)P_B.$$

In a local KMS regime,

$$S_H^{\text{proj}}(\omega) = 2\pi\rho_{QQ}^H(|\omega|)\coth\left(\frac{\beta_{\text{loc}}|\omega|}{2}\right).$$

If

$$S_H^{\mathrm{proj}}(\omega) = S_0 + O(\omega^2),$$

then

$$\boxed{\rho_{QQ}^H(\omega) = \frac{\beta_{\mathrm{loc}} S_0}{4\pi}\omega + O(\omega^3).}$$

This is the exact sense in which a warm horizon supplies an Ohmic candidate. It supplies the infrared slope after projection. It does not supply a universal scalar spectrum before projection.

Matching this slope to the Drude infrared expansion

$$\rho_{QQ}^{\mathrm{D}}(\omega) = \frac{g_Q^2}{\pi\omega_c}\omega + O(\omega^3)$$

gives

$$\boxed{\frac{g_{Q,H}^2}{\omega_c} = \frac{\beta_{\mathrm{loc}}}{4}\lambda_H^2 P_A S_H^{AB}(0) P_B,}$$

with any alternative Fourier or tensor normalization stated explicitly. The horizon fixes only this conditional ratio. Identifying ω_c with a surface-gravity scale requires an additional matching law.

VII.C Schwarzschild scaling

For the gravitational Schwarzschild channel described by Danielson, Satishchandran, and Wald, the local tidal noise has the schematic scaling

$$P_A S_H^{AB}(0) P_B \sim P_{\mathcal{E}}^{ab} P_{\mathcal{E}}^{cd} \Pi_{ab,cd} \frac{M^5}{D^{10}},$$

where $\Pi_{ab,cd}$ denotes the state- and geometry-dependent tensor projector. Therefore

$$\rho_{QQ}^H(\omega) \sim \frac{\beta_{\mathrm{loc}}\lambda_H^2}{4\pi} P_{\mathcal{E}}^{ab} P_{\mathcal{E}}^{cd} \Pi_{ab,cd} \frac{M^5}{D^{10}}\,\omega.$$

This is not a mass-universal or location-independent coefficient. It depends on:

- black-hole mass M;
- apparatus distance D;
- state;
- redshift and local time convention;
- tensor polarization;
- the STF curvature gradient or apparatus projector;
- the microscopic matching coefficient λ_H;
- which modes are assigned to system and environment.

The linked papers therefore provide a scaling target, not a numerical STF diagonal.

VII.D Cutoff and bandwidth

A Killing horizon brings a characteristic scale set by its surface gravity κ, while the v8.2 memory response uses ω_c. The low-frequency results support

$$\rho_H(\omega) \propto \omega \qquad (\omega \ll \kappa)$$

in a warm projected channel. They do not prove

$$\omega_c = \kappa.$$

The greybody potential, apparatus response, finite world tube, and material projection can introduce additional scales. A horizon can match the Drude infrared slope while failing to reproduce the exact Lorentz–Drude turnover. Conversely, the v8.2 Drude regulator can be a phenomenological representation of several microscopic sectors rather than a literal horizon spectrum.

VII.E Double-counting gate

The v8.2 physical composite susceptibility contains a gravitational contribution schematically of the form

$$\chi_{QQ}^{\text{grav}} = P_A G_{\text{grav}}^{AB} P_B.$$

Horizon tidal fluctuations are gravitational field fluctuations. If the gravitational Green function G_{grav}^{AB} already includes the horizon boundary condition and state, then adding the same modes again as an independent X_α bath double counts them.

A horizon contribution can be called an independent ρ_{QQ} only after a system–environment split has been stated, for example:

1. retain near-zone metric/readout variables as the system;
2. integrate out horizon or far-zone radiative modes;
3. derive the induced scalar force kernel on the varied world tube;
4. subtract the overlap with the retained gravitational Green function;
5. match the remaining kernel and counterterms at a declared scale.

Without this construction, the horizon is relevant to the total physical QQ susceptibility but not automatically to the independent environmental coefficient used in the rank-one Drude parent.

VIII. Supply, bound, or irrelevance classification

HORIZON/BODY SETTING	WHAT THE LINKED PAPERS PROVIDE	RELATION TO STF P_{QQ}	GRADE
uniformly accelerated electromagnetic dipole	exact Ohmic coefficient and warm steady-decoherence rate	supplies a worked analog; not the gravitational STF scalar channel	analog only
Schwarzschild, Unruh state	local electric/tidal low-frequency noise and M, D scaling	conditional additive infrared supplier after covariant projection and non-overlap matching	conditional pas
Schwarzschild, Hartle–Hawking state	thermally populated horizon and infinity sectors	conditional KMS noise supplier after projection; state differs from the astrophysical Unruh setting	conditional pas

HORIZON/BODY SETTING	WHAT THE LINKED PAPERS PROVIDE	RELATION TO STF ρ_{QQ}	GRADE
Schwarzschild, Boulware state	spontaneous soft emission with logarithmic growth	does not supply the warm constant-noise Drude limit; does not erase the commutator channel	not a warm match
static star without internal dissipative modes	absence of horizon-originating modes	no horizon-type supplier	irrelevant/abse
material body with suitable internal multipoles	possible mimic of black-hole low-frequency spectra	candidate ordinary material environment; requires its own world-tube vertex	open/condition
optimal post-t_c purification	filter on the future coherent source history and irrecoverable decoherence	does not change ρ_{QQ}; can bound a protocol-specific influence exponent after matching	irrelevant to spectral normalization
horizon modes already contained in $G_{\rm grav}$	part of the inherited physical composite response	adding them as X_α is double counting	not an independent bath

The requested three-way answer is therefore:

$$\boxed{\begin{array}{ll}\text{Supplies:} & \text{yes, conditionally, as a projected additive Ohmic infrared sector;}\\ \text{Bounds:} & \text{no model-independent bound on } g_Q^2 \text{ or the full } \rho_{QQ};\\ \text{Irrelevant:} & \text{only when the channel is absent, unprojected, protocol-only, or already}\\ & \text{included in the retained gravitational susceptibility.}\end{array}}$$

No numerical bound is available because the papers do not provide an STF world-tube coupling λ_H, the normalized eleven-state projector, a finite-radius STF apparatus solution, or an observed STF decoherence limit. Their results can be turned into a bound only after all four are supplied.

IX. Claim ledger and grading

CLAIM	RESULT OF THIS CALCULATION	GRADE
a diagonal-covariant scalar $Q_\Delta X_\alpha$ vertex exists	explicit doubled finite-bath action given	derived for the declared completion class
windowing may multiply the bath kinetic term	would change kinetic rank at $W = 0$	rejected
finite-bath ρ_{QQ} is positive	sum of $c_\alpha^2/(2\Omega_\alpha)$ delta functions	theorem
zero-DC response follows without a contact	bare oscillators have nonzero static response	false
once-subtracted dispersion is causal and positive	explicit spectral representation	theorem

CLAIM	RESULT OF THIS CALCULATION	GRADE
the exact v8.2 selected kernel has a positive continuum	Lorentz–Drude spectrum derived	theorem/existence
the Drude normalization obeys a spectral moment	$g_Q^2 = 2\int \rho/\Omega$	theorem
KMS fixes the noise from ρ_{QQ}	explicit positive noise and finite DC limit	theorem in the stationary KMS regime
KMS fixes g_Q^2 without a microscopic coupling	temperature fixes occupation, not normalization	false
compact capacity Hessian supplies ρ_{QQ}	fixed-base auxiliary susceptibility remains zero	disproved as before
common bath preserves rank-one equality	exact outer-product factorization	pass
vertex changes the $58/116$ primary structural subtotal	no new velocity Hessian	no change
complete gravitational constraint rank follows	secondary and CMC matrices remain unfinished	open
warm horizon gives an Ohmic environmental analog	supported by all local/FDT results	pass as an analog
horizon gives STF ρ_{QQ} without a projector	tensor field spectrum is not the scalar force spectrum	false
projected Unruh/Hartle–Hawking sector can contribute to ρ_{QQ}	FDT gives conditional linear slope	conditional pass
Boulware state supplies the same warm Drude noise	only logarithmic long-time growth	false
a static nondissipative star supplies the horizon channel	required modes are absent	false
optimal purification changes the bath commutator spectrum	it changes the coherent continuation	false
horizon papers numerically determine g_Q^2 or r	no STF projection or matching coefficient	open/not supplied
unintegrated total physical Ward identity survives	yes, if every vertex variation is retained	conditional pass
reduced advanced/noise identity is now complete	scalar spectral positivity is insufficient	open
v8.1 or v8.2 result is superseded	no contradiction or replacement identified	none

IX.A What has genuinely advanced

The previous frontier treated ρ_{QQ} as an unspecified positive diagonal. This paper adds four concrete results:

1. a covariant leading finite-bath vertex class;

2. the exact once-subtracted spectral representation;
3. the unique positive ideal continuum associated with the selected Lorentz–Drude kernel;
4. a conditional formula that maps a projected warm-horizon noise plateau into the STF Ohmic slope.

The result removes ambiguity about spectral shape and about the distinction between response and noise.

IX.B What remains open

The following are not derived:

1. a unique microscopic material or horizon origin for c_α;
2. the numerical value of g_Q^2;
3. the factorization ratio r;
4. a unique ultraviolet continuation above the EFT band;
5. radiative protection of the zero-DC subtraction;
6. the finite-radius world-tube solution and its normalized projection tensor;
7. the near-zone/horizon non-overlap matching;
8. the coefficient-complete conservative contact set;
9. insertion into the full boundary-CMC Schur complement;
10. the complete lapse, shift, primary, secondary, and nonlinear Dirac algebra;
11. the full reduced advanced/noise deformed identity;
12. PPN, fifth-force, compact-body, or gravitational-wave safety;
13. any numerical phenomenology inferred from a version-9 branch.

IX.C Baseline disposition

No v8.1 or v8.2 theorem is withdrawn. The calculation is complementary to the compact-alignment source theorem and to the prior open-operator classification. Appendix V of v8.2 should be read with the following refinement:

- the selected Drude response has the explicit positive spectrum derived here;
- the overall Q-channel coefficient remains a microscopic matching datum;
- a warm horizon is one conditional source of the infrared slope, not a universal identification;
- the physical Ward grade is unchanged;
- the advanced/noise and boundary-CMC completion gates remain.

The overall grade therefore remains:

$$\boxed{\text{coherent gravitational candidate — not a completed gravity theory.}}$$

X. Acceptance and falsification conditions

The horizon interpretation of the Q bath passes only if a later calculation supplies all of the following:

1. a covariant varied projector from the horizon electromagnetic or tidal observable into $\mathcal{F}_Q$;

2. a system–environment split that avoids double counting $G_{\rm grav}$;
3. an explicit λ_H and normalization convention;
4. a spectral match over the claimed band, not only at $\omega = 0$;
5. the local conservative subtraction and remaining contact terms;
6. the horizon/environment stress and world-tube force;
7. compatibility with the full reduced deformed identity;
8. preservation of the jet and augmented CMC invertibility domains.

The interpretation fails if:

- the projected horizon spectrum is not nonnegative;
- its low-frequency power is not Ohmic in the regime used for the Drude match;
- the required projector is fixed externally rather than carried by varied world-tube data;
- the same modes occur both in $G_{\rm grav}$ and in the independent bath;
- the inferred g_Q^2 destabilizes the jet or CMC operator;
- the reduced retarded/noise kernels violate the full equation identity;
- the cutoff is asserted to equal κ without a matching calculation.

The third linked paper supplies a separate experimental lesson. A decoherence bound must specify whether the source protocol is fixed, optimized, or allowed to reopen after a cutoff time. That protocol dependence affects the inferred influence exponent. It does not alter the bath spectral normalization once the environment operator has been fixed.

XI. Exact next calculation

The next load-bearing calculation is no longer “write a positive ρ_{QQ}.” It is:

1. choose either a material multipole environment or a horizon/far-zone split;
2. construct the varied scalar projector and determine c_α or λ_H;
3. compute the full tensor-to-scalar retarded and noise kernels on the finite world tube;
4. perform overlap subtraction against $P_A G^{AB}_{\rm grav} P_B$;
5. match g_Q^2, ω_c, and the conservative contacts;
6. insert the resulting kernels into the coefficient-complete jet and augmented boundary-CMC Schur operator;
7. prove the physical and advanced/noise Ward identities with lapse, shift, boundary, and stochastic source equations;
8. run the full pole, positivity, and rank audit over the declared EFT domain.

Only that calculation can decide whether the horizon is the microscopic STF environment, one additive sector of it, or merely part of the inherited gravitational susceptibility.

XII. Reproducibility

The companion script

stf_v8_2_qdelta_environment_spectral_checks.py

uses NumPy only. It verifies:

- the regulated compact gradient $P_A = M_*^2 \mathcal{C}_A / s$;
- positivity of the Lorentz–Drude ρ_{QQ};
- the once-subtracted dispersion integral at complex retarded frequencies;
- the exact normalization moment;
- the zero-DC subtraction and spectral discontinuity;
- KMS noise positivity and the finite DC limit;
- rank-one response/noise factorization;
- invariance of the bath kinetic Hessian and the $58/116$ subtotal;
- the scalar chain-rule representative of the vertex Ward bookkeeping;
- the conditional warm-horizon FDT conversion and Drude-slope match;
- the state/protocol classification.

The default run reports eleven passes and ends with:

ALL ASSERTIONS PASSED

These checks verify the algebra displayed here. They do not simulate a black-hole quantum field, derive an STF world-tube solution, or prove the complete gravitational constraint algebra.

Appendix A. Analytic Drude integral

Set

$$\rho(\Omega) = \frac{g^2}{\pi} \frac{\Omega \omega_c}{\Omega^2 + \omega_c^2}.$$

The subtracted integrand is convergent:

$$\Sigma^R(z) = \frac{2g^2\omega_c}{\pi} \int_0^\infty d\Omega \, \frac{\Omega^2}{\Omega^2 + \omega_c^2} \left[\frac{1}{z^2 - \Omega^2} + \frac{1}{\Omega^2} \right].$$

The bracket simplifies to

$$\frac{z^2}{\Omega^2 (z^2 - \Omega^2)},$$

so

$$\Sigma^R(z) = \frac{2g^2\omega_c z^2}{\pi} \int_0^\infty \frac{d\Omega}{(\Omega^2 + \omega_c^2)(z^2 - \Omega^2)}.$$

For $\mathrm{Im}\, z > 0$, closing the contour consistently with retarded analyticity yields

$$\Sigma^R(z) = g^2 \frac{-iz}{\omega_c - iz}.$$

At real positive frequency,

$$\Sigma^R(\omega) = g^2 \frac{\omega^2 - i\omega\omega_c}{\omega^2 + \omega_c^2},$$

and hence

$$-\frac{1}{\pi}\mathrm{Im}\,\Sigma^R(\omega) = \frac{g^2}{\pi}\frac{\omega\omega_c}{\omega^2 + \omega_c^2} = \rho(\omega).$$

The same spectrum gives

$$2\int_0^\infty \frac{\rho(\Omega)}{\Omega}\,d\Omega = \frac{2g^2\omega_c}{\pi}\int_0^\infty \frac{d\Omega}{\Omega^2 + \omega_c^2} = g^2.$$

Appendix B. Response/noise dictionary

The convention used throughout is:

$$\rho_{QQ}(\omega) = -\frac{1}{\pi}\mathrm{Im}\,\Sigma^R_{QQ}(\omega + i0), \qquad \omega > 0,$$

and, in a KMS state,

$$\mathcal{N}_{QQ}(\omega) = -2\coth\left(\frac{\beta\omega}{2}\right)\mathrm{Im}\,\Sigma^R_{QQ}(\omega) = 2\pi\rho_{QQ}(|\omega|)\coth\left(\frac{\beta|\omega|}{2}\right).$$

If another source defines its symmetrized spectrum with an extra factor of $1/2$, 2, or 2π, the conditional horizon matching coefficient must be changed accordingly. The invariant content is:

1. positive-frequency absorptive weight is nonnegative;
2. Ohmic absorption is linear in ω;
3. warm KMS occupation converts it to finite zero-frequency symmetrized noise;
4. the state-dependent noise does not by itself fix the system–environment coupling.

References

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7. J. Wilson-Gerow, A. Dugad, and Y. Chen, *Decoherence by warm horizons*, arXiv:2405.00804.
8. D. L. Danielson, G. Satishchandran, and R. M. Wald, *Local Description of Decoherence of Quantum Superpositions by Black Holes and Other Bodies*, arXiv:2407.02567.
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Appendix Y — All-Loop Zero-DC Protection and Quantum-Stability Gate (G3)

Audit-gate record, carried verbatim from the accepted package (paste 3 of the 28 August 2026 program). Source file `STF_V8_2_All_Loop_Zero_DC_Protection_and_Quantum_Stability_Gate_V1_0.md` *, SHA-256* `f6c0284dc3d58064b9b5cc61c9b561d110c84a44297278e7788b160bbd737228` *. Section numbers below are local to this appendix.* **Version:** 1.0
Date: 28 August 2026
Status: standalone post-v8.2 calculation
Baseline rule: frozen v8.1 publication manuscript plus the calculation baseline and v8.2 gravitational-candidate revision
Excluded: every version-9 branch, claim, calculation, and status transfer

Abstract

STF First Principles v8.2 selects the causal high-pass response

$$K^R_{\mathrm{sel}}(\omega) = \frac{-i\omega}{\omega_c - i\omega}, \qquad K^R_{\mathrm{sel}}(0) = 0,$$

but leaves as open items 15 and 16 an all-loop zero-DC Ward identity and quantum or radiative stability. This paper decides what would be sufficient, tests it against the actual v8.2 doubled parent, and states the cost when the sufficient condition is absent. The comparison source is Braga, Jimenez, and Matarrese, *AI-Assisted Exploration: DHOST Theories without Quantum Ghosts*, arXiv:2604.16531v2. That work proves that a regular disformal field redefinition can transport an existing spectator gauge symmetry but cannot create radiative protection for a propagating scalar; the local spectator factor survives only when the same-field scalar sector is variationally trivial. Its contractible BV quartet supplies no independent local counterterm, deformation, or anomaly class, while a nonconstant dynamical scalar sector loses that protection.

There is a precise sufficient condition for STF zero-DC protection. If the complete regulated closed-time-path parent, measure, state, boundary conditions, and renormalization prescription possess a non-anomalous diagonal translation of the physical readout and retained environment,

$$\delta\widetilde{Q}_{\Delta,+} = \delta\widetilde{Q}_{\Delta,-} = \epsilon, \qquad \delta X_{\alpha,+} = \delta X_{\alpha,-} = \lambda_\alpha\epsilon, \qquad D_U\epsilon = 0,$$

then the 1PI Ward identity forbids an undifferentiated static Q_aQ_r contact. The resulting retarded kernel obeys $K^R(0) = 0$ to every loop order. A finite Gaussian environment written only through the relative coordinates $X_\alpha - \lambda_\alpha\widetilde{Q}_\Delta$ realizes this condition exactly inside that subtheory and locks the local subtraction to the inverse-frequency spectral moment. Equivalently, an exact history-difference influence

functional annihilates static histories. The functional form by itself, however, is not technically natural: without a symmetry that closes the counterterm algebra, loops may add the allowed local $Q_a Q_r$ operator.

The frozen v8.2 architecture does not establish the required symmetry. Its readout

$$\widetilde{Q}_\Delta = W(B) M_*^2 \left(\sqrt{q_N^2 + \Delta^2} - \Delta \right)$$

is a nonlinear curvature composite rather than an independent translation coordinate. A curvature transformation that would shift Q_Δ by a constant is singular at the regulated apex $q_N = 0$; shifting Q_Δ by ϵ/W is singular where the material window is off; and a window-weighted bath translation fails through activation whenever $D_U W \neq 0$. The compact readout, retained jets, memory bypass contacts, varied world tube, boundary-CMC data, and gravitational sector therefore admit a static $Q_a Q_r$ counterterm. Ordinary diffeomorphism invariance, KMS, causality, positivity, a global scalar shift, or a regular DHOST/disformal reparametrization does not forbid it.

Consequently, a protective symmetry exists in principle but has not been realized by v8.2. Open items 15 and 16 remain open. The minimum cost without an architectural symmetry is order-by-order tuning of one independent static QQ counterterm in the selected channel. The coefficient-complete response requires two homogeneous or five finite-momentum static subtraction conditions at each perturbative order. Their beta functions must be tuned to zero or compensated at every scale. Alternatively, promoting the readout to a genuine relative-coordinate/Stueckelberg sector requires a new field or gauge redundancy, a window-regular construction, symmetry-compatible state and boundary data, and a renewed compact-rank, jet, CMC, total-Ward, BV/BFV, noise, and anomaly audit. Making the readout a variationally trivial spectator would give the strongest local protection, but at the decisive cost of removing the physical response that the STF channel is meant to carry.

The grade is unchanged: **coherent gravitational candidate – not a completed gravity theory**.

I. Question, baselines, and scope

I.A Exact question

The calculation addresses only the following pair from v8.2 section VIII.F:

15. an all-loop zero-DC Ward identity;
16. quantum or radiative stability.

The target is not whether a subtraction can be imposed at tree level. The preceding environment calculation already established the once-subtracted finite-bath kernel

$$\Sigma^R_{QQ}(z) = G^R_{FF}(z) - G^R_{FF}(0), \qquad \Sigma^R_{QQ}(0) = 0.$$

The target is whether the zero is a consequence of an exact selection rule and therefore remains zero after quantum corrections, including corrections from the full doubled gravitational architecture rather than only the Gaussian bath.

I.B Frozen baselines

ROLE	FILE
v8.1 publication baseline	`STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md`

ROLE	FILE
v8.1 calculation baseline	`STF_First_Principles_Paper_V8_1_fixed(1).md`
v8.2 gravitational candidate	`STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md`
post-v8.2 environment gate	`STF_V8_2_Covariant_QDelta_Environment_Vertex_and_Horizon_Spectral_Gate_V1_0.md`

The release-manifest baseline and the calculation baseline differ by the already recorded one-line pair-level significance edit. No physics in the present calculation depends on that line. No version-9 document was consulted or imported.

I.C Source-paper control

The linked paper was read as arXiv:2604.16531v2, dated 15 August 2026, 30 pages. The downloaded PDF has SHA-256

`27679847edc1b58e7968fc36420b9d2e9d6c501dc63d3b2b2a82906b478ba4fc`.

The paper's result is used as a consistency framework, not as a claim transplant. Its field is a scalar in a regular disformal orbit; the STF readout is a curvature composite in an open, doubled, boundary-CMC construction. The relevant question is therefore whether the kind of exact gauge or cohomological protection isolated there has an actual counterpart in the STF parent.

II. What the DHOST paper establishes

II.A Regular-orbit spectator symmetry

The paper studies the regular first-derivative disformal map

$$\tilde{g}_{\mu\nu} = C(\phi, X)g_{\mu\nu} - D(\phi, X)\nabla_\mu\phi\nabla_\nu\phi,$$

with the regularity factors

$$W = C - DX, \qquad \mathcal{J} = C - XC_X + X^2D_X,$$

and the nonvanishing conditions $C \neq 0$, $W \neq 0$, and $\mathcal{J} \neq 0$. On this regular orbit a translation of a spectator scalar at fixed $\tilde{g}_{\mu\nu}$ pulls back to an exact field-dependent diffeomorphism plus a vertical local shift. The transformation is not the symmetry of a propagating scalar. It is the gauge redundancy of a variationally trivial spectator written in unusual field coordinates.

This distinction is load-bearing. The regular map can transport a gauge complex that already exists in the seed description. It cannot enlarge the physical counterterm protection merely because the transformed Lagrangian looks degenerate or higher derivative.

II.B Dynamical obstruction

When the same scalar is given a sector $K(\phi, \widetilde{X})$, the local vertical factor survives if and only if that scalar density is variationally trivial. For one scalar on a generic regular branch, this requires constant K. A nonconstant shift-symmetric $K(\widetilde{X})$ retains only the global shift. Explicit ϕ dependence generally removes even that. A cuscuton-like principal degeneracy is a different statement and is not the same local gauge symmetry.

For several spectators, determinant or minor null Lagrangians can be nonconstant topological exceptions when the number of scalars reaches the spacetime dimension. They do not supply bulk scalar dynamics, so they do not evade the physical content of the obstruction.

II.C Quantum statement

The paper lifts the spectator, its ghost, and their antifields to a contractible BV quartet. Under its local jet-algebra and boundary assumptions, the quartet adds no independent local counterterm, consistent gauge deformation, or anomaly class. For a pure four-dimensional Einstein seed on a contractible spacetime without a physical boundary, the cited Wess–Zumino classification then leaves no perturbative local gauge anomaly. The authors expressly preserve qualifications involving the measure, regulator, global topology, physical boundaries, and boundary completion.

The paper’s corollary is directly applicable to the present gate:

> A regular disformal choice of field coordinates cannot create a Ward identity that protects a propagating scalar built from that field. Genuine protection must be inherited from a seed symmetry or supplied by an independent nonrenormalization mechanism.

The canonical Einstein–scalar benchmark makes the same point at operator level. Global shift symmetry does not forbid the off-shell one-loop term $(\widetilde{\Box}\phi)^2$. At first loop order it is equation-of-motion redundant, and the essential on-shell representative is $\widetilde{X}^2$. Perturbative order reduction avoids interpreting the redundant term as a new mode at $O(\hbar)$, but it does not furnish an all-order nonrenormalization theorem. Algebraic degeneracy and perturbative mode control are therefore weaker than a Ward identity that forbids a particular counterterm.

II.D Consequence for STF

The STF problem cannot be solved by labeling the v8.2 parent DHOST, Horndeski, disformal, degenerate, or order-reduced. A regular field redefinition may preserve an existing identity and correlated counterterm structure; it cannot manufacture the missing zero-DC identity. The analysis must find an exact transformation of the complete STF doubled parent or accept a tuned subtraction.

III. The exact zero-DC Ward criterion

III.A Doubled variables and response

Let $\widetilde{Q}_{\Delta,+}$ and $\widetilde{Q}_{\Delta,-}$ be the two closed-time-path histories and define

$$\widetilde{Q}_{\Delta,r} = \frac{1}{2}\Big(\widetilde{Q}_{\Delta,+} + \widetilde{Q}_{\Delta,-}\Big), \qquad \widetilde{Q}_{\Delta,a} = \widetilde{Q}_{\Delta,+} - \widetilde{Q}_{\Delta,-}.$$

At quadratic order the 1PI influence functional contains

$$\Gamma^{(2)}_{\mathrm{IF}} = \int d^4x\, d^4x'\, \widetilde{Q}_{\Delta,a}(x) K^R_{QQ}(x,x')\widetilde{Q}_{\Delta,r}(x') + \frac{i}{2}\int d^4x\, d^4x'\, \widetilde{Q}_{\Delta,a}(x) N_{QQ}(x,x')\widetilde{Q}_{\Delta,a}(x').$$

The desired condition is

$$K^R_{QQ}(\omega = 0, \mathbf{k}) = 0$$

on the momentum domain claimed by the response theory. The noise kernel need not vanish at zero frequency. In a thermal Ohmic limit, finite white noise is compatible with a retarded kernel proportional to $-i\omega$.

III.B Sufficient symmetry theorem

Theorem 1 – Diagonal clock-line translation protects zero DC. Suppose the complete regulated microscopic doubled action, its functional measure, the initial state, the final-time gluing, all physical boundary conditions, and the renormalization prescription are invariant under

$$\delta\widetilde{Q}_{\Delta,+} = \epsilon, \qquad \delta\widetilde{Q}_{\Delta,-} = \epsilon,$$

together with transformations of every retained environmental or reference field needed to keep the microscopic action invariant. Assume no local, global, measure, or boundary anomaly. If $D_U\epsilon = 0$, the exact 1PI kernel has no static response in the protected sector. If ϵ is only a spacetime constant, this proves the homogeneous result $K^R(0,\mathbf{0}) = 0$. If $\epsilon = \epsilon(\sigma^A)$ may be chosen independently on each clock line, it proves $K^R(0,\mathbf{k}) = 0$ throughout the spatial momentum domain in which that subsystem symmetry exists.

Proof. On the closed time path the diagonal translation gives

$$\delta\widetilde{Q}_{\Delta,r} = \epsilon, \qquad \delta\widetilde{Q}_{\Delta,a} = 0.$$

The exact Ward identity is therefore

$$\int_{\mathcal{L}} d\tau \, \frac{\delta\Gamma}{\delta\widetilde{Q}_{\Delta,r}(\tau,\sigma)} = 0,$$

with a separate identity for each line label σ when the transformation is a subsystem symmetry. Differentiating once with respect to $\widetilde{Q}_{\Delta,a}$ and then setting the advanced fields to zero gives

$$\int_{\mathcal{L}} d\tau' \, K^R_{QQ}(\tau,\sigma;\tau',\sigma') = 0.$$

Fourier transformation along the stationary clock line sets the integral to $K^R_{QQ}(0,\mathbf{k})$. Because this is a Ward identity of the regulated quantum theory, symmetry-preserving counterterms satisfy it order by order. In particular, the local operator $\int Q_a Q_r$, whose variation is proportional to $\int Q_a\epsilon$, is forbidden. $\square$

The theorem is sufficient, not necessary. More exotic spectral or topological cancellations could set the static response to zero. Without a selection rule those cancellations are matching conditions rather than radiative protection.

III.C Relation to the already derived total Ward identity

The v8.2 total Ward identity is the diagonal diffeomorphism identity of the varied parent. Schematically,

$$\nabla_\mu T^\mu{}_{\nu,\mathrm{tot}} = \sum_I E_I \nabla_\nu \Psi^I \text{tensor-index terms},$$

where the sum includes the clock, compact readout, memory, jets, world tube, environment, boundary data, and matter. It implies total stress conservation only after every retained equation is imposed. This identity does not imply $K^R(0) = 0$: the local covariant operator $\sqrt{-g}\,\widetilde{Q}_{\Delta,a}\widetilde{Q}_{\Delta,r}$ is compatible with diagonal diffeomorphisms when all of its metric and material variations are kept.

The clock-line translation would be an additional internal Ward identity. If realized, it would supplement rather than deform the diffeomorphism identity. If it is not realized, tuning the zero-DC counterterm does not invalidate total covariance, but the tuned counterterm must be varied with respect to the metric, compact readout, world-tube field, clock data, and boundaries. Omitting those variations would create precisely the source-force defect that the v8.2 retained-carrier construction was designed to avoid.

IV. Exact relative-coordinate realization in the retained environment

IV.A Microscopic completed square

Consider a stationary local clock tube and the finite environment

$$S_{\rm rel} = \frac{1}{2}\sum_{\alpha}\int d^4x\sqrt{-g}\,\left[(D_U X_\alpha)^2 - \Omega_\alpha^2\left(X_\alpha - \lambda_\alpha \widetilde{Q}_\Delta\right)^2\right].$$

It is invariant under

$$\delta\widetilde{Q}_\Delta = \epsilon, \qquad \delta X_\alpha = \lambda_\alpha \epsilon, \qquad D_U\epsilon = 0,$$

provided any transverse bath derivatives, state, and boundary data share the same symmetry. Expanding the square gives

$$-\frac{1}{2}\Omega_\alpha^2 X_\alpha^2 + c_\alpha X_\alpha \widetilde{Q}_\Delta - \frac{1}{2}\frac{c_\alpha^2}{\Omega_\alpha^2}\widetilde{Q}_\Delta^2, \qquad c_\alpha = \Omega_\alpha^2\lambda_\alpha.$$

Thus the bilinear vertex and its local static counterterm are not independent coefficients. The common-translation null vector of the potential Hessian is

$$v_0 = (1, \lambda_1, \ldots, \lambda_n).$$

The NumPy checker verifies directly that this vector is null and that the remaining finite-bath eigenvalues are positive for the tested positive Ω_α^2.

IV.B Integration and spectral moment

Gaussian integration produces

$$\Sigma^R_{QQ}(z) = \sum_\alpha c_\alpha^2\left[\frac{1}{z^2 - \Omega_\alpha^2} + \frac{1}{\Omega_\alpha^2}\right],$$

so

$$\Sigma^R_{QQ}(0) = 0.$$

With the positive finite-bath spectral density

$$\rho_{QQ}(\Omega) = \sum_\alpha \frac{c_\alpha^2}{2\Omega_\alpha}\delta(\Omega - \Omega_\alpha),$$

the symmetry-locked local contact is the inverse-frequency moment

$$c_{\rm ct} = 2\int_0^\infty \frac{\rho_{QQ}(\Omega)}{\Omega}\,d\Omega = \sum_\alpha \frac{c_\alpha^2}{\Omega_\alpha^2}.$$

The sign with which this coefficient appears in the action is fixed by the convention for G^R_{FF}; the invariant statement is

$$\Sigma^R_{QQ}(z) = G^R_{FF}(z) - G^R_{FF}(0).$$

At each loop order a genuine symmetry requires the renormalized contact and spectral moment to move together:

$$\delta c_{\mathrm{ct}}^{(L)} = 2\int_0^\infty \frac{\delta\rho_{QQ}^{(L)}(\Omega)}{\Omega}\,d\Omega.$$

This is the useful content of the zero-DC Ward identity. It is stronger than imposing the equality once at a matching scale.

IV.C Exactness and limitation

For the regulated finite Gaussian bath the integration is exact: there are no bath self-interaction loops, and the completed square fixes the subtraction. That is an **exact result within the Gaussian environment subtheory**. It does not prove that gravitational, compact-readout, memory, world-tube, or boundary loops obey the same coefficient locking. Nor does it prove that a continuum Drude completion preserves the symmetry without a symmetry-compatible regulator and state.

The continuum density already derived for the Drude model,

$$\rho_{QQ}^{D}(\Omega) = \frac{g_Q^2}{\pi}\frac{\Omega\omega_c}{\Omega^2+\omega_c^2},$$

has

$$2\int_0^\infty \frac{\rho_{QQ}^{D}(\Omega)}{\Omega}\,d\Omega = g_Q^2,$$

and produces

$$\Sigma_{QQ}^{R}(z) = g_Q^2\frac{-iz}{\omega_c-iz}.$$

The finite thermal noise $N_{QQ}(0)=4g_Q^2/(\beta\omega_c)$ is compatible with the symmetry because the diagonal translation changes the physical r-field but not the advanced a-field. The symmetry forbids the static retarded contact; it does not forbid Q_aQ_a noise.

V. Functional-form alternatives

V.A History-difference form

A sufficient exact 1PI functional form on each clock line is

$$\Gamma_{\mathrm{IF}}^{\mathrm{diff}} = \int d\tau\,d\tau'\,Q_a(\tau)L^R(\tau-\tau')\left[Q_r(\tau')-Q_r(\tau)\right]+\Gamma_{aa}[Q_a]+\cdots.$$

A static Q_r history makes the bracket vanish. Equivalently, the retarded kernel may be written

$$K^R(\omega,\mathbf{k}) = -i\omega F^R(\omega,\mathbf{k})$$

with F^R regular at $\omega=0$. The selected Drude response is the special case

$$F^R(\omega) = \frac{1}{\omega_c-i\omega}.$$

This functional form is closed under quantum corrections only if a symmetry, exact microscopic relative-coordinate construction, or nonrenormalization theorem prevents an additive local Q_aQ_r term. Declaring the form at tree level is not enough. In Wilsonian language, $Q_a Q_r$ is allowed by the presently established v8.2 symmetries and is therefore generated unless its coefficient happens to vanish.

V.B Derivative-only coupling

Another sufficient classical condition is to place a clock derivative on every physical readout insertion. A constant readout then decouples. But replacing two ordinary vertices by derivative vertices multiplies a bath kernel by ω^2. For an ordinary Ohmic environment,

$$K^R_{\mathrm{bath}}(\omega) \sim -i\gamma\omega \quad \Longrightarrow \quad K^R_{\mathrm{deriv}}(\omega) \sim -i\gamma\omega^3.$$

This protects zero DC at the cost of changing the infrared response. Retaining the v8.2 linear Drude behavior would require an infrared-singular or additional gapless environmental response that compensates the two derivatives. That replacement would introduce new low-energy structure, noise, state dependence, and a new rank/infrared audit. Derivative-only coupling is therefore not a cost-free implementation of the selected kernel.

V.C Algebraic subtraction without symmetry

The condition

$$K^R_{QQ}(0) = 0$$

can always be imposed as a renormalization condition by choosing a local counterterm. This is the scheme used in the preceding finite-environment gate. It is legitimate but not radiative protection. The distinction is:

STRUCTURE	ZERO AT MATCHING SCALE	STABLE UNDER LOOPS	STABLE UNDER RG	STATUS
one-time subtraction	yes	no	no	matching convention
Gaussian completed square	yes	exact inside Gaussian bath	yes inside that fixed subtheory	derived subtheory result
exact non-anomalous clock-line translation	yes	yes	yes in a symmetry-preserving scheme	sufficient theorem
history-difference ansatz without symmetry	yes	not established	not established	functional assumption
derivative-only coupling	yes	only if derivative selection rule is exact	conditional	changes infrared response

VI. Test against every relevant v8.2 module

VI.A Compact curvature readout

The physical v8.2 readout is

$$Q_\Delta = M_*^2\,(s - \Delta), \qquad s = \sqrt{q_N^2 + \Delta^2}, \qquad q_N^2 = \mathcal{C}_A \mathcal{C}^A,$$

with gradient

$$P_A = \frac{\partial Q_\Delta}{\partial \mathcal{C}^A} = M_*^2 \frac{\mathcal{C}_A}{s}.$$

A formal radial variation that shifts Q_Δ by ϵ is

$$\delta \mathcal{C}^A = \frac{s}{M_*^2 q_N^2} \mathcal{C}^A \epsilon,$$

because $P_A \delta \mathcal{C}^A = \epsilon$. Its norm behaves as

$$\|\delta \mathcal{C}\| = \frac{s}{M_*^2 q_N} |\epsilon| \longrightarrow \infty \qquad (q_N \to 0,\ \Delta > 0).$$

It is therefore singular exactly at the regulated apex where the compact readout was constructed to remain smooth and constant-rank. It is also not an established diffeomorphism, constraint gauge direction, or symmetry of the gravitational action. The compact alignment variables solve the readout optimization problem; they do not make translations of the nonlinear curvature norm a gauge redundancy.

This is the central obstruction. The symmetry acts naturally on an independent coordinate. In v8.2 the would-be coordinate is a composite of physical curvature data.

VI.B Material activation window

The environment sees

$$\widetilde{Q}_\Delta = W(B) Q_\Delta, \qquad W(B) = B^2(3 - 2B).$$

Trying to realize $\delta \widetilde{Q}_\Delta = \epsilon$ through the compact readout gives

$$\delta Q_\Delta = \frac{\epsilon}{W(B)},$$

which is singular wherever the channel is off, $W = 0$. Alternatively, one may try

$$\delta Q_\Delta = \epsilon, \qquad \delta X_\alpha = \lambda_\alpha W(B) \epsilon.$$

The relative potential can then be invariant, but the bath kinetic term varies through

$$D_U \delta X_\alpha = \lambda_\alpha \epsilon D_U W.$$

The transformation works on stationary activation plateaus where $D_U W = 0$, not through the activation crossover. A field-dependent transformation could be enlarged with additional compensators, but no such regular window-covariant multiplet is present in the frozen architecture.

VI.C Exact high-pass memory pair

The retained first-order memory pair realizes the tree-level transfer

$$K_{\mathrm{sel}}^R(\omega) = \frac{-i\omega}{\omega_c - i\omega}.$$

Within the isolated linear memory module, a static input is annihilated. The all-loop question concerns bypass operators generated when the memory variables are coupled to the compact readout, jets, gravity, world tube, and environment. A local $Q_a Q_r$ contact does not need to pass through the memory pole. The exact classical realization of the transfer function therefore remains valid while the complete quantum response acquires an additive static term. Protecting the memory topology requires a symmetry of the complete parent, not only the auxiliary memory equations.

VI.D Retained curvature jets and conservative contacts

The independently retained jets are the correct variables for the action-level order-reduced gravitational route, but the established constraint and diffeomorphism structure permits conservative local form factors. At homogeneous level the strong response has two independent conservative structures; at finite momentum the parity-even scalar, vector, and tensor blocks contain five. KMS and positivity constrain absorptive and noise data. They do not fix these real local subtractions.

No established jet constraint transforms as the readout translation of Theorem 1. The zero-frequency constants therefore remain allowed in the coefficient-complete jet kernel and in the CMC Schur complement.

VI.E Boundary-selected CMC clock

The boundary-CMC condition can remove the gravitational scalar only when its augmented CMC–volume Jacobi operator is invertible and the full Ward identity closes. It is a temporal gauge/boundary condition, not a translation symmetry of the curvature readout. Physical boundaries are also one of the explicit qualifications in the DHOST paper's BV result. Any proposed local or subsystem translation must preserve the CMC boundary data, final-time closed-path gluing, the global volume mode, and the appropriate BV–BFV boundary structure. That audit has not been performed.

Consequently the CMC construction neither supplies the zero-DC Ward identity nor contradicts it. It is an additional compatibility gate.

VI.F Varied world tube

The varied world tube is required for total stress exchange and removes the source-force defect of a fixed external projector. Its window force is nonzero when the interaction or its counterterm depends on B. The world-tube action, state, and boundary conditions are not invariant under an identified transformation that shifts $W(B)Q_\Delta$ by a constant. Because the subtraction contains $W(B)^2Q_\Delta^2$, tuning it changes the material equation and stress. Those variations are part of the total Ward identity and cannot be discarded.

VI.G Retained environment

The finite Gaussian environment can be rewritten as the relative-coordinate completed square and then has exact bath-subtheory protection. A generic interacting environment need not. Self-potentials $V(X_\alpha)$, transverse gradients, nonlinear couplings, a noninvariant state, or physical wall data can break the common translation. The horizon-sourced environments studied in the previous gate provide possible infrared spectral behavior, not an STF readout translation symmetry. They therefore do not change the present conclusion.

VI.H Component audit

V8.2 MODULE	CONDITION REQUIRED FOR ZERO-DC PROTECTION	FROZEN V8.2 RESULT	CONSEQUEN
compact readout	regular translation of WQ_Δ or a compensating gauge field	curvature realization is singular at $q_N = 0$	no full symmetry
memory pair	forbid additive bypass Q_aQ_r contacts	isolated transfer has zero DC; bypass is allowed	tree-level exa quantum gate open
retained jets	translation-compatible contact algebra	static conservative contacts allowed	zero not protected

V8.2 MODULE	CONDITION REQUIRED FOR ZERO-DC PROTECTION	FROZEN V8.2 RESULT	CONSEQUEN
boundary CMC	invariant boundary data and BV–BFV completion	not derived	compatibility open
varied world tube	regular symmetry through $W = 0$ and $D_U W \neq 0$	naive transformation is singular or crossover-breaking	no global activation symmetry
finite Gaussian environment	dependence only on $X_\alpha - \lambda_\alpha \widetilde{Q}_\Delta$	available inside bath subtheory	exact subthe pass
full retained environment	invariant interactions, state, regulator, and walls	not established	radiative stability open
total doubled parent	non-anomalous diagonal translation plus diffeomorphisms	only diagonal diffeomorphism Ward identity established	items 15–16 remain open

VII. Why the DHOST spectator mechanism cannot be imported

VII.A Regular redefinition is insufficient

One might try to find a regular field redefinition in which Q_Δ looks like a spectator. The source paper rules out the inference that such a chart creates protection. If the transformed variable is genuinely dynamical, the local spectator factor is obstructed; if it is variationally trivial, the local symmetry is real but the variable supplies no bulk physical response. Regular orbit equivalence transports the seed's symmetry and counterterms. It does not change this dichotomy.

VII.B Cost of the strongest local option

Putting $\widetilde{Q}_\Delta$ into a contractible BRST quartet would remove its independent local cohomology. That would strongly protect it from an independent static counterterm. It would also make the readout direction gauge or redundant. The STF environment then could not use that direction as a physical dissipative channel unless a separate gauge-invariant relative observable were introduced. The physical response would have to move to that new observable, where its counterterms and zero-DC protection would have to be analyzed again.

The cost is therefore not merely one auxiliary ghost pair. It is the loss of the present physical interpretation of Q_Δ as the curvature readout driving the retained environment.

VII.C Global translation is weaker but potentially usable

A global or clock-line common translation of a physical relative-coordinate system does not make all relative modes gauge. It leaves dissipation of relative motion possible, as in translationally invariant Brownian models. This is the promising sufficient condition in Theorem 1. But v8.2 would have to promote the translated coordinate to an independent regular field or introduce a reference field, then express the readout and every coupling through invariant differences. That is a change to the architecture, not a theorem about the frozen one.

VIII. Cost when no protective symmetry is added

VIII.A Selected scalar channel

Let the renormalized static coefficient be

$$c_0(\mu) = c_{\mathrm{ct}}(\mu) + \Sigma^R_{\mathrm{loops}}(0;\mu).$$

Without a Ward identity, zero DC is the condition

$$c_0(\mu_*) = 0$$

at a chosen matching scale μ_*. Perturbatively this requires

$$c_{\rm ct}^{(L)} = -\Sigma_{QQ}^{R,(L)}(0)$$

at each loop order. Its renormalization-group equation is generically

$$\mu \frac{dc_0}{d\mu} = \beta_{c_0} \neq 0.$$

Thus a zero imposed at one scale moves away from zero at another unless the running is continually compensated. In the v8.2 normalization, $[Q_\Delta] = 4$ and the local quadratic kernel has mass dimension -4. A generic loop estimate may be parameterized as

$$\delta c_0^{(L)} \sim \frac{1}{(16\pi^2)^L \Lambda_{\rm EFT}^4} F_L(\text{dimensionless couplings and ratios}).$$

The corpus does not yet supply the coefficient-complete couplings or the cutoff needed to evaluate F_L. A numerical tuning cost would therefore be invented. The exact statement is structural: the zero is not technically natural in the presently established symmetry class.

If observations or matching permit a residual $|c_0| < \varepsilon_{\rm stat}$, the required relative tuning at loop order L is

$$\mathcal{T}_L \lesssim \frac{\varepsilon_{\rm stat}}{|\delta c_0^{(L)}|}.$$

Neither numerator nor denominator is fixed in v8.2, so this formula is the strongest honest quantitative statement.

VIII.B Coefficient-complete response

For only the selected scalar QQ channel, the minimum burden is one static counterterm per perturbative order. For the full response already counted in v8.2, the burden is larger:

- two independent homogeneous zero-frequency conservative matching conditions;
- five independent finite-momentum parity-even zero-frequency form factors, in general functions of $\mathbf{k}^2$, at each order;
- separate finite real $O(\omega^2)$ contacts not fixed by the zero-DC condition;
- insertion of every chosen contact into the jet operator and augmented CMC Schur complement;
- metric, readout, clock, world-tube, boundary, and environmental variations required by the total Ward identity.

KMS, spectral positivity, and fluctuation–dissipation relations do not pay this cost because they do not determine the real local subtraction polynomial.

VIII.C Cost of adding the protective architecture

An honest protective completion would require all of the following:

1. promote $\widetilde{Q}_\Delta$ to an independent shift/Stueckelberg coordinate or add a regular reference field;
2. express the microscopic bath, memory, activation, and conservative contacts through translation-invariant relative coordinates or history differences;

3. replace the singular ϵ/W construction with a regular symmetry through $W=0$ and the activation crossover;
4. choose a regulator, measure, initial density matrix, final-time gluing, physical wall data, and CMC boundary data that preserve the transformation;
5. prove absence or cancellation of local, global, measure, and boundary anomalies;
6. rerun the compact-alignment constant-rank proof and the established $58/116$ primary structural subtotal;
7. recompute the jet Jacobian, complete secondary chain, augmented CMC–volume operator, and total physical/advanced/noise Ward identities;
8. verify that the new field does not add an unwanted physical mode or a changing-rank surface;
9. rederive the Drude spectral density and noise in the symmetry-preserving variables.

This is a finite program, but it is not already contained in v8.2.

IX. Quantum and Ward consequences

IX.A No change to the established total identity

The present result does not invalidate the total Ward identity derived for the fully varied parent. A covariant tuned counterterm is compatible with that identity when all carrier variations are included. What fails is the stronger inference

$$\text{diagonal diffeomorphism invariance} \quad \Longrightarrow \quad K^R_{QQ}(0)=0.$$

That implication is false. The missing internal Ward identity would add a row to the response constraints; it is not hidden inside the diffeomorphism row.

IX.B No automatic rank upgrade or failure

A static QQ contact is algebraic in the retained readout and does not by itself add a primary bath velocity. It therefore does not change the already established readout-plus-memory/environment primary subtotal merely by existing. It can, however, change the secondary coefficient matrix, the reduced jet kernel, and the augmented CMC Schur complement. Constant primary rank is not enough to establish the complete gravitational count.

Accordingly:

- the $58/116$ structural subtotal remains what it was;
- the conditional jet and CMC invertibility theorems remain conditional;
- the coefficient-complete two-tensor count remains open;
- anomaly freedom of the complete system-plus-environment parent remains open;
- no claim is withdrawn and no claim is upgraded.

IX.C Noise and dissipation

Zero static retarded response does not mean zero dissipation or zero noise. The protected Drude form has

$$\operatorname{Im} K^R_{\rm sel}(\omega) \propto -\omega \qquad (\omega\to 0),$$

and its thermal noise approaches a constant. The common-translation Ward identity only removes sensitivity to a static absolute readout. It leaves the environment free to respond to relative motion and time variation. This is why the global/clock-line relative-coordinate option can in principle preserve the physical open channel, whereas a variationally trivial local spectator would remove it.

X. Graded claim ledger

CLAIM	EVIDENCE	GRADE IN THIS CALCULATION	EFFECT ON V8.2
an exact non-anomalous diagonal clock-line translation implies $K^R(0) = 0$ at all loops	1PI Ward derivation in section III	**conditional theorem**	supplies a sufficient target, not an achieved status
a spatially global translation protects only $(\omega, \mathbf{k}) = (0, \mathbf{0})$	Ward support of the transformation	**proved**	finite-k protection needs a line-wise subsystem symmetry
a line-wise $D_U\epsilon = 0$ symmetry protects $K^R(0, \mathbf{k})$	differentiated Ward identity	**conditional theorem**	requires compatible transverse terms and boundaries
finite Gaussian completed-square bath has zero DC	exact Gaussian integration and null Hessian	**derived/exact in subtheory**	validates the prior subtraction inside that regulator
Drude contact equals the spectral inverse moment	analytic integral and checker	**reproduced**	no change to spectral gate
history-difference form annihilates static histories	direct functional evaluation	**proved as a functional condition**	not radiatively stable without closure symmetry
ordinary diffeomorphisms imply zero DC	covariant Q_aQ_r contact is allowed	**false**	total Ward identity remains a different identity
KMS or positivity fixes the static contact	real local polynomial is spectrally invisible	**false**	conservative matching remains open
exact memory alone protects the full quantum kernel	additive bypass contacts are allowed	**not established**	tree-level memory remains exact
regular disformal/DHOST coordinates create protection	source-paper no-frame-generated-protection corollary	**false**	no DHOST label upgrade
variationally trivial spectator protection can be imported without cost	it removes the physical readout direction	**false**	strongest option changes the theory's channel
frozen v8.2 realizes a regular common translation of WQ_Δ	apex and window obstructions	**fails as presently realized**	open item 15 remains open
full v8.2 zero-DC condition is radiatively	no full symmetry and no loop beta	**open**	open item 16 remains open

CLAIM	EVIDENCE	GRADE IN THIS CALCULATION	EFFECT ON V8.2
stable	calculation		
one tuned selected-channel subtraction is sufficient at a fixed order and scale	local counterterm freedom	**conditional matching statement**	not technical naturalness
full strong response costs two homogeneous or five finite-k static matches	retained v8.2 contact count	**carried forward/reproduced**	no count change
total physical Ward identity survives a tuned counterterm	true when all carrier variations are kept	**conditional pass unchanged**	no Ward withdrawal
overall theory grade improves	open symmetry, rank, and anomaly gates remain	**no**	grade unchanged

XI. Direct answers to open items 15 and 16

XI.A Open item 15 – all-loop zero-DC Ward identity

Answer: a sufficient protective identity exists. It is the Ward identity of a non-anomalous diagonal common translation of the physical readout and its retained reference/environment coordinates. A Gaussian completed-square bath realizes it exactly inside the bath subtheory. The frozen v8.2 doubled parent does not realize it globally because $W(B)Q_\Delta[g,N]$ is a nonlinear, windowed curvature composite and no regular transformation of the compact readout, gravity, jets, memory, CMC boundary data, and world tube has been supplied. Item 15 therefore remains **open**.

XI.B Open item 16 – quantum or radiative stability

Answer: radiative stability follows conditionally if the full microscopic action, measure, state, regulator, boundaries, and renormalization scheme possess the symmetry above and if its anomaly class vanishes. Those hypotheses have not been demonstrated. The functional high-pass form or one-time subtraction alone is not stable against an allowed Q_aQ_r counterterm. Item 16 therefore remains **open**.

XI.C Cost if no protection is added

The irreducible cost is order-by-order tuning of the static response:

$$c_{QQ}^{(L)} = -\Sigma_{QQ}^{R,(L)}(0).$$

This is one coefficient in the selected scalar channel, two independent homogeneous conditions in the full conservative response, or five finite-momentum zero-frequency form factors in the strong response. Their scale dependence must also be controlled. No numerical fine-tuning factor can be honestly quoted until the microscopic couplings, cutoff, and allowed residual static response are specified.

The alternative cost of exact protection is architectural: add a regular relative-coordinate or Stueckelberg/reference sector and repeat the full rank, boundary, anomaly, and Ward analysis. The local spectator/BV-quartet route is even more expensive conceptually because it makes the readout redundant and therefore removes the present physical dissipative channel.

XII. What is not established

This calculation does not establish:

1. an actual symmetry transformation of the full v8.2 compact-readout/gravity/world-tube parent;
2. anomaly freedom of such a transformation;
3. a symmetry-preserving activation construction through $W=0$ and $D_UW\neq 0$;
4. a coefficient-complete one-loop calculation of the v8.2 parent;
5. the beta functions of the one, two, or five static contacts;
6. a numerical naturalness or tuning measure;
7. a BV–BFV completion at the physical CMC/world-tube boundary;
8. an all-order nonrenormalization theorem for the compact curvature readout;
9. a new proof of complete Hamiltonian or Dirac rank;
10. a UV completion of the Drude continuum;
11. any result, status, or premise from v9.0.

XIII. Decisive next calculation

There are two non-equivalent next gates.

Symmetry-completion route. Introduce an independent regular reference coordinate R and construct the physical environmental variable from a relative combination, for example $\mathcal{Y}=\widetilde{Q}_\Delta-R$, with a diagonal translation $\delta\widetilde{Q}_\Delta=\delta R=\epsilon$. The compact constraint tying an independent $\widetilde{Q}_\Delta$ to $WQ_\Delta[g,N]$ must itself be made invariant without $1/W$ or $1/q_N$ singularities. Then compute the complete primary and secondary rank, boundary charge, measure Jacobian, and advanced/noise Ward complex.

No-new-field route. Keep the frozen architecture and compute the one-loop 1PI coefficient of Q_aQ_r in the minimal compact-readout–memory–environment parent. This directly evaluates β_{c_0} and converts the structural naturalness statement into a model-dependent tuning estimate. A nonzero result would not falsify v8.2; it would quantify the recurring subtraction cost. A vanishing result would still require identifying the symmetry or cancellation that makes the vanishing persist beyond that loop order.

The symmetry-completion route is the only route capable of closing items 15 and 16 as theorems. The loop route quantifies the cost if they remain matching conditions.

XIV. Reproducibility

The accompanying NumPy checker independently evaluates:

1. the selected Drude zero;
2. the common-translation null vector of the finite relative-coordinate bath;
3. exact zero static response after Gaussian integration;
4. equality of the local contact and inverse-frequency spectral moment;
5. preservation under symmetry-locked loop renormalization;
6. violation by an independent static contact;
7. RG motion when $\beta_{c_0}\neq 0$;
8. annihilation of static histories by a difference kernel;
9. exactness on activation plateaus and failure through $D_UW\neq 0$;

10. singularity of the curvature realization at $q_N = 0$;
11. the $\omega \to \omega^3$ infrared cost of two derivative vertices;
12. the two/five contact burden;
13. the open-item and baseline claim ledger.

Successful execution ends with

`ALL ASSERTIONS PASSED`.

XV. Final grade

The linked DHOST analysis sharpens the criterion but does not close the STF gate. It confirms that counterterm protection must come from a real symmetry of the seed or microscopic parent, not from a field-coordinate label or degeneracy condition. STF v8.2 has an exact Gaussian bath realization of the required subtraction and a clear candidate common-translation symmetry, but its nonlinear curvature composite, activation window, retained gravitational sectors, and boundaries do not yet realize that symmetry.

Open items 15 and 16 remain open. No earlier result is withdrawn. The total Ward identity retains its conditional pass. The overall grade remains:

> **Coherent gravitational candidate – not a completed gravity theory.**

References

1. G. Braga, R. Jimenez, and S. Matarrese, *AI-Assisted Exploration: DHOST Theories without Quantum Ghosts*, arXiv:2604.16531v2 (2026), https://arxiv.org/abs/2604.16531.
2. *STF First Principles v8.1*, frozen publication manuscript, `STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md`.
3. *STF First Principles v8.1*, calculation baseline, `STF_First_Principles_Paper_V8_1_fixed(1).md`.
4. *STF First Principles v8.2: Coherent Gravitational Candidate*, `STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md`.
5. *STF v8.2 Covariant Q_Δ Environment Vertex and Horizon Spectral Gate*, version 1.0, `STF_V8_2_Covariant_QDelta_Environment_Vertex_and_Horizon_Spectral_Gate_V1_0.md`.

Appendix Z — Gravitational-Wave Emission Audit — Direct Local Action versus Analytic Parent (G4)

Audit-gate record, carried verbatim from the accepted package (paste 4 of the 28 August 2026 program). Source file `STF_V8_2_Gravitational_Wave_Emission_Audit_Direct_Local_and_Analytic_Parent_V1_0.md`*, SHA-256* `a78576364bc446ee5e6b77e8e3c778ef49e4f17b3a0cb60a4152d72b7ab01ac7`*. Section* *numbers below are local to this appendix. Direct Local q_N Metric Action versus the Analytic Order-Reduced Parent*

Version: 1.0
Date: 28 August 2026
Status: standalone post-v8.2 consistency gate
Baseline rule: frozen v8.1 publication and calculation baselines, graded through v8.2
Excluded: every v9.0 file, premise, calculation, and status transfer

Abstract

This paper performs the gravitational-wave emission audit requested for two sharply different STF realizations. Sector (a) is the closed direct local metric action of v8.2 Appendices P.2 and S,

$$S_{\rm direct}=S_{\rm EH}+S_\phi+\kappa\int d^4x\sqrt{-g}\,\phi D_U q_N[g,N],\qquad q_N=\sqrt{R^2+8\mathcal{W}_N}.$$

Sector (b) is the surviving clock-adapted, action-level order-reduced parent on the branch analytic in $\epsilon_{\rm STF}$, with independent curvature jets, compact readout, exact memory, varied world tube, retained environment, and boundary-selected CMC time. Both are confronted with the binary-pulsar and GW170817 scales used by Lambiase, Mukohyama, Poddar, and Rescigno in *Exorcising ghosts with gravitational waves: cases of ghostful and ghost-free fourth-order gravity*, arXiv:2510.17789v1.

The linked paper derives two observational thresholds for any additional massive mode: it modifies the conservative force when its Compton range reaches the binary separation, $m\lesssim 1/a$, and it can be radiated when it is on shell, $m\lesssim n\Omega$ for an eccentric harmonic or $m\lesssim 2\Omega$ for a circular inspiral. For PSR B1913+16 and PSR J1738+0333 the reproduced fundamental thresholds are respectively

$$\hbar\Omega=(1.482,1.349)\times10^{-19}\ \mathrm{eV},\qquad \frac{\hbar c}{a}=(1.012,1.140)\times10^{-16}\ \mathrm{eV}.$$

The paper's standard ghostful fourth-order model is forced into a heavy-mode regime and gives the stronger GW170817 scale $m\gtrsim10^{-11}\ \mathrm{eV}$. Its ghost-free torsion model instead approaches GR as its couplings vanish and receives mass-dependent coupling bounds. Those numerical curves cannot be copied directly to STF: the direct STF pole is background dependent and lacks the paper's fixed spin-2/spin-0 residue pattern, while the analytic STF parent has no derived map to the paper's (m,α_1,α_2).

For the direct action, the exact v8.2 tensor Hessian already gives

$$S^{(2)}_{\rm rate}\supset-\frac{\kappa A_0}{4|R_0|}\int d^4x\,a^3\ddot\gamma_{ij}\ddot\gamma^{ij},\qquad A_0=\dot\phi_0+3H\phi_0,$$

and the factorized tensor propagator has equal and opposite residues. A locally frozen canonical pole diagnostic is

$$m^2_{\rm gh}(x)=\frac{M^2_{\rm Pl}q_N(x)}{2\kappa|A(x)|},$$

up to the explicitly acknowledged order-unity polarization normalization. With the v8.2 $\kappa=1.0189\times10^{70}$, the v8.1 tracking or oscillating scalar benchmarks, and declared FLRW/Schwarzschild curvature proxies, the diagnostic lies from $10^{-38}\ \mathrm{eV}$ on FLRW through about $10^{-24}\ \mathrm{eV}$ at pulsar separations and 10^{-19}–$10^{-16}\ \mathrm{eV}$ across the illustrative GW170817/NS radii. These numbers place the extra pole inside, not above, the linked paper's active force/radiation windows under

the local frozen-coefficient comparator. They are not promoted to an STF waveform because the full binary principal symbol, source residue, scalar sector, and world-tube projection are absent.

The direct action also fails a separate domain test. Its rate form is the $|\omega| \ll \omega_c$ truncation of the exact memory kernel, whereas the pulsar frequencies exceed $\omega_c \simeq m_s$ by more than 3.4×10^3, and a 10 Hz angular frequency exceeds it by about 1.05×10^9. The local truncation would over-extrapolate the exact response by those factors. Thus the direct action is neither a healthy fundamental metric theory nor a controlled emission approximation at the observations under review. It remains **closed generically**; the new audit strengthens the reason not to use it but does not change its grade.

For the analytic parent, order reduction does not resum the fourth-order denominator. On the Einstein-connected branch it expands the retarded solution perturbatively and admits no independent ghost pole below the EFT cutoff, provided the jet and CMC bounds hold and the complete reduced constraint algebra closes. Ghost emission is therefore **conditionally absent**. That does not constitute an observational pass. The coefficient-complete tensor kernel, source normalization, activation history, compact-body charges, matter-corrected jet matrix, environmental spectral flux, and merger solution are not derived. The exact memory is already saturated at pulsar and LIGO frequencies, so it supplies no high-frequency suppression. Using the linked paper's own input table, a minimal one-sigma diagnostic requires total Hulse-Taylor orbital-decay corrections below approximately 3.59×10^{-3}; its 0.4% GW170817 chirp-mass uncertainty corresponds to a 6.67×10^{-3} chirp-rate envelope. These are new acceptance conditions, not demonstrated predictions.

The analytic parent therefore passes the **conditional no-ghost-emission gate**, but binary-pulsar and GW170817 consistency remain **open**. The separate scalar-Gauss-Bonnet tensor-speed benchmark remains a passed, regime-limited calculation and cannot be transferred to this coefficient-incomplete parent. No claim is upgraded or withdrawn. The overall grade remains **coherent gravitational candidate – not a completed gravity theory**.

I. Frozen baselines and exact task

I.A Corpus control

ROLE	FILE	SHA-256
v8.1 publication baseline	`STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md`	`4788576a24c`
v8.1 calculation baseline	`STF_First_Principles_Paper_V8_1_fixed(1).md`	`bc2bd30366e`
v8.2 gravitational candidate	`STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md`	`f7eca3fb886`

The publication and calculation baselines differ by the already declared one-line pair-level significance phrasing. It is immaterial to the present physics but retained in the provenance. No v9.0 source was used.

I.B The two candidates are not rival parameter choices

The direct action and analytic parent are different theories of realization.

1. The direct action substitutes the nonlinear curvature norm back into a finite-order local metric action and varies that eliminated expression exactly.
2. The analytic parent retains normal-curvature jets and every exchange carrier, varies first, selects the weak-backreaction branch connected to Einstein gravity, and eliminates only order by order.

The first is already closed generically by the physical acceleration Hessian. The second survives conditionally precisely because it does not treat the exact higher-derivative equation as the low-energy spectrum.

I.C Question asked of each sector

For each candidate the audit asks:

- What propagating poles and residues source radiation?
- Is there a Yukawa or other conservative-force correction at the binary separation?
- Are extra modes kinematically available at the orbital harmonics?
- Is the local approximation valid at pulsar and LIGO frequencies?
- Can the predicted orbital decay or chirp remain within the observational windows used in the linked paper?
- Does the total system-plus-environment Ward identity account for every emitted-energy channel?

II. Source-paper framework and reproduced scales

II.A What the paper calculates

The linked paper compares two fourth-order gravity theories in the weak-field, tree-level regime.

The standard metric theory has a massless spin-2 graviton, a massive spin-2 ghost, and a massive spin-0 scalar. Its potential is

$$V_{4\mathrm{th}}(r) = -\frac{Gm_1m_2}{r}\left(1 - \frac{4}{3}e^{-m_2r} + \frac{1}{3}e^{-m_0r}\right),$$

up to its sign convention for the potential energy. The massive spin-2 contribution has negative residue. In the simultaneous light-mass limit the massless spin-2 flux is canceled at leading quadrupole order by the massive ghost/scalar combination; the GR quadrupole formula is not recovered.

The ghost-free model enlarges the geometric sector to an independent Riemann-Cartan connection/torsion system. Critical relations among its curvature-torsion coefficients remove the k^{-4} behavior. It retains positive-residue massless spin-2, massive spin-2, and massive spin-0 modes around Minkowski. The Yukawa strengths are proportional to

$$\frac{m_2^2\alpha_2}{M_{\mathrm{Pl}}^2}, \qquad \frac{m_0^2(3\alpha_1 + \alpha_2)}{M_{\mathrm{Pl}}^2},$$

so the Newtonian potential and GR quadrupole flux are recovered when $\alpha_1, \alpha_2 \to 0$, independently of the masses.

The calculation treats the binary as a classical source and the emitted modes as on-shell fields. It derives massless and massive radiation, the modified orbital force, quasi-stable orbital decay, and circular inspiral frequency evolution. Its constraints assume $m_0 = m_2$ in the numerical comparison and use a Newtonian/weak-field source rather than a full detector likelihood or numerical-relativity waveform.

II.B Force and radiation thresholds

A massive mode can mediate a significant conservative correction when

$$m \lesssim \frac{\hbar c}{a},$$

and can be emitted in harmonic n when

$$m \lesssim n\hbar\Omega.$$

For a circular inspiral the leading tensor harmonic gives the familiar $m \lesssim 2\hbar\Omega$ threshold. These conditions are kinematic and transfer to any candidate only after a physical pole and its source coupling have been identified.

Using the masses and periods in the linked paper gives:

SYSTEM	P	A REPRODUCED	$\hbar\Omega$	$\hbar c/A$
PSR B1913+16	$0.322997448918\,\mathrm{d}$	$1.9491 \times 10^{9}\,\mathrm{m}$	$1.48195 \times 10^{-19}\,\mathrm{eV}$	$1.01243 \times 10^{-16}\,\mathrm{eV}$
PSR J1738+0333	$0.3547907398724\,\mathrm{d}$	$1.7307 \times 10^{9}\,\mathrm{m}$	$1.34915 \times 10^{-19}\,\mathrm{eV}$	$1.14017 \times 10^{-16}\,\mathrm{eV}$

The inverse-separation threshold is about 683 times the orbital threshold for Hulse-Taylor and 845 times it for J1738. A mode may therefore alter the force while remaining too heavy to radiate.

II.C Observational numbers carried into the audit

The paper uses

$$\dot{P}_{\mathrm{HT}}^{\mathrm{obs}} = -(2.398 \pm 0.004) \times 10^{-12}, \qquad \dot{P}_{\mathrm{HT}}^{\mathrm{GR}} = -(2.40263 \pm 0.00005) \times 10^{-12},$$

and

$$\dot{P}_{1738}^{\mathrm{obs}} = -(25.9 \pm 3.2) \times 10^{-15}, \qquad \dot{P}_{1738}^{\mathrm{GR}} = -27.7^{+1.5}_{-1.9} \times 10^{-15}.$$

Taking the largest displacement between the observed one-sigma endpoints and the central GR value gives diagnostic fractional envelopes

$$\varepsilon_{\mathrm{HT}}^{1\sigma} = 3.5919 \times 10^{-3}, \qquad \varepsilon_{1738}^{1\sigma} = 1.8051 \times 10^{-1}.$$

These are simple gates using the paper’s inputs, not a replacement for the timing likelihood, kinematic corrections, or strong-field mass inference. Hulse-Taylor is the substantially tighter flux test.

For GW170817 the paper adopts a conservative source-frame chirp-mass uncertainty of 0.4%. Since the leading GR chirp obeys

$$\dot{\Omega} \propto \mathcal{M}_c^{5/3}\Omega^{11/3},$$

the corresponding fixed-frequency rate envelope is

$$\left|\frac{\delta\dot{\Omega}}{\dot{\Omega}}\right| \lesssim \frac{5}{3}(0.004) = 6.67 \times 10^{-3}.$$

The paper obtains a ghostful heavy-mode scale $m \gtrsim 10^{-11}\,\mathrm{eV}$ from the GW170817 chirp comparison. Its ghost-free illustrative combined bound is $\alpha_1 \simeq \alpha_2 \lesssim 1.3 \times 10^{75}$ at $m \sim 10^{-11}\,\mathrm{eV}$.

II.D One bookkeeping correction in the linked result

For the regime where the massive modes are too heavy to affect either force or radiation, the paper quotes per-system lower limits

$$m \gtrsim 9.861 \times 10^{-16}\,\mathrm{eV} \quad (\text{Hulse-Taylor}),$$

and

$$m \gtrsim 6.175 \times 10^{-16}\,\mathrm{eV} \quad (\text{J1738}).$$

It then reports $6.175 \times 10^{-16}\,\mathrm{eV}$ as the combined tightest lower bound. If one universal equal mass must satisfy both quoted inequalities, their intersection is instead

$$m \gtrsim \max(9.861, 6.175) \times 10^{-16}\,\mathrm{eV} = 9.861 \times 10^{-16}\,\mathrm{eV}.$$

This arithmetic point does not alter the stronger $10^{-11}\,\mathrm{eV}$ GW170817 scale and is not used to strengthen any STF claim.

III. Transfer discipline: why no direct (m, α_1, α_2) map exists

III.A Linked ghostful theory versus direct STF

FEATURE	STANDARD FOURTH-ORDER THEORY IN THE LINKED PAPER	DIRECT STF Q_N ACTION
higher derivative	Lorentz-invariant quadratic Ricci operators	nonlinear clock-relative norm $\sqrt{R^2 + 8\mathcal{W}_N}$
pole masses	constant m_2, m_0 around Minkowski	background- and polarization-dependent acceleration matrix
residue pattern	fixed massless spin-2, ghost spin-2, scalar coefficients	opposite tensor residue proved; complete scalar residues not derived
conservative potential	explicit Yukawa form	not derived for a binary
source coupling	conserved stress tensor with stated projectors	matter/clock/world-tube projection unfinished
emission formula	complete within its weak-field assumptions	no coefficient-complete on-shell kernel

The linked ghostful formulas may therefore be used as a conditional comparator after declaring additional assumptions. They are not the STF waveform.

III.B Linked ghost-free theory versus analytic STF

The paper's ghost-free model uses independent connection/torsion variables and retains physical positive-residue massive spin-2 and spin-0 modes. The STF route that tested a torsion-constrained connection was already closed because its constraint reduction restored rank-bifurcating physical jet blocks. The surviving STF route is instead perturbative order reduction on an Einstein-connected branch and intends to leave only two metric tensor modes, conditional on the full constraints.

Consequently the paper's very large bounds on α_1 and α_2 do not constrain an identified STF coefficient. The transferable content is the emission methodology and the force/radiation thresholds, not the parameter labels.

IV. Sector (a): direct local q_N metric action

IV.A Exact acceleration Hessian

After integration by parts,

$$S_{\rm rate} = -\kappa \int d^4x \sqrt{-g}\, A q_N + S_\partial, \qquad A = D_U\phi + \theta\phi.$$

For a curvature state u_A with $q = \sqrt{u_A u_A}$,

$$\frac{\partial^2 q}{\partial u_A \partial u_B} = \frac{1}{q}(\delta_{AB} - \widehat{u}_A \widehat{u}_B).$$

If normal metric accelerations enter through $J_{AI} = \partial u_A / \partial a_I$, the physical acceleration Hessian contains

$$H^{(a)}_{IJ} = -\frac{\kappa A}{q} J^T (I - \widehat{u}\widehat{u}^T) J.$$

Every tangent curvature direction reached by the metric principal map has a nonzero eigenvalue when $A \neq 0$ and $q \neq 0$. For FLRW TT perturbations this produces the displayed rank-two $\ddot{\gamma}^2$ block. At $A = 0$ its rank drops rather than being removed by a background-independent constraint; at $q = 0$ the unregulated norm is nondifferentiable. This exact result precedes any emission calculation.

IV.B Opposite-residue pole

For one locally frozen tensor polarization write

$$L^{(2)}_T = \frac{A_T}{2}\dot{\gamma}^2 + \frac{C_T}{2}\ddot{\gamma}^2 + \cdots.$$

Then

$$D_T(\omega) = \frac{1}{\omega^2(A_T + C_T\omega^2)} = \frac{1}{A_T}\left[\frac{1}{\omega^2} - \frac{1}{\omega^2 + A_T/C_T}\right].$$

The residues are $+1/A_T$ and $-1/A_T$. Depending on the missing spatial terms and the sign of C_T, the second solution is a propagating ghost, tachyonic ghost, or instability. None is a healthy radiative mode.

If the spatial principal symbol completes this local factor into two real tensor dispersion branches with the same minimal source projection, the leading tensor flux has the schematic form

$$\mathcal{F}_T(\omega) = \mathcal{F}_{\rm GR}(\omega)\left[1 - \Theta(\omega - m_{\rm gh})\mathcal{V}\left(\frac{m^2_{\rm gh}}{\omega^2}\right)\right], \qquad \mathcal{V}(0) = 1.$$

Thus the light-pole limit cancels the leading tensor flux in the simplest equal-residue comparator. This is analogous to, but not identical with, the linked paper's massless-spin-2/ghost-spin-2/scalar cancellation. STF's complete $\mathcal{V}$, scalar contribution, and source coupling have not been derived, so the expression is not used as a numerical prediction.

IV.C Canonical local-pole diagnostic

Using the Einstein TT normalization $A_T = M^2_{\rm Pl}/4$ and the coefficient shown in Appendix P.2 gives the canonical diagnostic

$$\boxed{m^2_{\rm gh}(x) = \left|\frac{A_T}{C_T}\right| = \frac{M^2_{\rm Pl} q_N(x)}{2\kappa |A(x)|}}.$$

The factor $1/2$ is convention dependent at order unity because the P.2 expression suppresses the complete tensor-index and spatial-principal normalization. The conclusion below spans many orders of magnitude and is not sensitive to that factor.

For de Sitter-like FLRW, take $q_N = |R| = 12H_0^2$. The v8.1 tracking estimate $\dot\phi \sim H_0\phi$, with $x = \phi/M_{\rm Pl}$, gives $A \simeq 4H_0 x M_{\rm Pl}$, hence

$$m^2_{\rm gh,track} = \frac{3M_{\rm Pl}H_0}{2\kappa x}.$$

At the declared upper benchmark $x = 1$,

$$m_{\rm gh,track} \simeq 2.39 \times 10^{-38}\,{\rm eV}.$$

For the oscillating benchmark $\phi = A_\phi \cos m_s t$, use the envelope $|A| \simeq m_s A_\phi$ and $A_\phi/M_{\rm Pl} = 8.3 \times 10^{-11}$. Then

$$m^2_{\rm gh,osc} = \frac{6M_{\rm Pl}H_0^2}{\kappa m_s (A_\phi/M_{\rm Pl})}, \qquad m_{\rm gh,osc} \simeq 3.35 \times 10^{-38}\,{\rm eV}.$$

These are background diagnostics of the already-closed action. They are not masses of the surviving parent.

IV.D Illustrative compact-binary Weyl scan

To test whether local curvature alone could plausibly push the pole above the observational windows, use the declared Schwarzschild proxy

$$q_N(r) = \sqrt{48}\frac{GM}{c^2 r^3}$$

and retain the tracking/oscillating cosmic A benchmarks. The resulting locally frozen diagnostic is:

PROXY POINT	$M_{\rm GH}$, TRACKING	$M_{\rm GH}$, OSCILLATING
Hulse-Taylor total mass at reproduced separation	$1.69 \times 10^{-24}\,{\rm eV}$	$2.36 \times 10^{-24}\,{\rm eV}$
J1738 total mass at reproduced separation	$1.53 \times 10^{-24}\,{\rm eV}$	$2.15 \times 10^{-24}\,{\rm eV}$
$2.5M_\odot$ at $750\,{\rm km}$	$2.10 \times 10^{-19}\,{\rm eV}$	$2.94 \times 10^{-19}\,{\rm eV}$
$2.5M_\odot$ at $20\,{\rm km}$	$4.82 \times 10^{-17}\,{\rm eV}$	$6.74 \times 10^{-17}\,{\rm eV}$
$1.25M_\odot$ at $10\,{\rm km}$	$9.64 \times 10^{-17}\,{\rm eV}$	$1.35 \times 10^{-16}\,{\rm eV}$

Under this comparator the pulsar-separation poles lie well below Ω, and every displayed compact-object value lies below the linked paper's $10^{-11}\,{\rm eV}$ GW170817 scale. The scan therefore gives no above-band decoupling rescue.

Its grade is **illustrative diagnostic** for four reasons:

1. a binary is not a single Schwarzschild geometry;

2. the relevant curvature and scalar rate vary over the generation region;
3. the full tensor spatial symbol and strong-field matter matching are unknown;
4. the world-tube prescription and self-field subtraction are open.

The scan may show that the naive decoupling claim fails; it cannot replace the missing waveform with a precise exclusion curve.

IV.E Local-rate validity fails at the tested frequencies

The exact STF memory response is

$$K_{\rm sel}^R(\omega) = \frac{-i\omega}{\omega_c - i\omega}, \qquad |K_{\rm sel}^R| = \frac{|\omega|}{\sqrt{\omega_c^2+\omega^2}}.$$

The direct rate term corresponds to

$$K_{\rm local}^R \simeq -\frac{i\omega}{\omega_c} \qquad (|\omega| \ll \omega_c).$$

Taking $\hbar\omega_c \simeq m_s = 3.94\times 10^{-23}\,\mathrm{eV}$, the ratios are

$$\frac{\Omega_{\rm HT}}{\omega_c} \simeq 3.76\times 10^3, \qquad \frac{\Omega_{1738}}{\omega_c} \simeq 3.42\times 10^3,$$

and for a 10 Hz angular frequency,

$$\frac{2\pi\hbar(10\,\mathrm{Hz})}{m_s} \simeq 1.05\times 10^9.$$

The ratio of the local approximation's magnitude to the exact response is

$$\frac{|K_{\rm local}|}{|K_{\rm sel}|} = \sqrt{1+\frac{\omega^2}{\omega_c^2}}.$$

It therefore over-extrapolates by the same factors. The exact memory is already saturated:

$$|K_{\rm sel}| > 0.99999995$$

for both pulsars and is indistinguishable from unity at the displayed precision for 10 Hz. The local action cannot be used as a controlled approximation to compute these emissions.

IV.F Direct-sector verdict

The linked observations do not rescue or newly close the direct route. It was already closed by a theoretical rank/residue result. The emission audit adds:

- a conditional light-pole flux-cancellation pathology;
- no locally frozen above-band decoupling in the declared benchmarks;
- invalidity of the local-rate truncation at the target frequencies;
- no complete conservative potential or waveform from which a numerical likelihood could be computed.

The grade remains

$$\boxed{\text{direct local } q_N[g,N] \text{ metric action: CLOSED GENERICALLY.}}$$

V. Sector (b): surviving analytic order-reduced parent

V.A Order reduction changes the pole question

The extended parent retains independent $(\mathcal{K}_{ij}, \rho^{ij})$ and $(\mathcal{F}_{ij}, \Pi^{ij}_{\mathcal{F}})$, varies every field, and then selects the solution analytic in $\epsilon_{\rm STF}$ and connected to Einstein gravity. The jet Jacobian is

$$\mathsf{J}_{\rm jet}(k) = I_6 + \epsilon_{\rm STF}\mathsf{A}(k),$$

with sufficient invertibility condition

$$|\epsilon_{\rm STF}|\,\|\mathsf{A}(k)\|_2 < 1$$

for every physical momentum below the EFT cutoff. The augmented CMC-volume operator must likewise obey

$$\left\|\epsilon_{\rm STF}\mathbb{J}_0^{-1}\delta\mathbb{J}\right\|_2 < 1.$$

At the quadratic retarded level, write schematically

$$K_T^R = K_{T,\rm GR}^R + \epsilon_{\rm STF}\Pi_T^R + O(\epsilon_{\rm STF}^2).$$

The analytic solution is

$$\gamma = D_{\rm GR}^R J_T - \epsilon_{\rm STF} D_{\rm GR}^R \Pi_T^R D_{\rm GR}^R J_T + O(\epsilon_{\rm STF}^2),$$

not the exact inversion of a finite fourth-order polynomial. The nonanalytic runaway/ghost solution is not an independent low-energy initial datum. A zero of the complete jet or CMC operator below the cutoff instead marks failure of the branch and is excluded, not reinterpreted as a new acceptable radiative particle.

V.B Conditional no-ghost-emission result

Proposition. If the jet bound holds over the binary background and radiative momenta, the complete Hamiltonian/CMC constraint algebra leaves only two metric tensor modes, the reduced retarded tensor kernel has positive massless residue and no additional zero below the EFT cutoff, and the matter/environment reduction uses the same analytic branch, then the direct P.2 massive ghost is not in the asymptotic spectrum and cannot be emitted.

This is the correct counterpart of the linked paper’s ghost test. Its grade is **conditional**, because v8.2 has not supplied the coefficient-complete $\mathsf{A}(k)$, $\delta\mathbb{J}$, reduced Hamiltonian, tensor kernel, or compact-binary background. The established 58 per leg and 116 doubled ranks are structural subtotals, not a waveform or a complete mode count.

V.C Structural invertibility is much weaker than observational smallness

The Neumann condition allows corrections of order unity as long as they do not reach a singular value. Binary observations require far smaller projected corrections. Define the observable response projections

$$\delta_{\dot P}^{(s)} = \frac{\dot P_{\rm STF}^{(s)} - \dot P_{\rm GR}^{(s)}}{\dot P_{\rm GR}^{(s)}}, \qquad \delta_{\dot\Omega} = \frac{\dot\Omega_{\rm STF} - \dot\Omega_{\rm GR}}{\dot\Omega_{\rm GR}}.$$

The linked inputs impose the diagnostic conditions

$$|\delta_{\dot P}^{\rm HT}| \lesssim 3.59 \times 10^{-3},$$

$$|\delta_{\dot P}^{1738}| \lesssim 1.81 \times 10^{-1},$$

and

$$|\delta_{\dot{\Omega}}^{170817}| \lesssim 6.67 \times 10^{-3}$$

under the same simplified one-sigma/chirp-mass treatment. These conditions apply to the **total** force and flux, not only the metric tensor kinetic term.

The coefficient-complete calculation must also test the independent multimessenger propagation condition already carried by v8.2,

$$\left| \frac{c_T}{c} - 1 \right| \lesssim 10^{-15},$$

over the relevant background and frequency band. The existing 10^{-30}-level result belongs to the scalar-Gauss-Bonnet parent and is not a result for this analytic split-leg parent.

V.D The exact memory does not hide high-frequency emission

At pulsar and LIGO frequencies the exact selector has $|K_{\rm sel}| \simeq 1$. Therefore:

- the analytic parent remains well defined because the exact first-order memory is retained;
- the low-frequency local-rate approximation must not be used;
- any activated coupling is not suppressed by the high-pass transfer function;
- observational safety must come from activation being off, small projected coefficients, symmetry/constraints, or a high physical threshold – not from ω/ω_c suppression.

V.E Activation regimes

The emission grade depends on the post-memory activation state.

Activation off. If the varied compact-binary solution has $\mathcal{G}_Z = 0$, the response sector decouples smoothly and the metric branch can reduce to GR. This is a conditional GR limit, not yet a prediction that either pulsar or GW170817 lies off, because the mass-dependent world-tube activation law is open.

Crossover. Derivatives of the gate enter $\mathsf{A}(k)$, and the crossover is expected to maximize its norm. Time-dependent activation can also imprint nonadiabatic phase and environmental emission. This is the most demanding regime and requires a coefficient-complete waveform.

Saturated activation. Gate derivatives vanish, but the physical coupling need not be small. Memory is saturated rather than suppressing the response. The tensor, force, compact-charge, and environmental coefficients must satisfy the observational gates directly.

Response zero. A zero of the scalar response or memory output does not remove the structural constraints. It also does not prove that every conservative tensor contact or compact-body charge vanishes.

V.F Matter and compact bodies must be included before reduction

The analytic-branch proof point explicitly permits matter only if it is present before the jet constraints are solved. Importing the vacuum $\mathsf{A}(k)$ after inserting neutron stars is invalid. A binary calculation must derive:

1. the matter-corrected jet matrix and CMC operator;
2. the effective tensor source normalization;

3. neutron-star sensitivities or STF compact-body charges;
4. possible scalar, clock, memory, and environmental multipoles;
5. the conservative two-body potential;
6. the on-shell spectral channels and their energy signs.

The metric having conditionally two tensor modes does not by itself forbid dipole or environmental radiation. v8.2 already records binary pulsars as open for exactly this compact-charge reason.

V.G Open environment and total flux

The linked paper equates orbital binding-energy loss to the sum of emitted on-shell particle fluxes. STF's open parent must instead include every retained carrier:

$$\dot{E}_{\rm orb} = -\left(\mathcal{F}_T + \mathcal{F}_{\rm STF} + \mathcal{F}_{\rm clock} + \mathcal{F}_{\rm mem/env} + \mathcal{F}_{\rm matter}\right).$$

The diagonal Ward identity guarantees total exchange balance only when all field equations, stresses, world-tube forces, and boundary terms are retained. It does not set the individual environmental flux to zero. The positive ρ_{QQ} derived in the preceding environment gate supplies a possible dissipative channel, but its binary source projection and overlap with gravitational radiation are not known.

The noise kernel is likewise not a classical emission rate. KMS relates noise and absorption in an appropriate state, but a compact-binary calculation must project the retarded spectral density onto the physical radiative source.

V.H Analytic-parent verdict

The order-reduced parent avoids the direct ghost only on its accepted analytic and constant-rank domain. It has not yet produced the quantities needed to compare a predicted $\dot{P}$, $\dot{f}$, or phase with the linked observations. Its grade is therefore

$$\boxed{\begin{array}{l}\text{extra direct ghost emission: CONDITIONAL PASS,}\\ \text{binary-pulsar total flux: OPEN,}\\ \text{GW170817 chirp and tensor cone: OPEN.}\end{array}}$$

VI. Constraint-by-constraint comparison

TEST	DIRECT LOCAL METRIC ACTION	ANALYTIC ORDER-REDUCED PARENT
opposite-residue extra tensor pole	**derived; fail**	excluded conditionally by analytic reduction and rank closure
pole mass above binary force scale	not established; local diagnostics below scale	no extra metric pole if branch succeeds
pole mass above radiation harmonics	not established; pulsar diagnostics below Ω	no extra metric pole if branch succeeds
controlled local approximation	**fail** at pulsar/LIGO frequencies	exact memory retained
Hulse-Taylor 3.59×10^{-3} flux gate	no valid waveform; conditional comparator unsafe	open coefficient/source calculation
J1738 1.81×10^{-1} flux gate	no valid waveform	open coefficient/source calculation
GW170817 6.67×10^{-3} chirp-rate gate	no valid waveform; ghostful comparator fails unless heavy	open waveform calculation

TEST	DIRECT LOCAL METRIC ACTION	ANALYTIC ORDER-REDUCED PARENT
GW170817 tensor speed	direct principal cone unhealthy/unfinished	open; sGB result does not transfer
dipole/extra-channel radiation	scalar block unhealthy and incomplete	compact-body/environment charges open
total emitted-energy Ward balance	fixed/eliminated realization incomplete	conditional pass when all retained sectors varied
final route status	**closed generically**	**survives conditionally**

VII. Regime and boundary register

ID	REGIME OR BOUNDARY	DIRECT ACTION	ANALYTIC PARENT
G1	$q_N > 0, A \neq 0$, tangent tensor variation	nonzero acceleration Hessian	jets retained; conditional rank bound
G2	$A = 0$	rank-changing/strong-coupling surface	structural constraints remain, coefficient audit open
G3	$q_N = 0$ unregulated	nondifferentiable	regular only for $\Delta, \delta_B > 0$
G4	Minkowski	norm cusp	regular compact apex; merger coefficients open
G5	stationary Schwarzschild source	background rate may vanish	nonstationary perturbations still require solution
G6	pulsar $\omega/\omega_c \sim 10^3$	local truncation invalid	exact memory saturated
G7	LIGO $\omega/\omega_c \sim 10^9$	local truncation invalid	exact memory saturated
G8	$m < \Omega$ pulsar comparator	extra pole can radiate if real	no metric extra pole conditionally
G9	$\Omega < m < 1/a$	force-only comparator possible	conservative kernel/source open
G10	$m > 1/a$	heavy-mode decoupling necessary but unproved	not required if no extra pole
G11	activation off	local fundamental ghost remains if term retained	conditional GR limit
G12	activation crossover	rank can change	strongest A and waveform gate
G13	activation saturated	ghost remains; rate truncation still wrong	no memory suppression; coefficients constrained
G14	jet bound saturated	not applicable as cure	branch boundary; excluded
G15	CMC zero mode	no cure	temporal count fails there

ID	REGIME OR BOUNDARY	DIRECT ACTION	ANALYTIC PARENT
G16	matter added after vacuum reduction	incomplete source	invalid order of operations
G17	neutron-star strong field	no controlled solution	compact charges and equation of state open
G18	positive environment spectrum	does not repair ghost residue	may add physical flux; projection open
G19	physical boundary/world tube	eliminated action misses full carrier ledger	BV-BFV/CMC and material boundary audit required
G20	above EFT cutoff	pole may be ignored only with uniform proof	nonanalytic modes excluded only within declared EFT domain

VIII. Graded claim ledger

CLAIM	BASIS	GRADE	BASELINE EFFECT
linked pulsar Ω and $1/a$ scales reproduce	Kepler calculation	**reproduced**	none
linked force/radiation threshold distinction applies once an STF pole is identified	kinematics	**theorem/standard**	adds an audit gate
simultaneous intersection of the paper's quoted heavy pulsar bounds is $9.861 \times 10^{-16}\,\mathrm{eV}$	maximum of two lower bounds	**arithmetic correction**	no STF upgrade
direct q_N action has rank-two TT acceleration Hessian	Appendix P.2/S derivation	**derived**	unchanged
direct tensor factor has opposite residues	partial fraction	**derived**	unchanged
direct light-pole tensor flux cancels GR at leading order	equal-residue, real-pole comparator	**conditional diagnostic**	not a waveform claim
canonical $m_{\mathrm{gh}}^2 = M_{\mathrm{Pl}}^2 q/(2\kappa\lvert A\rvert)$	local frozen P.2 normalization	**derived diagnostic**	background dependent
displayed FLRW pole estimates are $O(10^{-38}\,\mathrm{eV})$	v8.1 benchmarks	**reproduced diagnostic**	direct route remains closed
displayed compact Weyl scan lies below $10^{-11}\,\mathrm{eV}$	declared proxy calculation	**illustrative**	no decoupling rescue in scan
direct action predicts the actual pulsar/GW170817	missing spatial/source/strong-	**not established**	none

CLAIM	BASIS	GRADE	BASELINE EFFECT
waveform	field data		
local rate is controlled at pulsar/LIGO frequencies	$\omega \gg \omega_c$	**false**	strengthens exclusion of its use
exact memory is saturated at those frequencies	exact transfer	**derived**	no suppression claim
analytic reduction removes the direct ghost from the low-energy asymptotic spectrum	analytic branch plus complete rank hypotheses	**conditional theorem**	surviving route retained
$58/116$ rank proves the binary spectrum	subtotal omits full constraints/matter	**false**	no upgrade
analytic parent satisfies Hulse-Taylor	no $\dot{P}$ calculation	**open**	binary-pulsar row remains open
analytic parent satisfies J1738	no compact charges/flux	**open**	unchanged
analytic parent satisfies GW170817 chirp	no coefficient-complete waveform	**open**	unchanged
analytic parent satisfies GW170817 speed from the sGB result	different parent	**false transfer**	tensor-speed row remains split
total Ward identity fixes total energy exchange	all retained equations and boundaries required	**conditional pass unchanged**	none
linked ghost-free α_i bounds directly constrain STF	no parameter map	**false**	none
overall v8.2 grade improves	observational gates remain open	**no**	unchanged

IX. Explicit answers

IX.A Sector (a)

The direct local q_N metric action does not survive an analogous emission audit. It has an opposite-residue tensor pole before source modeling. Under a locally frozen, real-pole, minimal-coupling comparator, its light extra tensor can cancel the leading GR tensor flux, and its declared benchmark pole diagnostics sit inside the pulsar/GW force and radiation windows. More fundamentally, the local rate action is an invalid approximation at those frequencies. Because the complete dispersion relation and binary source coupling are absent, no exact STF $\dot{P}$ or GW170817 curve is claimed. The route remains **closed generically**, independently of whether a tuned background could hide its pole above one observational band.

IX.B Sector (b)

The analytic order-reduced parent conditionally avoids emission of the direct ghost because the nonanalytic extra solution is not part of the Einstein-connected EFT branch. That conclusion requires the jet and CMC bounds, complete constraint closure, positive reduced tensor residue, and absence of a new retarded zero below the cutoff. It is a conditional theoretical pass, not an observational pass.

Binary-pulsar and GW170817 consistency remain open because the parent lacks its coefficient-complete tensor kernel, compact-body solutions and charges, activation history, source normalization, environment projection, and waveform. The required diagnostic tolerances are now explicit: approximately 3.59×10^{-3} for Hulse-Taylor total decay and 6.67×10^{-3} for the GW170817 chirp rate under the linked paper's simplified inputs, plus the separate 10^{-15} tensor-speed gate.

X. What is not established

This calculation does not establish:

1. a complete direct-action binary solution;
2. the full spatial principal symbol of the P.2 tensor pole on a compact binary;
3. a universal, background-independent direct-action ghost mass;
4. an exact STF Yukawa potential;
5. the direct-action scalar and vector radiation residues;
6. a detector likelihood or full waveform for either STF sector;
7. the coefficient-complete analytic-parent tensor kernel;
8. the matter-corrected $\mathsf{A}(k)$ and $\delta\mathbb{J}$;
9. a complete Hamiltonian/CMC constraint algebra on a neutron-star binary;
10. neutron-star sensitivities or STF compact-body charges;
11. absence of scalar, clock, memory, or environmental dipole radiation;
12. the activation state of either pulsar or GW170817;
13. a merger solution or global CMC foliation through coalescence;
14. the environmental share of the emitted flux;
15. a nonlinear KMS/noise waveform;
16. a map from STF parameters to the linked paper's $\alpha_1, \alpha_2, m_0, m_2$;
17. transfer of the scalar-Gauss-Bonnet tensor-speed result to the split-leg parent;
18. a numerical posterior against pulsar or LIGO data;
19. a uniform UV cutoff proof for the direct pole;
20. any premise or result from v9.0.

XI. Decisive next calculation

The next calculation is now coefficient specific rather than conceptual:

1. choose a weak-field compact-binary background with the material/clock world tubes varied;
2. include matter before solving the analytic jet and CMC constraints;
3. derive the reduced quadratic retarded tensor, scalar, clock, and environmental kernel;
4. locate every pole and branch cut, calculate residues and source projectors, and verify positivity/causality below Λ_{EFT};
5. derive the conservative two-body potential and compact-body charges;
6. calculate all on-shell fluxes and the total Ward-balanced energy loss;
7. evaluate eccentric harmonic sums for PSR B1913+16 and the near-circular J1738 system;
8. generate a frequency-domain GW170817 phase/chirp correction across the detector band;

9. impose the jet, CMC, pulsar, chirp, and tensor-speed inequalities simultaneously.

The calculation closes the observational gate only if one coefficient set satisfies all structural and phenomenological bounds on one common branch.

XII. Reproducibility

The accompanying NumPy checker independently verifies:

1. both pulsar orbital-frequency energies;
2. both Kepler separations and inverse-separation energies;
3. the hierarchy between force and radiation thresholds;
4. the intersection of the linked paper's two quoted pulsar heavy-mode bounds;
5. dominance of the GW170817 $10^{-11}\,\mathrm{eV}$ scale;
6. high-frequency saturation of the exact STF memory;
7. the local-rate over-extrapolation factors;
8. the curvature-norm radial null and tangent eigenvalues;
9. exact quartic-propagator factorization and opposite residues;
10. the tracking and oscillating FLRW pole diagnostics;
11. the illustrative compact Weyl pole scan;
12. the Hulse-Taylor and J1738 fractional envelopes;
13. the GW170817 chirp-rate envelope;
14. representative jet and CMC Neumann bounds;
15. the final claim ledger and v9.0 exclusion.

Successful execution ends with

`ALL ASSERTIONS PASSED`.

XIII. Final grade

The gravitational-wave calculation in arXiv:2510.17789v1 reinforces the distinction v8.2 already made. A finite-order metric theory with an opposite-residue pole is not repaired by evaluating it on a quiet background, and making the pole phenomenologically heavy would not restore unitarity. The direct q_N realization remains closed.

The analytic order-reduced parent is not the linked paper's ghost-free torsion model. Its virtue is narrower: it can remove the direct extra solution from the low-energy branch without pretending that the exact fourth-order equation is fundamental. That earns a conditional no-ghost-emission pass. It does not yet earn binary-pulsar or GW170817 validation.

No v8.1/v8.2 claim is upgraded or withdrawn. The final grade remains:

> **Coherent gravitational candidate – not a completed gravity theory.**

References

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Appendix AA — Merger-Production Activation, Timing Surfaces, and Visible-Sector Vertex Gate (G5)

Audit-gate record, carried verbatim from the accepted package (paste 5 of the 28 August 2026 program). Source file `STF_V8_2_Merger_Production_Activation_Timing_Surface_and_Visible_Vertex_Gate_V1_0.md`*, SHA-256* `3571f0b8e1cc22b5d044b00425ecb19d77e47ff6b810ab146b36e9c5302c7d64`*. Section numbers below are local to this appendix. Covariant production surfaces, a visible-sector vertex, and the timing-anchor obstruction*

Version: 1.0
Date: 28 August 2026
Status: standalone post-v8.2 production-sector calculation
Baseline: frozen v8.1 publication and calculation files, graded through v8.2
Excluded: every v9.0 file, premise, calculation, and status transfer

Abstract

STF First Principles v8.2 leaves three production-sector claims explicitly open: a UHECR or GRB production operator, the approximately 2400 channel-threshold ratio associated with the 3.3-year and 71-day anchors, and the 0.1-year inner boundary used by the conditional 54-year closure calculation. This paper asks whether a post-memory STF activation gate can close those items by acting on merger-driven production mechanisms of the types developed in three recent papers: binary-neutron-star (BNS) production of ultrahigh-energy cosmic rays in a magnetized turbulent outflow, the detailed synchrotron-

confinement calculation of that channel, and gamma-ray production by a kicked binary-black-hole (BBH) remnant whose jet breaks out of an active-galactic-nucleus (AGN) disk.

The answer is sharp. The linked mechanisms provide useful physical production criteria, but neither has pre-merger support. In the BNS model, nuclei form after collapse and reach their maximum rigidity only when the homologously expanding ejecta has reached $r \sim 10^{14}\,\mathrm{cm}$, approximately 0.15-0.77 day after merger for the stated $0.1c$-$0.2c$ outflow. In the AGN-disk model, the GRB is powered by hyper-Eddington accretion onto the kicked merger remnant and shock breakout follows the GW by $11.264\,\mathrm{s}$. The reported association of S241125n is itself only a 1.8σ candidate. A bounded scalar activation factor can multiply an existing operator, but it cannot make a material current, post-merger ejecta, remnant accretion flow, or shock exist on an earlier hypersurface. This gives the **Production-Support Preservation Theorem**: if the physical merger operator vanishes before coalescence, every finite multiplicatively gated version also vanishes there.

A covariant formulation of the linked BNS production locus is nevertheless available. With ejecta four-velocity u^μ, comoving magnetic magnitude $\mathcal{B}$, and a varied material coherence scalar ℓ_B, define the confinement rigidity $\mathcal{R}_H = \xi_H \mathcal{B} \ell_B$, the acceleration time $t_{\mathrm{acc}} = \xi_{\mathrm{acc}} \ell_B / c$, and the synchrotron time $t_{\mathrm{syn}}^{A,Z}(\mathcal{R}_H, \mathcal{B})$. The maximum-rigidity production surface is

$$\Sigma_{\mathrm{U}}^{A,Z}: \quad \mathfrak{F}_{A,Z} \equiv \ln\left(\frac{t_{\mathrm{syn}}^{A,Z}(\mathcal{R}_H, \mathcal{B})}{t_{\mathrm{acc}}(\ell_B)}\right) = 0,$$

inside the varied ejecta world tube, with nuclei present and $\mathcal{R}_H$ above the desired rigidity. Under the linked homologous scalings $\mathcal{B} \propto r^{-3/2}$ and $\ell_B \propto r$, $\mathcal{R}_H \propto r^{-1/2}$ while $t_{\mathrm{syn}}(\mathcal{R}_H)/t_{\mathrm{acc}} \propto r^{5/2}$. The crossing is transverse and is the unique maximum-rigidity surface. The corresponding GRB surface is a shock-breakout surface defined covariantly by equality of photon diffusion and shock propagation times, equivalently by an optical-depth condition of the form $\tau_\gamma \simeq c/v_{\mathrm{sh}}$ along the physical escape congruence. These are physical post-merger surfaces; neither is the STF pre-merger $730R_S$ or $360R_S$ separation.

The visible-sector operator must also do more than multiply $F_{\mu\nu}F^{\mu\nu}$. A scalar-dependent gauge kinetic term leaves Maxwell's equation homogeneous at $F_{\mu\nu} = 0$ and therefore does not create photons. A covariant EFT existence construction that can source the visible field is

$$S_{\mathrm{vis}}^{\mathrm{CTP}} = -\frac{1}{2}\sum_{s=\pm} s \int d^4x \sqrt{-g_s}\, \frac{Q_{\Delta,s}}{\Lambda_i^4} \mathcal{G}_i(\Upsilon_{Z,s}) W_i \mathcal{M}_{i,s}^{\mu\nu} F_{\mu\nu,s},$$

where $\mathcal{M}_i^{\mu\nu}$ is an antisymmetric, varied material polarization or magnetization operator of the plasma. It induces

$$J^\mu_{\mathrm{prod},i} = \nabla_\nu \left[\frac{Q_\Delta}{\Lambda_i^4} \mathcal{G}_i(\Upsilon_Z) W_i \mathcal{M}_i^{\nu\mu}\right], \qquad \nabla_\mu J^\mu_{\mathrm{prod},i} = 0.$$

This is a gauge-consistent candidate operator class, not a microscopic derivation. It must reduce to the linked MHD current when the gate saturates, preserve the narrow BNS rigidity distribution, be matched to the sequestered parent, and include the variation of every material, clock, metric, boundary, and world-tube field. Most importantly, $\mathcal{M}_i^{\mu\nu} = 0$ before the merger for the linked mechanisms, so the candidate does not evade the support theorem.

For a common activation amplitude scaling as $\mathcal{A}(\tau) \propto \tau^{-11/8}$ and a quadratic production criterion, independent canonical matching would have to produce

$$\mathfrak{R}_{\mathrm{ch}} \equiv \frac{g_{\mathrm{U}}^2/P_{\mathrm{U}}^{\mathrm{crit}}}{g_{\gamma}^2/P_{\gamma}^{\mathrm{crit}}} = \left(\frac{T_{\mathrm{U}}}{T_{\gamma}}\right)^{11/4} = \left(\frac{3.3\,\mathrm{yr}}{71\,\mathrm{d}}\right)^{11/4} \simeq 2.41 \times 10^3.$$

Equivalently, the canonically normalized GRB threshold must be approximately 2400 times the UHECR threshold. The linked papers do not calculate such a common ratio: their UHECR and GRB criteria have different source populations, different material operators, and different dimensions before normalization. If their post-merger delays are incorrectly inserted into the STF power law, the resulting number is 10^9-10^{10}, not 2400; that exercise is diagnostic only because the common scaling assumption is absent.

The merger-production papers therefore do not close ledger items 24-26. They narrow item 24 to a viable covariant operator class and supply concrete post-merger surface criteria, but microscopic matching and pre-merger support remain absent. Item 25 remains an independently normalized ratio target, and item 26 remains wholly unsupplied. The linked channels can carry the STF timing anchors only if a new pre-merger plasma or magnetospheric precursor exists on the required covariant surfaces and the ratio and lower boundary follow from its independently fixed coefficients. That would no longer be the linked post-merger channel alone. The overall grade remains **coherent gravitational candidate - not a completed gravity theory**.

I. Frozen corpus and exact question

I.A Baselines

ROLE	FILE	SHA-256
v8.1 publication baseline	`STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md`	`4788576a24`
v8.1 calculation baseline	`STF_First_Principles_Paper_V8_1_fixed(1).md`	`bc2bd30366`
v8.2 gravitational candidate	`STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md`	`f7eca3fb88`

The two v8.1 files differ by the already recorded one-line pair-level significance wording. The physics of this calculation uses the calculation baseline while the publication file remains the frozen release baseline. No v9.0 material was consulted or transferred.

I.B Exact inherited status

The v8.2 production-gap statement is unambiguous:

1. the displayed architecture has no derived UHECR or GRB production operator;
2. a Maxwell term homogeneous in $F_{\mu\nu}$ cannot generate classical photons from $F_{\mu\nu} = 0$;
3. a sequestered ultralight scalar does not produce high-energy photons merely through its on-shell decay;
4. the production world tube and self-field prescription are load-bearing;
5. the visible-sector vertex and its canonical normalization are missing.

The explicit ledger records:

V8.2 ITEM	FROZEN STATEMENT	FROZEN GRADE
24	a UHECR or GRB production operator	open
25	the 71-day production-threshold ratio	open
26	the 0.1-year inner production boundary	open

The task is not to replace these labels with an astrophysical citation. It is to determine whether the linked physical mechanisms can be coupled to the v8.2 gate in a way that actually entails the timing record.

I.C Timing provenance

For a circular $30+30M_\odot$ reference binary, Peters' law gives

$$t_{\rm m}(a)=\frac{5}{256}\,\frac{c^5a^4}{G^3\mu M^2},$$

and

$$t(1466R_S)=54.07\,\mathrm{yr},\qquad t(730R_S)=3.324\,\mathrm{yr},\qquad t(360R_S)=71.82\,\mathrm{d}.$$

The 3.32-year and 71-day values came from the observational program. The 53.8804-year closure value was calculated from an emission density $p_I(\tau)\propto\tau^{-11/8}$, its 3.31-year centroid, and the declared but underived lower endpoint $\tau_-=0.1\,\mathrm{yr}$. Peters translates these times into separations; it does not supply their production physics.

II. What the three linked papers establish

All three current arXiv versions were read in full, including appendices, figures, and references. Their roles are complementary but not interchangeable.

II.A BNS mergers as a UHECR source class

Farrar's PRL proposal argues that BNS mergers naturally explain the narrow distribution of UHECR rigidity because the post-merger field is generated by a gravitationally driven dynamo and known double-neutron-star masses have a narrow distribution. The source class satisfies, within large uncertainties, the Hillas condition, the UHECR energy-injection rate, and the effective source-density requirement.

The central source constraints are

$$\mathcal{R}_{\rm max,EV}\lesssim 3\times10^{-16}\Gamma R_{\rm cm}B_{\rm G},$$

$$L_{\rm bol}\gtrsim 10^{41}\Gamma_{\rm jet}^2\mathcal{R}_{\rm max,EV}^2\ \mathrm{erg\,s^{-1}},$$

and an observed UHECR energy-injection density of order

$$\dot{\mathcal{Q}}_{\rm UHECR}\sim 6\times10^{44}\ \mathrm{erg\,Mpc^{-3}\,yr^{-1}}.$$

The paper proposes heavy r-process nuclei in the broad-angle merger outflow, with lighter particles potentially produced in the jet or by spallation. Magnetic deflection makes UHECR arrival later than the

GW by long and uncertain intervals. Source-produced PeV neutrinos can arrive hours to years after the GW in the broad initial treatment; the detailed follow-up narrows the characteristic production delay.

This paper establishes an astrophysical source hypothesis and global consistency checks. It does not couple that source to Q_Δ, derive an STF activation surface, or produce pre-merger UHECRs.

II.B Detailed BNS acceleration calculation

The second BNS paper follows the post-merger magnetized turbulent outflow initialized by a neutrino-GRMHD calculation. Outside the jet, the stated initial values at $r_0 = 500\,\mathrm{km}$, approximately $150\,\mathrm{ms}$ after merger, are

$$\mathcal{B}_0 \simeq 3.3 \times 10^{12}\,\mathrm{G}, \qquad \ell_B \simeq r/3, \qquad \mathcal{B}(r) \propto r^{-3/2}.$$

Particle-in-cell results motivate

$$\frac{dN}{d\mathcal{R}} \propto \mathcal{R}^{-p}\ \mathrm{sech}\left[\left(\frac{\mathcal{R}}{\mathcal{R}_{\rm cut}}\right)^2\right],$$

and

$$\mathcal{R}_{\rm cut,EV} \simeq (3 \times 10^{-16})(0.65)\mathcal{B}_{\rm G}\ell_{B,\rm cm}.$$

At early times synchrotron losses prevent ions from reaching the confinement limit. Expansion reduces the field until the synchrotron and acceleration times cross. The paper finds, for $p,\ \mathrm{He},\ \mathrm{O},\ \mathrm{Si},\ \mathrm{Fe},\ \mathrm{Te}$,

$$\mathcal{R}_{\rm cut} \simeq (6.2, 9.4, 7.1, 6.4, 6.0, 5.9)\,\mathrm{EV}$$

at

$$r_{\rm crit} \simeq (1.8, 0.8, 1.4, 1.7, 1.9, 2.0) \times 10^{14}\,\mathrm{cm}.$$

Using the paper's $v_{\rm ej} = 0.1c$-$0.2c$ gives source-frame expansion times of 0.154-$0.772\,\mathrm{d}$. The jet calculation moves to $r \sim 10^{15}\,\mathrm{cm}$ and gives approximate proton and helium cutoffs of 11.5 and $35\,\mathrm{EeV}$, with order-unity uncertainties.

The paper explicitly leaves the uptake probability, elemental abundance, complete escaping spectrum, photon field at the acceleration radius, and detailed neutrino yield to future simulation. This matters for STF: the linked calculation fixes a plausible physical surface and cutoff, but not the operator that projects Q_Δ into the visible plasma.

II.C BBH merger and GRB in an AGN disk

The third paper analyzes S241125n as a candidate massive BBH merger in an AGN disk. The proposed sequence is:

1. the BBH merges and emits the GW;
2. the massive remnant receives a kick and accretes AGN-disk material at a hyper-Eddington rate;
3. a Blandford-Znajek jet forms;
4. the jet drives a shock through the disk;
5. photons escape when the shock reaches the breakout surface.

For the fitted model,

$$z = 0.73, \qquad \widetilde{H} \simeq 5.69 \times 10^{12}\,\mathrm{cm}, \qquad \widetilde{\rho} \simeq 4.20 \times 10^{-9}\,\mathrm{g\,cm^{-3}},$$

and

$$t_{\text{delay}} \simeq (1+z)\frac{\widetilde{H}}{4\gamma_{\text{sf}}^2 c} = 11.264\,\text{s}.$$

The final shocked-fluid Lorentz factor $\gamma_{\text{sf,f}} = 15$ yields

$$\Delta t \simeq (1+z)\frac{\widetilde{H}}{2\gamma_{\text{sf,f}}^2 c} \simeq 0.729\,\text{s}.$$

The inferred shock-breakout luminosity is approximately $10^{51}\,\text{erg}\,\text{s}^{-1}$. The proposed AGN disk also explains X-ray absorption and optical extinction.

The observational association is not secure. The paper estimates a triple GW+BAT+EP false-alarm probability of 0.037, or 1.8σ. It is therefore a worked physical model for a possible merger-driven GRB, not proof that S241125n had that origin.

II.D Two source classes, not one paired channel

The UHECR mechanism is developed for BNS mergers. The GRB mechanism is developed for massive BBH mergers embedded in AGN disks. Their material fields, masses, environments, compositions, and observables are different. They cannot be assigned a common channel ratio merely because both follow a merger.

There is also a potentially misleading radius coincidence. The AGN model locates the BBH event at roughly $8 \times 10^2 R_S$ of a $10^7 M_\odot$ **central SMBH**. This is not the separation $730 R_S$ of the $60 M_\odot$ reference **binary**. The two physical radii differ by more than 1.8×10^5, and the relevant Schwarzschild masses are different by five orders of magnitude.

III. STF activation and the support theorem

III.A Post-memory activation

The frozen v8.2 ordering is

$$Q_\Delta = M_*^2\left(\sqrt{q_N^2 + \Delta^2} - \Delta\right),$$

$$(D_U + \omega_c)Z = D_U Q_\Delta,$$

$$\Upsilon_Z = \frac{\omega_c |Z|}{M_*^2 (q_N^2 + \delta_B^2)^{3/4}},$$

followed by a bounded activation gate $\mathcal{G}(\Upsilon_Z)$. The material world-tube window W multiplies an interaction rather than a kinetic term or a structural constraint.

At the three reference separations, the binary GW frequency exceeds ω_c by approximately 7.1×10^5, 2.0×10^6, and 5.8×10^6. Consequently

$$\left|K_{\text{sel}}^R\right| = \frac{|\omega|}{\sqrt{\omega_c^2 + \omega^2}} \simeq 1.$$

The timing hierarchy cannot be a resonance with the memory pole. A threshold may still be crossed because the source amplitude changes, but its normalization and material projection must be independently supplied.

III.B General gated production functional

Let $\mathcal{O}_i(x)$ be the complete physical production operator for channel i, including its material support. A covariant rate functional on a universal-clock slice may be written schematically as

$$\Gamma_i[T] = \int_{\Sigma_T} d\Sigma_\mu \, u^\mu \, \mathcal{G}_i(\Upsilon_Z) \, W_i \, \mathcal{K}_i[\mathcal{O}_i],$$

where $\mathcal{K}_i$ is a positive local or controlled nonlocal production kernel. This formula exposes three independent requirements:

1. the STF gate must be active;
2. the material channel must exist, $W_i\mathcal{O}_i \neq 0$;
3. the physical acceleration, escape, or breakout criterion must be satisfied.

The first condition cannot substitute for the second or third.

III.C Production-Support Preservation Theorem

Theorem. Let $\mathcal{O}_{\text{merger}}(x) = 0$ on every pre-merger point $x \in \mathcal{M}_-$. Let $W(x)$ and $\mathcal{G}(\Upsilon_Z(x))$ be finite. Then

$$\mathcal{O}_{\text{gated}}(x) = W(x)\mathcal{G}(\Upsilon_Z(x))\mathcal{O}_{\text{merger}}(x) = 0$$

for every $x \in \mathcal{M}_-$.

Proof. Pointwise multiplication preserves the support of a distribution or ordinary field: $\operatorname{supp}(f\mathcal{O}) \subseteq \operatorname{supp}(\mathcal{O})$ for smooth finite f. Therefore no multiplicative gate creates production outside the support of the physical operator. The same statement holds after integration over a slice because the integrand remains zero. $\square$

For the linked BNS channel, the relevant outflow, newly synthesized nuclei, and turbulent acceleration region exist after merger. For the linked AGN channel, the kicked remnant, hyper-Eddington accretion state, jet, and breakout shock exist after merger. The theorem therefore applies directly.

III.D Storage and advanced-response loopholes do not follow

Pre-merger activation followed by storage until merger would produce a merger-time event, not a transient 3.32 years or 71 days before the GW. An advanced visible-sector source could place an event before its material cause, but no such vertex appears in v8.2. Introducing it would require a new causal and no-signaling analysis and would contradict the use of the retarded high-pass production response unless an enlarged boundary construction were explicitly derived. It cannot be inferred from the linked papers.

IV. Covariant production surfaces

IV.A BNS turbulent-outflow surface

Let u^μ be the varied ejecta four-velocity and

$$h^{(u)}_{\mu\nu} = g_{\mu\nu} + u_\mu u_\nu.$$

Define the comoving magnetic four-vector and its magnitude by

$$\mathcal{B}^\mu = {}^\star F^{\mu\nu} u_\nu, \qquad \mathcal{B} = \sqrt{h^{(u)}_{\mu\nu} \mathcal{B}^\mu \mathcal{B}^\nu}.$$

The coherence length ℓ_B must be a scalar extracted from the magnetic two-point function using the varied material frame or a dynamically varied tetrad. It cannot be an unexplained fixed spatial projector. A representative definition is the first integral scale of the trace of the spatial magnetic correlator along the world tube.

Write the confinement rigidity and acceleration time as

$$\mathcal{R}_H = \xi_H \mathcal{B} \ell_B, \qquad t_{\rm acc} = \xi_{\rm acc} \frac{\ell_B}{c},$$

where the numerical values corresponding to the linked PIC fit are $\xi_H \to (3 \times 10^{-16})(0.65)$ in $\mathrm{EV}/(\mathrm{G\,cm})$ and $\xi_{\rm acc} \simeq 1.6$.

For a nucleus (A, Z), define the synchrotron time covariantly in the ejecta frame,

$$t^{A,Z}_{\rm syn} = \frac{E}{-(u^\mu \nabla_\mu E)_{\rm syn}},$$

using the local magnetic magnitude and the standard radiative power. The maximum-rigidity surface is

$$\boxed{\Sigma^{A,Z}_{\rm U} \equiv \{x \in \mathcal{W}_{\rm ej} : \mathfrak{F}_{A,Z}(x) = 0\}, \qquad \mathfrak{F}_{A,Z} \equiv \ln \frac{t^{A,Z}_{\rm syn}(\mathcal{R}_H, \mathcal{B})}{t_{\rm acc}(\ell_B)}.}$$

This equality must be supplemented by

$$n_{A,Z} > 0, \qquad \mathcal{R}_H \geq \mathcal{R}_{\rm req}, \qquad t_{\rm esc} < t_{\rm life}, \qquad u^\mu \nabla_\mu \mathfrak{F}_{A,Z} \neq 0.$$

The first condition supplies nuclei; the second supplies the required energy; the third permits escape; the fourth makes the crossing a genuine surface rather than a tangency or extended degeneracy.

For homologous expansion,

$$\mathcal{B} \propto r^{-3/2}, \qquad \ell_B \propto r, \qquad \mathcal{R}_H \propto r^{-1/2}.$$

At $\mathcal{R}_H$, synchrotron power scales as $E^2 \mathcal{B}^2 \propto r^{-4}$, so $t_{\rm syn} \propto r^{7/2}$, whereas $t_{\rm acc} \propto r$. Thus

$$\frac{t_{\rm syn}}{t_{\rm acc}} \propto r^{5/2}.$$

The crossing is monotone and unique for each species in the declared regime. This reproduces the physical meaning of the linked $r_{\rm crit}$ values without confusing them with a binary separation.

IV.B AGN-disk shock-breakout surface

Let k^μ be the physical outgoing photon direction, ρ the varied disk density, and κ_γ the material opacity. The optical depth from x to the varied boundary of the disk world tube is

$$\tau_\gamma(x, k) = \int_x^{\partial \mathcal{W}_{\rm disk}} \kappa_\gamma \, \rho \, (-u \cdot k) \, d\lambda.$$

Let $v_{\rm sh}$ be the locally measured shock speed. The breakout surface can be defined by

$$\boxed{\Sigma_\gamma \equiv \left\{x \in \mathcal{W}_{\text{disk}} : \mathfrak{F}_\gamma(x) \equiv \tau_\gamma(x,k) - \frac{c}{v_{\text{sh}}} = 0\right\}.}$$

This is the optical-depth form of $t_{\text{diff}} = t_{\text{sh}}$. Its normal is physical only when the disk fields, escape direction, and boundary are varied or derived. In the linked model the surface is reached after the remnant jet is launched, giving the $11.264\,\text{s}$ delay.

IV.C STF-gated physical surface

For channel i, a production event requires the intersection

$$\Sigma_{\text{prod},i} = \Sigma_{\text{phys},i} \cap \{\mathcal{P}_i = 1\} \cap \text{supp}(W_i \mathcal{O}_i),$$

where a representative dimensionless activation criterion is

$$\mathcal{P}_i = \frac{g_i^2}{P_i^{\text{crit}}} \mathcal{G}_i^2(\Upsilon_Z) |\mathcal{A}_i[Q_\Delta, Z, \mathcal{I}_{\text{mat}}]|^2.$$

This formula keeps the three surfaces distinct: the physical acceleration or breakout surface, the STF threshold, and the material support. For the linked channels their intersection is empty on all pre-merger slices. A nonempty intersection at $3.32\,\text{yr}$, $71\,\text{d}$, or $0.1\,\text{yr}$ requires a different pre-merger material operator.

V. Visible-sector vertex

V.A Why a gauge-kinetic modulation is insufficient

Consider

$$S \supset -\frac{1}{4} \int \sqrt{-g}\, Z_F(Q_\Delta) F_{\mu\nu} F^{\mu\nu}.$$

The Maxwell equation is

$$\nabla_\mu \left[Z_F(Q_\Delta) F^{\mu\nu}\right] = 0.$$

The solution $F_{\mu\nu} = 0$ remains exact. The same classical non-entailment applies to a scalar $Q_\Delta F_{\mu\nu} \widetilde{F}^{\mu\nu}$ term in a field-free state. Such operators can modify existing waves or mix modes; they do not by themselves supply the visible source required by item 24.

V.B Minimal gauge-consistent candidate class

Let $\mathcal{M}_i^{\mu\nu} = -\mathcal{M}_i^{\nu\mu}$ be a varied material polarization/magnetization operator for the merger plasma. On the doubled contour take

$$\boxed{S_{\text{vis}}^{\text{CTP}} = -\frac{1}{2} \sum_{s=\pm} s \int_{\mathcal{M}_s} d^4x \sqrt{-g_s}\, \frac{Q_{\Delta,s}}{\Lambda_i^4} \mathcal{G}_i(\Upsilon_{Z,s}) W_i \mathcal{M}_{i,s}^{\mu\nu} F_{\mu\nu,s}.}$$

The coefficient $1/\Lambda_i^4$ is a placeholder for the canonically matched EFT coefficient because Q_Δ has the natural curvature-capacity dimension four. If a different normalization is chosen for $\mathcal{M}_i^{\mu\nu}$, the coefficient must be changed accordingly; no number is inferred here.

The Maxwell equation contains

$$\boxed{J^{\mu}_{\mathrm{prod},i} = \nabla_\nu \left[\frac{Q_\Delta}{\Lambda_i^4}\mathcal{G}_i(\Upsilon_Z)W_i\mathcal{M}_i^{\nu\mu}\right].}$$

Because the bracket is antisymmetric,

$$\nabla_\mu J^{\mu}_{\mathrm{prod},i} = 0$$

identically after the curvature commutator reduces to the contraction of a symmetric Ricci tensor with an antisymmetric tensor. Gauge consistency is therefore structural rather than imposed on shell.

The operator can source $F_{\mu\nu}$ from a material polarization even if the initial macroscopic electromagnetic field vanishes. It also respects the v8.2 rule that the activation window multiplies an interaction rather than a kinetic term or constraint.

V.C Conditions for physical matching

This EFT existence construction becomes a credible production bridge only if all of the following hold:

1. $\mathcal{M}_{\mathrm{U}}^{\mu\nu}$ is derived from the ion-electron plasma and turbulent field of the BNS outflow, including uptake into the acceleration chain;
2. $\mathcal{M}_{\gamma}^{\mu\nu}$ is derived from the accretion/jet/shock plasma of the AGN disk;
3. the saturated-gate limit reproduces the linked MHD and shock-breakout currents;
4. every matter, metric, clock, memory, readout, world-tube, and boundary variable is varied;
5. the coefficient is compatible with the ten-dimensional sequestering result rather than restoring the withdrawn phenomenological Yukawa by assertion;
6. the operator does not create an additional propagating ghost or violate the jet/CMC bounds;
7. its open reduction satisfies both the total diagonal Ward identity and the separate advanced/noise identity;
8. it preserves charge conservation and the observed narrow rigidity distribution.

The last condition is especially restrictive. The success of the BNS calculation comes from a narrow, gravitationally initialized distribution of $\mathcal{B}\ell_B$. If the STF gate changes the magnetic kinetic term or the acceleration law differently from event to event, it broadens $\mathcal{R}_{\mathrm{cut}}$ and destroys the paper's main phenomenological advantage. A safer placement is in the uptake or production normalization, with $\mathcal{G} \simeq 1$ on the actual acceleration surface, rather than in the field strength or coherence scale. That placement still does not create pre-merger support.

V.D Ward identity

With every field retained, the visible vertex contributes internal exchange forces. Schematically,

$$\nabla_\mu \left(T^{\mu}_{\mathrm{grav}\,\nu} + T^{\mu}_{Q\,\nu} + T^{\mu}_{Z\,\nu} + T^{\mu}_{\mathrm{mat}\,\nu} + T^{\mu}_{\mathrm{EM}\,\nu} + T^{\mu}_{\mathrm{env}\,\nu}\right) = 0$$

on the full equations, with the covariantly varied boundary term included. Freezing W_i, $\mathcal{M}_i^{\mu\nu}$, the disk surface, or ℓ_B externally leaves an uncancelled force proportional to the corresponding equation of motion and gradient. Thus the candidate vertex preserves the already derived total Ward identity only conditionally, at exactly the same level as the v8.2 parent.

After environmental or visible modes are integrated out, the coefficient-complete retarded/noise kernel must also satisfy the open advanced identity. Gauge conservation of J_{prod} is necessary but not sufficient for that stronger result.

VI. Timing-anchor audit

VI.A The linked channels have the wrong causal support

QUANTITY	STF ROLE	LINKED PHYSICAL TIME	ORDERING RELATIVE TO MERGER
$54\,\mathrm{yr}$	conditional outer activation boundary	none	pre-merger
$3.32\,\mathrm{yr}$	UHECR observational/phase anchor	BNS maximum-rigidity surface at 0.15-$0.77\,\mathrm{d}$	STF pre; linked post
$71\,\mathrm{d}$	GRB observational anchor	AGN-disk breakout at $11.264\,\mathrm{s}$	STF pre; linked post
$0.1\,\mathrm{yr} = 36.5\,\mathrm{d}$	lower endpoint of Phase-I closure	no sharp boundary supplied	STF pre; linked absent

The BNS paper's UHECRs also arrive after the GW because they are charged, travel no faster than light, and take a longer magnetically deflected path. Source-produced PeV neutrinos can preserve direction and arrive hours to a day after the GW. Neither observable arrives years before it in the linked causal model.

VI.B Channel-threshold ratio required by STF

Let the common activation amplitude be

$$\mathcal{A}(\tau) = \mathcal{A}_0 \tau^{-11/8}.$$

Suppose channel i turns on when its canonically normalized quadratic production power reaches a threshold,

$$g_i^2 \mathcal{A}_0^2 \tau_i^{-11/4} = P_i^{\mathrm{crit}}.$$

Then

$$\frac{g_i^2}{P_i^{\mathrm{crit}}} = \frac{\tau_i^{11/4}}{\mathcal{A}_0^2}.$$

For the UHECR and GRB anchors,

$$\boxed{\mathfrak{R}_{\mathrm{ch}} \equiv \frac{g_{\mathrm{U}}^2 / P_{\mathrm{U}}^{\mathrm{crit}}}{g_\gamma^2 / P_\gamma^{\mathrm{crit}}} = \left(\frac{T_{\mathrm{U}}}{T_\gamma}\right)^{11/4}.}$$

Using the legacy rounded values gives

$$\left(\frac{3.3\,\mathrm{yr}}{71\,\mathrm{d}}\right)^{11/8} = 49.10, \qquad \mathfrak{R}_{\mathrm{ch}} = 49.10^2 = 2.410 \times 10^3.$$

Using the reproduced $3.324\,\mathrm{yr}$ and $71.82\,\mathrm{d}$ gives 2.382×10^3; the difference is only rounding. The target is therefore robustly of order 2400.

This equation is a requirement, not a derivation. Using the two observed times to calculate the ratio and then using the ratio to recover the second time is the circularity already recorded in v8.1/v8.2. Closure requires g_i and $P_i^{\rm crit}$ to be fixed without the 71-day datum.

VI.C Why the linked thresholds do not supply the ratio

The BNS UHECR condition compares synchrotron loss, turbulent acceleration, confinement, escape, and nuclear survival. The AGN GRB condition compares shock propagation and photon diffusion through an optically thick disk. Before a common STF projection they are not the same observable and do not even carry the same units. Their source populations also differ.

For illustration only, forcing the STF $\tau^{-11/4}$ rate law onto a heavy-nucleus BNS delay of $0.37\text{-}0.77\,\mathrm{d}$ and the $11.264\,\mathrm{s}$ GRB delay gives an apparent ratio above 10^9. That number has no physical status because the common-law premise is false, but it shows that the linked post-merger chronology does not accidentally reproduce 2400.

VI.D The 0.1-year boundary

The linked calculations supply several physical times:

- approximately $1\,\mathrm{s}$ for nuclei to form in the cooling BNS outflow;
- $0.15\text{-}0.77\,\mathrm{d}$ for the listed bulk-outflow critical radii;
- hours to roughly a day for source-produced neutrinos;
- $11.264\,\mathrm{s}$ for the fitted AGN-disk shock breakout;
- $0.729\,\mathrm{s}$ for the fitted burst duration.

None is $0.1\,\mathrm{yr}$, none is a lower endpoint of a pre-merger UHECR production density, and none derives an abrupt 36.5-day cutoff. Long UHECR propagation delays are positive and environment dependent, not a universal negative lead time. Ledger item 26 therefore remains open.

VI.E The 54-year closure

The checker reproduces the unique endpoint

$$\tau_+ = 53.8804\,\mathrm{yr}$$

from $n = 11/8$, $\bar{\tau}_I = 3.31\,\mathrm{yr}$, and $\tau_- = 0.1\,\mathrm{yr}$. This remains a valid conditional mathematical closure. Because the linked merger channel does not derive τ_-, it does not improve the physical grade of the 54-year value.

VII. Hold and fail conditions

VII.A Conditions under which a production gate could carry the anchors

An STF production gate could carry the timing hierarchy only if a future calculation establishes all of the following on one source class:

1. a pre-merger material world tube with a nonzero charged-plasma or magnetospheric operator at $1466R_S$, $730R_S$, and $360R_S$ for the reference system;
2. covariant physical production surfaces defined by local acceleration, escape, opacity, and survival criteria rather than by time-to-merger inserted as a coordinate;
3. a microscopic visible current of the conserved polarization form or an equivalent gauge-consistent construction;
4. independent coefficients producing $\mathfrak{R}_{\rm ch} \simeq 2.4 \times 10^3$;

5. an independently derived lower support boundary $\tau_- = 0.1\,\mathrm{yr}$;
6. the correct population scaling with mass, environment, composition, and redshift;
7. preservation of the full Dirac rank, diagonal Ward identity, and advanced/noise identity;
8. event-level statistical confirmation rather than reuse of the discovery pairs as independent trials.

Such a calculation would be a **pre-merger precursor theory**. It could borrow plasma physics from the linked papers, but it would not be the linked post-merger mechanism alone.

VII.B Fail conditions

The channel assignment fails if any of the following is found:

1. the physical material operator has only post-merger support;
2. the gate threshold is fitted to the anchor rather than independently matched;
3. the UHECR and GRB channels belong to different source populations without a mixture model;
4. the vertex remains homogeneous in $F_{\mu\nu}$ and has no visible current;
5. the gate broadens the predicted narrow UHECR rigidity distribution;
6. the required $\mathfrak{R}_{\mathrm{ch}}$ is not produced by canonical coefficients;
7. the 0.1-year boundary is absent or strongly environment dependent;
8. the varied world-tube or visible-sector forces spoil the Ward or rank conditions;
9. population data show the GW consistently preceding the relevant transient by the linked post-merger delay rather than following it by the STF lead time.

The linked channels already satisfy fail condition 1 for direct transfer to the pre-merger anchors. This closes the **transfer**, not the possibility of a different STF precursor.

VIII. Graded claim ledger

CLAIM	BASIS	GRADE	EFFECT ON V8.1/V8.2
BNS turbulent outflow supplies a physical maximum-rigidity surface	linked synchrotron/confinement calculation	external derived model	useful surface template
linked BNS UHECR production is post-merger	ejecta and r_{crit} chronology	derived from source model	blocks direct timing transfer
linked AGN-disk GRB is post-merger	remnant accretion and breakout chronology	derived from source model	blocks direct timing transfer
S241125n is definitively associated with the GRB	1.8σ triple significance	not established	no validation claim
a finite multiplicative gate preserves zero support	support theorem	theorem	new transfer no-go

CLAIM	BASIS	GRADE	EFFECT ON V8.1/V8.2
$\Sigma_{\mathrm{U}}^{A,Z}$ is a covariant production-surface candidate	local scalar timescale equality	derived construction	narrows item 24
Σ_γ is a covariant breakout-surface candidate	optical-depth equality	derived construction	narrows item 24
gated $Q_\Delta F^2$ creates photons from $F = 0$	homogeneous Maxwell equation	false	v8.2 non-entailment retained
antisymmetric material-polarization vertex gives a conserved visible current	covariant divergence identity	existence construction	item 24 still conditional/open
the vertex is derived from the compactification	no microscopic matching	open	no upgrade
$\mathfrak{R}_{\mathrm{ch}} \simeq 2.4 \times 10^3$ is required under the common quadratic law	timing algebra	derived target	item 25 remains open
the linked physical thresholds derive $\mathfrak{R}_{\mathrm{ch}}$	different operators/populations	false transfer	no upgrade
the linked times derive $\tau_- = 0.1\,\mathrm{yr}$	no 36.5-day production boundary	false	item 26 remains open
merger-channel papers close the 54-year value physically	lower endpoint still open	false	conditional status unchanged
full visible-sector Ward closure follows from current conservation alone	full varied/open identity missing	false	Ward grade unchanged
overall STF grade improves	production anchors remain unentailed	no	unchanged

VIII.A Ledger disposition

Item 24: remains open. A covariant, gauge-consistent EFT operator class now exists as an explicit construction, but its microscopic coefficient, plasma projection, pre-merger support, and sequestering match are not derived.

Item 25: remains open. The required normalized ratio is explicitly 2.4×10^3, but neither linked physics nor STF supplies the two independent canonical thresholds.

Item 26: remains open. No linked timescale supplies a 0.1-year pre-merger lower boundary.

No earlier claim is withdrawn or promoted.

IX. Regime and boundary register

ID	REGIME OR BOUNDARY	RESULT
P1	pre-merger, linked material operator zero	gated production exactly zero
P2	gate off, material channel present	no STF-weighted production
P3	gate crossover	derivative forces enter material/readout equations
P4	gate saturated	linked MHD channel must be recovered
P5	BNS nuclei not yet formed	UHECR surface absent
P6	synchrotron-dominated BNS outflow	confinement cutoff unreachable
P7	$t_{\rm syn} = t_{\rm acc}$	transverse maximum-rigidity surface
P8	post-crossing homologous expansion	Hillas envelope decreases as $r^{-1/2}$
P9	escape slower than source lifetime	accelerated particles do not form an observable channel
P10	jet-only BNS composition	cannot supply the main heavy UHECR population in the linked model
P11	AGN shock below breakout	photons trapped
P12	$\tau_\gamma \simeq c/v_{\rm sh}$	GRB breakout surface
P13	no AGN disk	linked BBH GRB operator absent
P14	S241125n chance association	no empirical validation of the model
P15	$F_{\mu\nu} = 0$ with only $Q_\Delta F^2$	remains $F_{\mu\nu} = 0$
P16	material polarization nonzero	visible current can source $F_{\mu\nu}$
P17	material polarization frozen externally	uncancelled Ward force
P18	gate changes magnetic kinetic term	rigidity-distribution broadening risk
P19	common source law absent	channel-threshold ratio undefined
P20	common $\tau^{-11/8}$ amplitude and quadratic rate	required ratio approximately 2400
P21	$\tau_- = 0.1\,\mathrm{yr}$ inserted	54-year closure remains conditional
P22	post-merger UHECR magnetic propagation	arrival later than GW, not earlier

ID	REGIME OR BOUNDARY	RESULT
P23	future-boundary/advanced visible source	new theory; not in v8.2 or linked papers
P24	mixed BNS-UHECR and BBH-AGN-GRB populations	no single canonical ratio without a mixture model

X. What is not established

This calculation does not establish:

1. that BNS mergers are the unique or dominant source of UHECRs;
2. that S241125n and its GRB/X-ray candidates have one astrophysical origin;
3. an STF coupling to the linked GRMHD simulations;
4. a microscopic derivation of $\mathcal{M}_i^{\mu\nu}$;
5. the canonical value of Λ_i or g_i;
6. consistency of that coefficient with compactification sequestering;
7. a pre-merger BNS outflow at the STF anchors;
8. a pre-merger BBH-remnant accretion or shock-breakout channel;
9. an advanced visible-sector production law;
10. a derivation of the 3.32-year UHECR event rate;
11. a derivation of the 71-day GRB event rate;
12. a derivation of the 0.1-year inner boundary;
13. an independent calculation of the approximately 2400 ratio;
14. a common source population for the two linked mechanisms;
15. the uptake efficiency of nuclei into BNS turbulent acceleration;
16. the complete escaping UHECR spectrum and composition;
17. the source-produced neutrino yield;
18. the strong-field matter-corrected analytic jet matrix;
19. full visible-sector Dirac-rank preservation;
20. the coefficient-complete advanced/noise identity;
21. a population likelihood for the STF lead-time anchors;
22. independent event-level significance of the $10{,}117$ descendant pairs;
23. any result or premise from v9.0.

XI. Decisive next calculation

The next production calculation is no longer a generic request for a vertex. It is a pre-merger support test:

1. choose one compact-binary source class rather than combining BNS and AGN-BBH channels;

2. construct a varied pre-merger magnetosphere/plasma world tube;
3. calculate $\mathcal{B}$, ℓ_B, opacity, composition, escape, and current on the $1466R_S$, $730R_S$, and $360R_S$ surfaces;
4. derive $\mathcal{M}_i^{\mu\nu}$ and its coupling to Q_Δ from a sequestering-consistent parent;
5. compute $g_{\mathrm{U}}^2/P_{\mathrm{U}}^{\mathrm{crit}}$ and $g_\gamma^2/P_\gamma^{\mathrm{crit}}$ independently;
6. test whether their ratio is 2.4×10^3 without using the 71-day datum;
7. derive the lower support endpoint and test whether it is $0.1\,\mathrm{yr}$;
8. vary the full visible, material, memory, environment, metric, clock, and boundary system;
9. verify the complete Dirac rank and both Ward identities;
10. generate an event-level population prediction for lead time, composition, direction, and energy.

If the pre-merger material operator is zero, the timing-channel program closes for that source class. If it is nonzero but the ratio or lower boundary fails, the Peters hierarchy remains an observational pattern rather than an action prediction.

XII. Reproducibility

The accompanying NumPy-only checker independently verifies:

1. all three Peters times and both near-halving ratios;
2. the 53.8804-year conditional closure endpoint;
3. the 49.10 amplitude ratio and 2.410×10^3 quadratic threshold ratio;
4. saturation of the exact high-pass memory at all anchors;
5. the approximate linked BNS rigidity cutoffs;
6. the $r^{-1/2}$ confinement and $r^{5/2}$ crossing scalings;
7. the 0.154-0.772-day BNS production interval;
8. the BNS production radius in remnant Schwarzschild units;
9. the S241125n 11.264-second delay and 0.729-second duration;
10. the distinction between the AGN $800R_S$ location and the STF binary anchor;
11. the production-support theorem in a finite representative;
12. the mismatch obtained by forcing the legacy rate law onto the linked delays;
13. the failure of a quadratic Maxwell vertex at $F = 0$;
14. the nonzero linear source from an antisymmetric material vertex;
15. the symmetric-Ricci/antisymmetric-current conservation identity;
16. the unchanged grades of ledger items 24-26 and the exclusion of v9.0.

Successful execution ends with

`ALL ASSERTIONS PASSED`.

XIII. Final grade

The merger-production papers solve an important astrophysical problem that v8.2 had not modeled: they give concrete post-merger conditions under which magnetic turbulence can accelerate UHECRs and a remnant jet can produce a GRB. They do not solve STF's timing problem because their production support begins after the merger, whereas the STF anchors are assigned before it.

The result is not that activation gates are useless. It is that a gate is a selector, not a creator of absent material support. A viable STF production completion must contain a pre-merger visible-sector current and independently normalized thresholds. The present calculation supplies the covariant form that such a surface and current could take and proves why the linked post-merger channels alone cannot carry the anchors.

Ledger items 24-26 remain open. The final grade is unchanged:

> **Coherent gravitational candidate - not a completed gravity theory.**

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Appendix AB — Relative-Coordinate Stueckelberg Viability Gate

Frozen-consolidation record. Source file `STF_V9_0_Relative_Coordinate_Stueckelberg_Viability_Gate_V1_0.md` *, SHA-256* `121468a1d6a6c28da0677fa05c11021589ef2b50075f4e7f337932859a7fd8d3` *. The scientific body is carried in full; Markdown heading levels are adjusted for nesting and missing-backslash LaTeX quad transport defects are repaired in the consolidated rendering. Section numbers below are local to this appendix.*

Scope. This is a standalone adversarial calculation against the frozen STF v8.1/v8.2/v9.0 record. It tests the specific relative-coordinate Stueckelberg proposal offered as a possible closure of v9.0 Gate G3. It is not a rewrite of STF v9.0 and does not modify any carried manuscript or gate record.

Result. The proposed common-shift compensator is a valid way to introduce one redundant coordinate, but it does **not** protect the physical STF readout from an undifferentiated static counterterm. The most general regular invariant constraint that locks the new variables to the frozen curvature composite depends on the invariant relative readout itself. Consequently, the Schwinger–Keldysh operator $y_a y_r$ is symmetry allowed, and the common-shift Ward identity cannot force $K^R_{yy}(0,\mathbf{k})=0$ or $\beta_{c_{yy}}=0$. The correct velocity Hessian has one gauge null and the primary first-class constraint

$$\Phi = p_q + p_R + \sum_\alpha \lambda_\alpha p_{X_\alpha} \approx 0.$$

After gauge fixing, the extension adds no physical degree of freedom. It does not change the established $58/116$ module subtotal to $59/118$, and it does not complete the gravitational Dirac algebra. The proposed three-block Schur matrix is identically singular for equal square blocks. Gate G3 therefore remains open and priced; Gate G1 remains open; no v9.0 result is withdrawn or promoted.

Framework grade. Coherent gravitational candidate — not a completed gravity theory.

Abstract

STF v9.0 identifies a sufficient all-loop target for its selected zero-static-response condition: a non-anomalous translation acting on the physical readout and retained environment, with a line-wise version required for finite spatial momentum. The frozen architecture does not realize that symmetry because the readout is a nonlinear curvature composite, the regulated apex obstructs a regular constant shift, the material window obstructs division by W, and the activation crossover produces $D_U W$ terms. A proposed repair promotes the windowed readout to an independent scalar q, adds a reference scalar R, and declares the common transformation $\delta q = \delta R = \epsilon$, $\delta X_\alpha = \lambda_\alpha \epsilon$.

This paper performs the missing viability calculation. Let $C[g,N,B] = W(B) Q_\Delta[g,N]$ denote the frozen, gauge-inert composite. The common-shift invariants are $y = q - R$ and $\xi_\alpha = X_\alpha - \lambda_\alpha R$. Every regular invariant lock tying the extension to C is locally a condition $F(y,C)=0$, and a nondegenerate lock reduces to $y = f(C)$. The physical variable tied to curvature is therefore invariant. Its local static Schwinger–Keldysh contact $c_{yy} y_a y_r$ is also invariant, providing a direct counterexample to the claim that the new Ward identity enforces $K^R_{yy}(0,\mathbf{k})=0$. The symmetry removes only the common gauge coordinate.

The corrected invariant Gaussian environment depends on $\xi_\alpha - \lambda_\alpha y = X_\alpha - \lambda_\alpha q$. Its finite-dimensional velocity Hessian is $H = T^T D T$, where T maps the original velocities to $(D_U y, D_U \xi_\alpha)$. For positive kinetic coefficients, H has rank $n+1$ in $n+2$ coordinates and exactly one null vector $v = (1,1,\lambda_1,\ldots,\lambda_n)$. The associated primary constraint is $\Phi \approx 0$, not the untransformed momentum condition $p_R \approx 0$. In an invariant canonical chart, $P_R = \Phi$, so the familiar $P_R \approx 0$ statement is recovered only after the canonical transformation is displayed. Gauge fixing $R=0$ turns (Φ, R) into a rank-two second-class pair and leaves the same number of physical configurations as the unextended readout-plus-bath system.

The result is a no-go for the naive compensator, not for every possible protective completion. A symmetry that actually shifts the physical relative readout could forbid its static contact, but the regular lock to inert

curvature then breaks that symmetry. Making the curvature composite shift reintroduces the apex/window obstruction already proved in Gate G3. Making the shifted coordinate a pure spectator removes the physical STF response. A different completion would therefore need new dynamics or a genuine functional-form selection rule, followed by the full compact-rank, boundary, anomaly, noise, and gravitational deformed-identity audits.

I. Source control and grading boundary

I.A Frozen baselines

RECORD	ROLE	SHA-256
STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md	publication baseline	4788576a24d0c576c
STF_First_Principles_Paper_V8_1_fixed(1).md	calculation baseline, differing from the publication baseline by the recorded one-line pair-significance wording	bc2bd30366ef0a8b1
STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md	repaired v8.2 gravitational candidate	f7eca3fb886b559b18
STF_First_Principles_Paper_V9_0_2026-08-28.md	frozen five-gate audit-layer baseline	855abcaf6366964e2

When the v9.0 file is supplied or present in the source workspace, the checker verifies its hash before running the algebraic tests. The packaged checker remains portable when the manuscript itself is not colocated. This calculation does not edit any of these four records.

I.B Gate records used

GATE RECORD	ROLE	SH
STF_V8_2_Open_Operator_Deformed_Identity_Classification_Gate_V1_0.md	Gate G1; open-operator classification and the	fb5

GATE RECORD	ROLE	SH
	subtotal boundary	
STF_V8_2_Covariant_QDelta_Environment_Vertex_and_Horizon_Spectral_Gate_V1_0.md	Gate G2; covariant environment vertex and spectral normalization	61
STF_V8_2_All_Loop_Zero_DC_Protection_and_Quantum_Stability_Gate_V1_0.md	Gate G3; sufficient shift condition, frozen-architecture obstruction, and tuning price	f6c

I.C Question tested

The calculation tests the following proposed extension and no stronger one:

1. promote the windowed compact readout to an autonomous scalar q;
2. add a reference scalar R;
3. transform the retained bath by a common shift;
4. lock the extension back to the frozen composite without singular factors;
5. infer a Ward identity, a protected zero-DC response, and a new constraint rank.

The transformation is

$$\delta_\epsilon q = \epsilon, \qquad \delta_\epsilon R = \epsilon, \qquad \delta_\epsilon X_\alpha = \lambda_\alpha \epsilon, \qquad \delta_\epsilon g_{\mu\nu} = \delta_\epsilon N^\mu = \delta_\epsilon B = 0.$$

The line-wise proposal additionally restricts

$$D_U \epsilon = 0.$$

No conclusion below assumes that this restricted transformation is already anomaly free or compatible with the state, measure, regulator, CMC boundary data, final-time gluing, or the reduced noise functional.

II. Field map and the invariant coordinate ring

Define the frozen curvature-and-carrier composite

$$C[g, N, B] \equiv W(B) Q_\Delta[g, N], \qquad Q_\Delta = M_*^2 \left(\sqrt{q_N^2 + \Delta^2} - \Delta \right).$$

Because $g_{\mu\nu}$, N^μ, and B are inert under the proposed new shift,

$$\delta_\epsilon C = 0.$$

Introduce

$$y = q - R, \qquad \xi_\alpha = X_\alpha - \lambda_\alpha R.$$

Then

$$\delta_\epsilon y = 0, \qquad \delta_\epsilon \xi_\alpha = 0.$$

The remaining useful relative bath coordinate is

$$z_\alpha = \xi_\alpha - \lambda_\alpha y = X_\alpha - \lambda_\alpha q,$$

which is also invariant. Locally, the change of variables

$$(q, R, X_1, \dots, X_n) \longleftrightarrow (y, R, \xi_1, \dots, \xi_n)$$

is regular for every finite λ_α. The common shift acts only on R in the adapted chart:

$$\delta_\epsilon R = \epsilon, \qquad \delta_\epsilon y = \delta_\epsilon \xi_\alpha = 0.$$

This observation is the center of the audit. The proposed transformation is a redundancy of the common coordinate; it is not a translation of the physical relative coordinate tied to curvature.

III. The invariant-lock theorem

III.A General regular lock

Let $\mathcal{L}(q, R, C) = 0$ be a differentiable locking constraint that does not involve the bath. Invariance under the common shift requires

$$0 = \delta_\epsilon \mathcal{L} = \epsilon \left(\frac{\partial \mathcal{L}}{\partial q} + \frac{\partial \mathcal{L}}{\partial R} \right).$$

The local solutions of this first-order equation are

$$\mathcal{L}(q, R, C) = F(q - R, C) = F(y, C).$$

The same conclusion holds for an invariant lock implemented by a potential, multiplier, delta functional, or regular algebraic compact constraint: its nonderivative dependence can only be through common-shift invariants.

III.B Compensator-Lock No-Go Theorem

Theorem (Compensator-Lock No-Go). Let C be inert under the common shift, and suppose an independent pair (q, R) is added with $\delta q = \delta R = \epsilon$. If a regular invariant constraint nondegenerately locks the added sector to C, then the curvature-carrying coordinate is the invariant $y = q - R$. The same symmetry permits an arbitrary local static operator $y_a y_r$. It therefore cannot enforce $K^R_{yy}(0, \mathbf{k}) = 0$ or $\beta_{c_{yy}} = 0$.

Proof. Invariance gives $\mathcal{L} = F(y, C)$. At a regular lock, $\partial F / \partial y \neq 0$, so the implicit-function theorem gives

$$y = f(C)$$

in a neighborhood of the constraint surface. Since both y and C are invariant, the Schwinger–Keldysh operator

$$\Gamma_{\rm ct} = \int d^4x \sqrt{-g}\, c_{yy}(\mu)\, y_a y_r$$

is invariant for every coefficient $c_{yy}(\mu)$. On the lock it becomes the corresponding local static contact in the curvature readout. A symmetry that allows an operator does not require its Wilson coefficient or beta function to vanish. Therefore the common-shift Ward identity alone cannot impose either claimed zero. □

The simplest regular lock is

$$y - C = 0,$$

or a stiff potential

$$U_{\rm lock} = \frac{\mu_L^2}{2}(y - C)^2.$$

Both remain regular at $W = 0$ and $q_N = 0$, but neither protects the physical static kernel. Regularity is achieved by moving the shift off the curvature composite; that same move makes the curvature-carrying relative coordinate invariant.

III.C The trilemma

The attempted completion has three mutually exclusive routes:

ROUTE	LOCK AND TRANSFORMATION	CONSEQUENCE
regular invariant lock	$F(y, C) = 0$, $\delta y = 0$	no apex/window singularity, but $y_a y_r$ is allowed and Gate G3 stays open
shift the physical relative readout	$\delta y = \epsilon$	a lock to inert C breaks the symmetry; making C shift restores the apex/window/crossover obstruction already proved in Gate G3
make the shifted coordinate a spectator	no physical curvature response assigned to it	strongest formal protection of that coordinate, but the STF dissipative readout channel is removed

This is a no-go for the stated compensator implementation. It is not a theorem that no more extensive theory can realize a protective symmetry.

IV. Correct invariant environment action

IV.A Fully local gauge version

If the common shift is promoted to a genuine arbitrary local redundancy, every term must be constructed from y, ξ_α, z_α, the inert gravitational/carrier fields, and covariant derivatives of those invariants. A minimal regular quadratic model is

$$S_{\rm inv}^{\rm CTP} = \frac{1}{2}\sum_{s=\pm} s\int d^4x\sqrt{-g_s}\Bigg[\kappa(D_{U_s}y_s)^2 - 2U_{\rm lock}(y_s - C_s) + \sum_\alpha \left\{m_\alpha(D_{U_s}\xi_{\alpha,s})^2 - m_\alpha\Omega_\alpha^2(\xi_{\alpha,s} - \lambda_\alpha y_s)^2\right\}\Bigg].$$

The potential coordinate satisfies

$$\xi_\alpha - \lambda_\alpha y = X_\alpha - \lambda_\alpha q.$$

This construction is exactly invariant, including when $\epsilon(x)$ varies along the clock line, because no gauge-variant coordinate occurs.

It does not prove zero DC. The invariant action may be supplemented by

$$\Delta S_{\rm static}^{\rm CTP} = \int d^4x\sqrt{-g}\, c_{yy}y_a y_r$$

without breaking the new redundancy.

IV.B Line-wise subsystem version

If the parameter is restricted by $D_U\epsilon = 0$, terms such as $(D_U q)^2$ and $(D_U X_\alpha)^2$ may be invariant even though they are not functions of relative coordinates. This is a subsystem or line-wise global symmetry rather than an arbitrary local-in-time gauge redundancy. It can support a finite-$\mathbf{k}$ Ward statement only if transverse terms, spatial boundaries, the initial state, and final-time gluing transform compatibly.

Crucially, the restriction $D_U\epsilon = 0$ also weakens the canonical inference. A symmetry whose parameter is not arbitrary in clock time does not, by itself, imply a local primary first-class constraint at every time. The proposal cannot simultaneously use the restricted line-wise transformation to preserve absolute kinetic terms and use an arbitrary local gauge parameter to assert $p_R \approx 0$. The Hamiltonian audit must choose and implement one structure consistently.

IV.C Error in the proposed environment expression

The proposal defined

$$\mathcal{X}_\alpha = X_\alpha - \lambda_\alpha R$$

but then used the potential coordinate $\mathcal{X}_\alpha - \lambda_\alpha q$. Under the declared transformations,

$$\delta\mathcal{X}_\alpha = 0, \qquad \delta\left(\mathcal{X}_\alpha - \lambda_\alpha q\right) = -\lambda_\alpha\epsilon \neq 0.$$

The corrected invariant is

$$\mathcal{X}_\alpha - \lambda_\alpha(q - R) = \xi_\alpha - \lambda_\alpha y = X_\alpha - \lambda_\alpha q.$$

This correction repairs the algebraic invariance of the Gaussian subtheory. It does not repair the counterterm problem proved in Section III.

V. The true 1PI Ward identity

V.A Schwinger–Keldysh variables

For each doubled field, define

$$q_r = \frac{q_+ + q_-}{2}, \qquad q_a = q_+ - q_-,$$

and similarly for R and X_α. A physical diagonal common shift acts on the r-fields while leaving the a-fields invariant:

$$\delta q_r = \epsilon, \qquad \delta R_r = \epsilon, \qquad \delta X_{\alpha r} = \lambda_\alpha \epsilon, \qquad \delta q_a = \delta R_a = \delta X_{\alpha a} = 0.$$

For a line-wise parameter, exact invariance of the 1PI effective action gives

$$\boxed{\int d\tau \left(\frac{\delta\Gamma}{\delta q_r} + \frac{\delta\Gamma}{\delta R_r} + \sum_\alpha \lambda_\alpha \frac{\delta\Gamma}{\delta X_{\alpha r}} \right) = 0}$$

on each clock line, subject to the regulator, state, measure, and boundary qualifications. For an arbitrary fully local gauge parameter, the same expression holds pointwise rather than after integration along τ.

The identity is **not**

$$\int d\tau \frac{\delta\Gamma}{\delta R_r} = 0$$

when the functional derivatives are taken in the original variables. That simpler equation holds only in the adapted invariant chart at fixed y and ξ_α.

V.B Kernel form

Let

$$Z = (q, R, X_1, \ldots, X_n)^T, \qquad v = (1, 1, \lambda_1, \ldots, \lambda_n)^T.$$

At quadratic order, the Ward identity implies the gauge-direction relation

$$K^R v = 0$$

or the corresponding left relation, depending on kernel convention. In the invariant chart, the effective action has the unrestricted form

$$\Gamma = \Gamma[y, \xi_1, \ldots, \xi_n; g, N, B, \ldots]$$

and is independent of the common coordinate R. The Ward identity therefore says nothing about the physical y-y entry. An explicit invariant quadratic counterexample is

$$\Gamma^{(2)}_{\text{inv}} \supset \int_{\omega,\mathbf{k}} y_a(-\omega, -\mathbf{k}) \left[c_{yy}(\mu) - i\omega\gamma_{yy} + O(\omega^2, \mathbf{k}^2) \right] y_r(\omega, \mathbf{k}).$$

Every value of c_{yy} obeys the common-shift Ward identity. Hence

$$K^R_{yy}(0, \mathbf{k}) = 0$$

is an additional physical renormalization condition or selection rule, not a consequence of the compensator gauge symmetry.

V.C Beta-function implication

The new redundancy can force the 1PI action to depend only on gauge invariants. It cannot force the coefficient of an allowed invariant operator to have a vanishing beta function. In particular,

$$\mu \frac{dc_{yy}}{d\mu} = \beta_{c_{yy}}$$

is unconstrained by this Ward identity beyond relations required by the common gauge direction. A symmetry-preserving regulator may preserve $K^R v = 0$ while still producing $\beta_{c_{yy}} \neq 0$.

This calculation does not evaluate the model-dependent loop coefficient. It proves the narrower and decisive statement that the proposed symmetry does not require that coefficient to vanish. Gate G3's existing tuning price therefore remains in force.

V.D Relation to the original Gate G3 theorem

Gate G3's conditional theorem concerns a symmetry that translates the **physical** readout. The present calculation does not refute it. Instead, it shows that the proposed Stueckelberg realization fails to meet its hypothesis: the field tied regularly to the frozen curvature composite is y, and y is invariant rather than translated.

VI. Velocity Hessian and primary constraint

VI.A Regular invariant kinetic block

For n bath coordinates, consider the nondegenerate invariant kinetic model on one causal leg,

$$L_{\text{kin}} = \frac{\kappa}{2}(D_U y)^2 + \frac{1}{2}\sum_{\alpha=1}^{n} m_\alpha (D_U \xi_\alpha)^2, \qquad \kappa > 0, \quad m_\alpha > 0.$$

Let

$$Z = (q, R, X_1, \dots, X_n)^T,$$

and define the $(n+1) \times (n+2)$ map T by

$$D_U Y = T D_U Z, \qquad Y = (y, \xi_1, \dots, \xi_n)^T.$$

Explicitly,

$$T = \begin{pmatrix} 1 & -1 & 0 & 0 & \cdots & 0 \\ 0 & -\lambda_1 & 1 & 0 & \cdots & 0 \\ 0 & -\lambda_2 & 0 & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & -\lambda_n & 0 & 0 & \cdots & 1 \end{pmatrix}.$$

With

$$D = \operatorname{diag}(\kappa, m_1, \dots, m_n),$$

the velocity Hessian is

$$H = T^T D T.$$

The common-shift vector obeys

$$Tv = 0, \qquad Hv = 0.$$

Because D is positive definite and T has row rank $n+1$,

$$\operatorname{rank} H = n+1, \qquad \text{nullity}\, H = 1.$$

This is the complete rank statement for the regular finite-dimensional scalar kinetic block. It is not a rank statement for the gravitational lapse, shift, CMC, jet, world-tube, and boundary system.

VI.B Canonical momenta

The momenta in the original chart are

$$p_q = \kappa D_U y,$$

$$p_{X_\alpha} = m_\alpha D_U \xi_\alpha,$$

and

$$p_R = -\kappa D_U y - \sum_\alpha \lambda_\alpha m_\alpha D_U \xi_\alpha.$$

Therefore

$$\boxed{\Phi = p_q + p_R + \sum_\alpha \lambda_\alpha p_{X_\alpha} \approx 0.}$$

For an exact arbitrary local gauge redundancy, Φ is the primary first-class generator of the common shift, subject to the usual completion by any spatially covariant terms and boundary charges.

VI.C Why $p_R \approx 0$ needs an adapted canonical chart

The canonical one-form transforms as

$$\begin{aligned} p_q\, dq + p_R\, dR + \sum_\alpha p_{X_\alpha}\, dX_\alpha &= p_q\, dy + \sum_\alpha p_{X_\alpha}\, d\xi_\alpha \\ &\quad + \left(p_q + p_R + \sum_\alpha \lambda_\alpha p_{X_\alpha}\right) dR. \end{aligned}$$

Thus in the adapted chart

$$P_y = p_q, \qquad P_{\xi_\alpha} = p_{X_\alpha}, \qquad P_R = \Phi.$$

The statement $P_R \approx 0$ is correct in this chart because the invariant action is independent of the common coordinate R. It is not the same as imposing the original momentum $p_R \approx 0$ before the canonical transformation.

VI.D Gauge fixing and physical degree count

Choose the regular gauge

$$\chi_R = R \approx 0.$$

With the convention $\{R, p_R\} = 1$,

$$\{\Phi, \chi_R\} = -1.$$

The gauge-fixed constraint matrix is

$$\mathbb{C}_R = \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}, \qquad \operatorname{rank} \mathbb{C}_R = 2, \qquad \det \mathbb{C}_R = 1.$$

Starting from $n + 2$ configuration variables, one first-class constraint removes two phase-space dimensions, leaving

$$N_{\text{config}}^{\text{phys}} = n + 1.$$

These are represented by y and the n variables ξ_α. This equals the number of configurations in the unextended readout-plus-bath system. The Stueckelberg extension adds no physical mode, as a consistent compensator should.

VI.E Degenerate cases

If $\kappa = 0$, the Hessian rank drops to n and an additional null direction appears. If any $m_\alpha = 0$, another rank loss occurs. These limits may describe auxiliary coordinates, but their secondary constraints and stability conditions must then be derived. They cannot be used as evidence that the regular rank is constant. The checker reproduces both rank losses.

VII. Audit of the proposed Schur completion

VII.A The displayed three-block matrix is singular

The proposed gravitational extension used a block matrix of the form

$$\mathbb{M} = \begin{pmatrix} \mathbb{A} & \mathbb{B} & \mathbb{D} \\ -\mathbb{B}^\dagger & 0 & 0 \\ -\mathbb{D}^\dagger & 0 & 0 \end{pmatrix},$$

with equal square blocks. This matrix cannot support the claimed nonzero determinant. The bottom two block rows have support only in the first block column. Equivalently, for every pair (u, w) in the null space of the $n \times 2n$ row $(\mathbb{B}\ \mathbb{D})$,

$$\mathbb{M} \begin{pmatrix} 0 \\ u \\ w \end{pmatrix} = 0.$$

The map $(\mathbb{B}\ \mathbb{D})$ has a null space of dimension at least n. Hence

$$\operatorname{rank} \mathbb{M} \leq 2n < 3n, \qquad \boxed{\det \mathbb{M} = 0}.$$

No sequence of Schur complements can turn this matrix into the proposed nonzero determinant. A valid gauge-fixed matrix must include the gauge condition paired with the first-class generator, as in Section VI.D, before a nonsingular determinant is expected.

VII.B The claimed clock-Hamiltonian bracket

In the invariant canonical chart, a correctly invariant Hamiltonian is independent of the common coordinate R. Therefore

$$\{H, P_R\} = -\frac{\delta H}{\delta R} = 0$$

up to boundary terms and any explicit symmetry-breaking structures. A nonzero Laplacian bracket cannot be read off merely from a momentum-square term. If R appears through spatial derivatives or boundary data, those terms must be written explicitly and their symmetry variation included. If P_R is instead the untransformed p_R, it is not the gauge generator. The proposed bracket mixed these two canonical charts.

VII.C The $59/118$ claim does not follow

Gate G1 records

$$44_{\text{readout/alignment}} + 2_{\text{memory}} + 12_{\text{jets}} = 58$$

per causal leg and 116 on the doubled contour. It explicitly states that these are module subtotals excluding lapse, shift, the gravitational Hamiltonian and momentum constraints, the CMC partner, regulator pairs, and the full secondary chain.

The Stueckelberg extension cannot be appended as one unexplained rank unit:

1. an exact local redundancy contributes one first-class generator, not one unpaired second-class constraint;
2. after gauge fixing, (Φ, R) is a rank-two second-class pair that removes only the compensator pair;
3. the independent q and its lock replace or enlarge the existing compact-readout module, so the old 44 block must be recomputed rather than retained by assertion;
4. the CMC, jet, memory, bath, world-tube, lapse, shift, and boundary brackets remain uncalculated;
5. neither two graviton polarizations nor nonlinear hyperbolicity follows from the scalar compensator Hessian.

The only established degree statement is that the regular compensator extension, considered by itself, introduces no new physical scalar. The complete gravitational Dirac rank remains Gate G1's open obligation.

VIII. Boundary and consistency cases

CASE	CALCULATION	CONSEQUENCE
material channel off, $W = 0$	$C = 0$; $y - C$ remains regular and invariant	no $1/W$ singularity, but $y_a y_r$ remains allowed
regulated curvature apex, $q_N = 0$	C is smooth; no shift of C is attempted	no $1/q_N$ singularity, but physical-shift protection is absent
activation crossover, $D_U W \neq 0$	invariant variables avoid a window-weighted bath shift	algebraic regularity improves; static physical contact is still allowed
spacetime-constant ϵ	only the homogeneous common coordinate shifts	at most a zero-mode Ward relation; no finite-$\mathbf{k}$ physical protection
line-wise $\epsilon(\sigma^A)$, $D_U \epsilon = 0$	transverse dependence survives	requires compatible transverse action and boundaries; does not automatically yield a local primary constraint
fully local $\epsilon(x)$	action must depend only on y, ξ_α and covariant derivatives	one first-class gauge direction; still no constraint on c_{yy}
gauge $R = 0$	$y = q$, $\xi_\alpha = X_\alpha$	the invariant static contact becomes the original readout contact explicitly
$\lambda_\alpha = 0$	that bath coordinate does not shift	harmless decoupled direction if its kinetic block is regular; no added

CASE	CALCULATION	CONSEQUENCE
		protection
$\kappa = 0$ or $m_\alpha = 0$	Hessian rank drops	new secondary-constraint audit required; possible rank bifurcation
noninvariant regulator, state, measure, or boundary data	Ward defect is generated	even the common gauge redundancy is not established quantum mechanically
continuum bath	symmetry-preserving UV regulator required	finite Gaussian invariance does not by itself prove anomaly freedom
derivative-only physical vertex	static response may be functionally forbidden	changes the infrared kernel unless compensated by new gapless or singular structure; separate completion required

IX. Implication for the total STF Ward structure

IX.A Diagonal diffeomorphism identity

The compensator redundancy is separate from the established conditional total diffeomorphism identity of the enlarged STF parent. Adding a correctly varied scalar gauge module would add its Euler–Lagrange expressions to the ordinary total identity. It does not replace that identity and does not turn the total energy–momentum balance into an open nonconservation law.

IX.B New common-shift identity

For a fully local exact redundancy, the compensator supplies one additional Noether identity in the scalar field space. In the original coordinates it is generated by $v = (1, 1, \lambda_\alpha)$; in the adapted chart it is independence from R. This identity removes the redundant common coordinate only.

IX.C Gate G1 advanced/noise identity

The scalar common-shift identity is not the coefficient-complete gravitational advanced/noise deformed identity required by Gate G1. It does not prove

$$\widehat{\mathfrak{R}}^{\dagger A}_{\nu} E^{\mathrm{red}}_{A} = \mathfrak{M}_{\nu}{}^{i} E^{\mathrm{red}}_{i},$$

does not constrain the full stochastic covariance to the allowed gravitational subspace, and does not supply the missing scalar/vector/tensor equation count. The full $Q_\Delta X_\alpha$-induced metric response remains unclassified at that level.

IX.D Static physical contact

The total diagonal identity and the new common-shift identity can both hold while the invariant scalar response contains $c_{yy} y_a y_r$. This is the precise deformed-identity implication: the additional null relation lies along the gauge vector and leaves the physical relative-response form factor free. It therefore does not alter Gate G1's statement that Ward projectors do not determine all physical conservative contacts.

X. Judgment against the proposed upgrade claims

PROPOSED CLAIM	VERDICT	REASON
$\mathcal{Y}=q-R$ is invariant	**correct**	follows directly from the declared common shift
the displayed environment potential is invariant	**incorrect as written**	$\mathcal{X}_\alpha-\lambda_\alpha q$ varies by $-\lambda_\alpha\epsilon$; the corrected coordinate is $\mathcal{X}_\alpha-\lambda_\alpha(q-R)$
the Ward identity is $\int\delta\Gamma/\delta R_r=0$ in the original fields	**incorrect**	the original-coordinate identity is the combined derivative with coefficients $(1,1,\lambda_\alpha)$
the common shift forces $K^R_{yy}(0,\mathbf{k})=0$	**false**	y is invariant, so $y_a y_r$ is allowed
$\beta_{c_0}=0$ at all loops	**not established and not implied**	an allowed invariant operator may run in a symmetry-preserving scheme
$p_R\approx 0$ is the original primary constraint	**incorrect without a canonical map**	the original constraint is $\Phi=p_q+p_R+\sum\lambda p_X\approx 0$; $P_R=\Phi$ only in the adapted chart
the scalar extension adds no physical mode	**conditionally correct**	true for a regular fully local invariant kinetic block with one first-class generator and regular gauge fixing
structural subtotal becomes $59/118$	**unsupported**	first-class and gauge-fixed ranks were conflated; the old 44 readout block must be recomputed
the displayed double Schur complement is nonsingular	**false**	the displayed three-block matrix has determinant zero identically
exactly two tensor graviton polarizations and nonlinear hyperbolicity follow	**not established**	neither result follows from the compensator scalar block
Gate G3 is closed	**no**	the physical static contact remains symmetry allowed
Gate G1 is closed	**no**	full secondary chains and reduced gravitational advanced/noise identity remain open

XI. Status ledger

XI.A Established in this calculation

1. **Invariant-lock theorem:** every regular common-shift-invariant lock to the inert frozen composite is locally $F(y,C)=0$.
2. **Compensator-lock no-go:** the physical curvature-carrying relative coordinate is invariant, so its static $y_a y_r$ contact is allowed.
3. **Correct Ward identity:** the original-coordinate 1PI identity contains the combined derivative in the common gauge direction.

4. **Correct Gaussian invariant:** $\xi_\alpha - \lambda_\alpha y = X_\alpha - \lambda_\alpha q$.
5. **Regular Hessian rank:** $n+1$ for $n+2$ scalar coordinates with positive invariant kinetic coefficients.
6. **Primary constraint:** $\Phi = p_q + p_R + \sum_\alpha \lambda_\alpha p_{X_\alpha} \approx 0$.
7. **Gauge-fixed rank:** (Φ, R) forms a rank-two second-class pair; the compensator adds no physical configuration degree of freedom.
8. **Schur singularity:** the proposed equal-block three-row matrix has determinant zero.
9. **No subtotal promotion:** $58/116 \nrightarrow 59/118$ by the stated argument.

XI.B Remains open

1. the actual one-loop coefficient and beta function of the selected physical static counterterm in a coefficient-complete microscopic parent;
2. a different symmetry or nonrenormalization theorem that shifts or otherwise forbids the physical relative readout contact while retaining a regular curvature lock;
3. anomaly freedom and preservation by the measure, regulator, state, gluing, world-tube data, and CMC boundaries;
4. the complete replacement rank of the compact readout, lock, compensator, memory, jets, environment, world tube, CMC, lapse, shift, and gravitational secondary chains;
5. the reduced gravitational advanced/noise deformed identity and its scalar/vector/tensor equation count;
6. nonlinear hyperbolicity and exactly two propagating tensor polarizations in the proposed extended parent;
7. simultaneous phenomenological passage of the Gate G4 emission bounds.

XI.C Effect on v9.0 ledger

LEDGER ITEM	EFFECT
15, all-loop zero-DC Ward identity	remains open; the tested compensator does not realize the required physical-readout symmetry
16, quantum/radiative stability	remains open and priced; no all-loop beta-function cancellation follows
33, coefficient-complete reduced advanced/noise identity and equation count	remains open; the scalar gauge identity is not the gravitational deformed identity
35, realized anomaly-free protective symmetry or explicit one-loop cost	remains open; this record rules out one naive symmetry implementation but does not compute the loop coefficient

No ledger item is closed. No result in Appendices W–AA is withdrawn. The zero-withdrawals record is preserved.

XII. Acceptance condition for any successor completion

A successor relative-coordinate construction may claim to close Gate G3 only if it demonstrates all of the following in one coefficient-complete parent:

$$\begin{gathered}\text{a regular symmetry acting nontrivially on the physical curvature-carrying readout,}\\ \text{an invariant lock valid at } q_N=0,\ W=0,\ \text{and } D_U W\neq 0,\\ \text{absence of every independent physical } y_a y_r \text{ static contact,}\\ \text{a symmetry-preserving measure, regulator, state, gluing, and boundary problem,}\\ \text{the complete primary and secondary constraint algebra,}\\ \text{the full reduced gravitational advanced/noise identity,}\\ \text{no new propagating ghost, rank bifurcation, or hyperbolicity failure.}\end{gathered}$$

If the physical static operator remains allowed, the alternative route is the one already recorded in v9.0: compute its loop coefficient and impose the required subtraction conditions order by order. Relabeling a common coordinate as gauge does not remove that price.

XIII. Reproducibility

The accompanying NumPy checker verifies:

1. the frozen v9.0 hash when the baseline file is supplied or found;
2. invariance of y and ξ_α;
3. noninvariance of the proposed $\xi_\alpha - \lambda_\alpha q$ expression;
4. invariance of the corrected bath coordinate;
5. invariance of the regular lock $y - C$ and breaking of the direct lock $q - C$;
6. allowance of the static $y_a y_r$ counterterm;
7. $Tv = 0$ and $Hv = 0$;
8. the regular Hessian rank and its unique null eigenvalue;
9. the primary constraint $\Phi \approx 0$;
10. the gauge-fixed rank and determinant;
11. a nonzero physical y-stiffness compatible with the Ward null;
12. rank loss when $\kappa = 0$ or a bath kinetic coefficient vanishes;
13. singularity of the proposed three-block Schur matrix;
14. the distinction between clock-line constancy and transverse variation.

The checker is a finite-dimensional algebraic verification. It does not substitute for a field-theoretic loop calculation, BV/BFV construction, boundary-charge analysis, or the full gravitational Dirac algorithm.

XIV. Final grade

The relative-coordinate compensator supplies a clean redundant-coordinate construction and a correct scalar gauge constraint when written entirely in invariant variables. It does not supply the missing physical selection rule. The static readout counterterm survives as an allowed gauge-invariant operator, and the proposed constraint-rank completion is algebraically invalid.

The correct outcome is therefore a sharpened negative gate:

$$\boxed{\text{The naive relative-coordinate Stueckelberg completion does not close Gate G3.}}$$

The frozen framework remains:

$$\boxed{\text{STF is a coherent gravitational candidate — not a completed gravity theory.}}$$

References

1. *STF First Principles Paper v8.1*, publication baseline, 26 August 2026.
2. *STF First Principles Paper v8.2: Gravitational Candidate*, repaired release, 28 August 2026.
3. *STF First Principles Paper v9.0*, five-gate audit-layer release, 28 August 2026.
4. *STF v8.2 Open-Operator Deformed-Identity Classification Gate*, Version 1.0, Appendix W source record.
5. *STF v8.2 Covariant Q_Δ Environment Vertex and Horizon Spectral Gate*, Version 1.0, Appendix X source record.
6. *STF v8.2 All-Loop Zero-DC Protection and Quantum-Stability Gate*, Version 1.0, Appendix Y source record.
7. P. A. M. Dirac, *Lectures on Quantum Mechanics*, Belfer Graduate School of Science, Yeshiva University (1964).
8. M. Henneaux and C. Teitelboim, *Quantization of Gauge Systems*, Princeton University Press (1992).

Appendix AC — One-Loop Static QQ Coefficient and Identifiability Gate

Frozen-consolidation record. Source file `STF_V9_0_One_Loop_Static_QQ_Coefficient_Identifiability_Gate_V1_0.md`*, SHA-256* `327eb75de93146cafc1cbcbea36c9ad490e52ff37874a11c90006af4d5eeebb4`*. The scientific body is carried in full; Markdown heading levels are adjusted for nesting and missing-backslash LaTeX quad transport defects are repaired in the consolidated rendering. Section numbers below are local to this appendix.*

Scope. This is the no-new-field calculation named by Gate G3 after the relative-coordinate Stueckelberg proposal failed its viability gate. It computes every one-loop static Q_aQ_r contribution fixed by the frozen STF record, proves which contributions vanish, and determines whether the full coefficient is identifiable. It does not modify v8.1, v8.2, v9.0, or the previous gate records.

Result. The maximal coefficient-complete subset of the frozen parent—the exactly constrained compact readout at fixed base geometry, the isolated linear memory map, and the finite Gaussian bath with its matched static contact—has

$$\boxed{\delta c^{(1)}_{0,\mathrm{quad}} = 0}$$

exactly. This zero is Gaussian vacuity, not radiative protection: the relevant Hessians are independent of the background readout, so their one-loop determinants cannot generate Q^2.

The full frozen parent does **not** determine a unique one-loop coefficient. Its world-tube action, bath self-interactions, material dependence of $c_\alpha(\mathcal{I})$, gravitational/jet propagators, composite-operator renormalization, regulator, cutoff, and boundary fluctuation operator are not coefficient complete. Two admissible completions with the same frozen quadratic response give different answers. A quartic bath mode gives, in a one-clock-line representative,

$$\delta c^{(1)}_{0,X^4} = \frac{uc^2}{4\Omega^5},$$

while a dynamical world-tube crossover gives

$$\delta c^{(1)}_{0,BX} = -\frac{c^2[W'(B_0)]^2}{2\Omega M_B(\Omega + M_B)}.$$

Neither coefficient can be evaluated from the frozen corpus because u, the B-mode kernel, and the relevant microscopic normalization are absent. Consequently, the requested full-parent number and beta function are **not identifiable**, rather than zero. Gate G3 remains open and priced; ledger item 35 remains open; no claim is withdrawn.

Framework grade. Coherent gravitational candidate — not a completed gravity theory.

Abstract

STF v9.0 requires the selected retarded readout kernel to obey $K^R_{QQ}(0) = 0$. Gate G3 established that this condition is not protected by the symmetries of the frozen architecture and named two possible next calculations. The relative-coordinate Stueckelberg route was tested first and failed because the curvature-carrying difference is gauge invariant, leaving $y_a y_r$ allowed. The remaining route is a direct one-loop calculation of the physical static coefficient.

This paper carries out that calculation to the limit permitted by the frozen action. The compact readout is a second-class constrained constitutive module. With its standard Dirac measure, the square root of the Dirac determinant cancels the constraint Jacobian, leaving a fixed-base generating functional linear in the readout source; it supplies no independent QQ loop. The first-order memory action is linear in its multiplier and has a Q-independent determinant; it supplies the exact high-pass transfer but no loop counterterm. The finite completed-square bath is Gaussian. Integrating it gives the already matched tree exchange and a determinant independent of Q; its one-loop static coefficient is exactly zero.

The full one-loop coefficient is obtained from the background-field Hessian,

$$c^{(1)}_0 = \frac{1}{2V}\mathrm{STr}\left[\mathbb{H}_0^{-1}\mathbb{H}_{,QQ} - \mathbb{H}_0^{-1}\mathbb{H}_{,Q}\mathbb{H}_0^{-1}\mathbb{H}_{,Q}\right].$$

The frozen architecture does not provide the two Hessian derivatives for the gravitational, world-tube, interacting-environment, jet, CMC, and boundary sectors. This is not a merely numerical omission. A constructive non-identifiability proof shows that two actions satisfying the same frozen Gaussian matching have distinct one-loop static responses. An X^4 self-interaction produces a positive tadpole contribution. Quantizing the already required varied carrier B produces a mixed B-X bubble proportional to $[W'(B_0)]^2$, which vanishes on the $B = 0$ and $B = 1$ plateaus but is nonzero through the activation crossover. In four dimensions the representative tadpole depends explicitly on the ultraviolet cutoff.

The result resolves the declared calculation without inventing missing parameters. The only actual zero is the exact quadratic-subtheory zero. The full-parent coefficient and β_{c_0} remain underdetermined until one microscopic environment and one varied world-tube action are supplied. The shortest next calculation is therefore the coefficient-complete B-X crossover fluctuation kernel, not another compensator and not a numerical-relativity run.

I. Source control and the requested coefficient

I.A Frozen records

RECORD	ROLE	SHA-256
STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md	publication baseline	4788576a24d0c576c
STF_First_Principles_Paper_V8_1_fixed(1).md	calculation baseline	bc2bd30366ef0a8b1
STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md	repaired v8.2 candidate	f7eca3fb886b559b18
STF_First_Principles_Paper_V9_0_2026-08-28.md	frozen audit-layer baseline	855abcaf6366964e2
STF_V9_0_Relative_Coordinate_Stueckelberg_Viability_Gate_V1_0.md	immediately preceding viability gate	121468a1d6a6c28da

The checker verifies the v9.0 hash when the manuscript is supplied or found. No baseline file is edited.

I.B Prior gate records

The calculation uses three prior results:

1. Gate G1: $58/116$ is a structural module subtotal, not a complete gravitational Dirac rank.
2. Gate G2: the finite covariant bath vertex and positive ρ_{QQ} exist, with a once-subtracted matching convention, but g_Q^2, the factorization ratio, and the microscopic continuation remain open.
3. Gate G3: the Gaussian completed square has exact zero DC in its subtheory, while the full frozen architecture admits an independent static Q_aQ_r counterterm.

The current calculation does not reopen those conclusions. It evaluates the loop coefficient they left outstanding.

I.C Definition of the target

On a stationary local clock tube, write the renormalized quadratic physical/advanced action as

$$\Gamma^{(2)}_{QQ} = \int_{\omega,\mathbf{k}} \widetilde{Q}_{\Delta,a}(-\omega,-\mathbf{k})\left[\Sigma^R_{\mathrm{hp}}(\omega,\mathbf{k}) + c_0(\mu,\mathbf{k})\right]\widetilde{Q}_{\Delta,r}(\omega,\mathbf{k}) + \cdots,$$

where

$$\widetilde{Q}_\Delta = W(B)Q_\Delta, \qquad Q_\Delta = M_*^2\left(\sqrt{q_N^2+\Delta^2}-\Delta\right).$$

The high-pass part obeys

$$\Sigma^R_{\rm hp}(0,\mathbf{k}) = 0.$$

The target is the one-loop correction

$$\delta c_0^{(1)}(\mathbf{k}) = \Sigma^{R,(1)}_{QQ}(0,\mathbf{k})$$

before the one-loop counterterm is retuned. The selected-channel matching condition would then require

$$c_{\rm ct}^{(1)}(\mathbf{k}) = -\delta c_0^{(1)}(\mathbf{k}).$$

This paper first evaluates the homogeneous coefficient. Finite-momentum generalization requires the transverse kernels that the frozen environment does not specify.

II. Background-field identity

II.A General formula

Let Ψ collect all fields integrated over at one loop and let $\bar{Q}$ be a static background readout. In Euclidean signature,

$$\Gamma^{(1)}[\bar{Q}] = \frac{1}{2}\,\mathrm{STr}\ln \mathbb{H}[\bar{Q}],$$

where

$$\mathbb{H}[\bar{Q}] = \frac{\delta^2 S_E}{\delta\Psi\,\delta\Psi}\bigg|_{\bar{Q}}$$

includes ghosts and constrained-measure factors with their appropriate signs.

Expand

$$\mathbb{H}[\bar{Q}] = \mathbb{H}_0 + \bar{Q}\,\mathbb{H}_{,Q} + \frac{\bar{Q}^2}{2}\mathbb{H}_{,QQ} + O(\bar{Q}^3).$$

If

$$\Gamma^{(1)}[\bar{Q}] \supset \frac{1}{2}V\,c_0^{(1)}\bar{Q}^2,$$

then

$$\boxed{c_0^{(1)} = \frac{1}{2V}\mathrm{STr}\left[\mathbb{H}_0^{-1}\mathbb{H}_{,QQ} - \mathbb{H}_0^{-1}\mathbb{H}_{,Q}\mathbb{H}_0^{-1}\mathbb{H}_{,Q}\right].}$$

This formula separates two questions that were previously mixed:

- whether the quadratic core has a Q-dependent Hessian;
- whether the full parent supplies the Hessian derivatives needed to compute the trace.

II.B Quadratic-core corollary

If the action is at most quadratic and the readout enters only as a linear source, then

$$\mathbb{H}_{,Q} = 0, \qquad \mathbb{H}_{,QQ} = 0,$$

and therefore

$$c_0^{(1)} = 0.$$

This is an exact determinant statement. It is not a Ward identity and does not survive arbitrary allowed interactions.

III. Exactly constrained compact readout

III.A Fixed-base module

The compact readout introduces $(\mathcal{C}^A, \Pi_A, p^A, \varpi_A)$ and the second-class set

$$\Phi_I = (\Pi_A, \chi_A, \varpi_A, \mathcal{F}_A), \qquad \chi_A = \mathcal{C}_A - \widehat{\mathcal{C}}_A.$$

Its Dirac matrix obeys

$$\det \mathbb{D}_{\mathrm{ro}} = (\det J)^2, \qquad \operatorname{rank} \mathbb{D}_{\mathrm{ro}} = 44$$

for $\Delta > 0$. At fixed base curvature, the constrained phase-space path integral has the standard local measure

$$\mathcal{D}\Gamma_{\mathrm{ro}}\, \delta[\Phi] \sqrt{\det \mathbb{D}_{\mathrm{ro}}}.$$

Integrating the alignment delta functions produces a factor $1/|\det J|$, while

$$\sqrt{\det \mathbb{D}_{\mathrm{ro}}} = |\det J|.$$

The factors cancel. The reduced source functional is

$$Z_{\mathrm{ro}}[j_Q|\widehat{\mathcal{C}}] = \mathcal{N}[\widehat{\mathcal{C}}] \exp\left(\int j_Q Q_\Delta[\widehat{\mathcal{C}}]\right),$$

with j_Q-independent normalization. Thus

$$\frac{\delta^2 \ln Z_{\mathrm{ro}}}{\delta j_Q\, \delta j_Q} = 0.$$

This reproduces the frozen fixed-base result

$$\chi_{QQ}^{\mathrm{aux}} = 0.$$

III.B What this does not remove

The result removes an **independent auxiliary loop**. It does not remove loops of the base curvature, retained jets, metric, clock, or CMC variables on which Q_Δ depends. Those contributions require the physical propagator

$$G^{R,AB}_{\mathrm{grav+CMC}}$$

and the coefficient-complete composite vertices generated by

$$P_A^{\rm eff} = M_*^2\frac{\mathcal{C}_A}{s}, \qquad H_{AB}^{\rm cap} = M_*^2\left(\frac{\delta_{AB}}{s} - \frac{\mathcal{C}_A\mathcal{C}_B}{s^3}\right).$$

The tensors $P_A^{\rm eff}$ and $H_{AB}^{\rm cap}$ are known; the propagator, jet contacts, higher vertices, gauge-fixed determinant, and boundary kernel are not. The compact module therefore contributes zero by itself but does not determine the gravitational composite-operator loop.

IV. Isolated linear memory

IV.A First-order action

The local memory representative is

$$\mathcal{L}_{\rm mem} = \sqrt{h}\,\rho\left[D_U y + \omega_c(y - \widetilde{Q}_\Delta)\right].$$

Integrating over ρ imposes

$$(D_U + \omega_c)y = \omega_c\widetilde{Q}_\Delta.$$

The functional Jacobian is

$$\det(D_U + \omega_c)^{-1},$$

which is independent of the readout. The solution gives

$$Z = \widetilde{Q}_\Delta - y, \qquad K_{\rm sel}^R(\omega) = \frac{-i\omega}{\omega_c - i\omega}.$$

Hence

$$K_{\rm sel}^R(0) = 0,$$

and the isolated memory determinant gives

$$\delta c_{0,\rm mem}^{(1)} = 0.$$

IV.B Bypass limitation

The memory pair is linear. It has no vertex with which to form an internal loop. A generated local Q_aQ_r operator can bypass the memory pole entirely. Once the memory output is coupled to gravity, activation, matter, or an interacting environment, the corresponding vertices—not the memory determinant—control the loop correction.

The memory and oscillator bath are alternative local representations of the response chain in the prior audit. Their zeros are verified separately here and are not added as two independent cancellations.

V. Finite Gaussian bath

V.A Exact integration

For a finite stationary bath, use the Euclidean schematic form

$$S_X = \frac{1}{2}X^T A X - \bar{Q}\, c^T X + \frac{1}{2}c_{\rm ct}\bar{Q}^2,$$

where at zero frequency

$$A(0) = \mathrm{diag}(\Omega_\alpha^2), \qquad c_{\rm ct} = \sum_\alpha \frac{c_\alpha^2}{\Omega_\alpha^2}.$$

Gaussian integration gives

$$\Gamma_X[\bar{Q}] = \frac{1}{2}\bar{Q}^2\left(c_{\rm ct} - c^T A^{-1} c\right) + \frac{1}{2}\mathrm{Tr}\ln A.$$

At zero frequency,

$$c^T A^{-1}(0) c = \sum_\alpha \frac{c_\alpha^2}{\Omega_\alpha^2} = c_{\rm ct},$$

so the classical exchange and local contact cancel. The determinant depends on A, not on the linear source $\bar{Q}c$. Therefore

$$\boxed{\delta c^{(1)}_{0,\rm bath} = 0}$$

for the specified finite Gaussian bath.

V.B Relation to the spectral subtraction

The exact response is

$$\Sigma^R_{QQ}(z) = \sum_\alpha c_\alpha^2 \left[\frac{1}{z^2 - \Omega_\alpha^2} + \frac{1}{\Omega_\alpha^2}\right],$$

and hence

$$\Sigma^R_{QQ}(0) = 0.$$

The corresponding spectral density is

$$\rho_{QQ}(\Omega) = \sum_\alpha \frac{c_\alpha^2}{2\Omega_\alpha}\delta(\Omega - \Omega_\alpha),$$

with

$$c_{\rm ct} = 2\int_0^\infty \frac{\rho_{QQ}(\Omega)}{\Omega}\, d\Omega.$$

The determinant calculation adds a new clarification: in the strictly Gaussian model there is no loop correction to either side because there is no interaction vertex. The exact equality is therefore stable **inside that fixed quadratic theory**.

V.C Gaussian-Vacuity Theorem

Theorem (Gaussian Vacuity). In the frozen fixed-base compact-readout module, isolated linear memory module, and finite Gaussian environment with the once-subtracted contact, the one-loop static selected-channel coefficient vanishes exactly:

$$\delta c^{(1)}_{0,\rm quad} = 0.$$

The vanishing follows from constraint reduction and Q-independent Hessians, not from a symmetry forbidding $Q_a Q_r$.

Proof. The compact auxiliary measure reduces to a j_Q-independent normalization times a source-linear exponential. The memory multiplier gives a Q-independent first-order determinant. The bath readout enters only as a linear source, and its Gaussian Hessian is Q-independent. Each one-loop determinant therefore has zero second derivative with respect to the background readout. The matched bath saddle has zero static coefficient. $\square$

VI. Why this zero does not price the full parent

VI.A Missing Hessian blocks

The frozen v8.2 action explicitly states that it is an architecture rather than a coefficient-complete action. The following inputs to the one-loop trace are missing:

SECTOR	REQUIRED ONE-LOOP DATUM	FROZEN STATUS
bath interactions	$V'''(X), V''''(X)$, transverse kernel, regulator	not specified; Gaussian existence construction only
world tube	quadratic B-kernel, normalization, state, boundary conditions	varied carrier required, action not coefficient complete
material coefficients	derivatives of $c_\alpha(\mathcal{I})$ and propagators of $\mathcal{I}$	symbolic
gravity and clock	gauge-fixed propagator and full scalar/vector/tensor Hessian	open
retained jets	coefficient-complete $\mathsf{A}(k)$ and conservative contacts	open
CMC boundary	augmented Jacobi operator, boundary determinant, BV/BFV measure	conditional/open
composite operator	renormalization/mixing of $Q_\Delta[\mathcal{C}]$	not supplied
ultraviolet data	cutoff, subtraction scheme, continuum completion	open

Without these blocks, neither $\mathbb{H}_{,Q}$ nor $\mathbb{H}_{,QQ}$ is known for the full parent.

VI.B Identifiability criterion

A coefficient is identifiable from the frozen data only if every completion satisfying those data gives the same value. It is enough to disprove identifiability by constructing two completions that:

1. have the same Ω_α, c_α, tree spectral density, and matched zero-DC contact;
2. respect the declared scalar covariance and doubled construction;
3. differ only by an interaction the frozen architecture leaves unspecified;
4. give different $c_0^{(1)}$.

Sections VII and VIII supply two such constructions.

VII. Interacting-bath counterexample

VII.A One-clock-line completion

Add one allowed quartic self-interaction to a bath mode:

$$S_X^E = \int d\tau \left[\frac{1}{2}X(-\partial_\tau^2+\Omega^2)X + \frac{u}{4!}X^4 - c\bar{Q}X + \frac{1}{2}\frac{c^2}{\Omega^2}\bar{Q}^2\right].$$

This changes none of the frozen tree-level Gaussian matching data at $u=0$, and for small u the renormalized Ω and c can be matched to the same infrared values. The frozen architecture does not set u .

For a static background,

$$X_{\rm cl} = \frac{c\bar{Q}}{\Omega^2} + O(u,\bar{Q}^3).$$

The fluctuation Hessian is

$$\mathbb{H}_X[\bar{Q}] = -\partial_\tau^2 + \Omega^2 + \frac{u}{2}X_{\rm cl}^2.$$

The one-loop determinant gives

$$\Gamma_X^{(1)}[\bar{Q}] - \Gamma_X^{(1)}[0] = \frac{u}{4}\frac{c^2\bar{Q}^2}{\Omega^4}I_1(\Omega) + O(u^2,\bar{Q}^4),$$

where

$$I_1(\Omega) = \int_{-\infty}^{\infty}\frac{d\nu}{2\pi}\frac{1}{\nu^2+\Omega^2} = \frac{1}{2\Omega}.$$

Therefore

$$\boxed{\delta c_{0,X^4}^{(1)} = \frac{uc^2}{2\Omega^4}I_1(\Omega) = \frac{uc^2}{4\Omega^5}.}$$

The coefficient is nonzero for $u\neq 0$. The same frozen quadratic data therefore admit both

$$\delta c_0^{(1)} = 0$$

and

$$\delta c_0^{(1)} = \frac{uc^2}{4\Omega^5}.$$

VII.B Field-theory cutoff dependence

For a d-dimensional Euclidean bath,

$$\delta c_{0,X^4}^{(1)} = \frac{uc^2}{2\Omega^4}I_d(\Omega), \qquad I_d(\Omega) = \int^{\Lambda}\frac{d^dp}{(2\pi)^d}\frac{1}{p^2+\Omega^2}.$$

In four dimensions with a spherical cutoff,

$$I_4(\Omega;\Lambda) = \frac{1}{16\pi^2}\left[\Lambda^2 - \Omega^2 \ln\left(1 + \frac{\Lambda^2}{\Omega^2}\right)\right].$$

The numerical checker demonstrates the explicit cutoff dependence. The frozen corpus supplies neither u nor Λ, so this contribution cannot be assigned a number or a unique beta function.

VII.C Interpretation

The quartic mode is not proposed as a new STF parameter. It is a counterexample proving non-identifiability. Because STF is declared parameter-free, u would have to be derived from the microscopic environment rather than selected to improve the result.

VIII. Dynamical world-tube crossover

VIII.A Existing nonlinearity

The frozen architecture already contains

$$W(B) = B^2(3 - 2B), \qquad W'(B) = 6B(1 - B).$$

Let

$$B = B_0 + b$$

and suppose the varied carrier has a regular quadratic fluctuation operator

$$A_B = -\partial_\tau^2 + M_B^2$$

in a local representative. Expanding

$$-c\bar{Q}W(B)X$$

gives the bilinear fluctuation mixing

$$-c\bar{Q}W'(B_0)bX.$$

The (X, b) Hessian is

$$\mathbb{H}_{XB}[\bar{Q}] = \begin{pmatrix} -\partial_\tau^2 + \Omega^2 & -cW'(B_0)\bar{Q} \\ -cW'(B_0)\bar{Q} & -\partial_\tau^2 + M_B^2 \end{pmatrix}.$$

VIII.B Mixed bubble

Expanding the determinant to quadratic order gives

$$\delta c_{0,BX}^{(1)} = -c^2[W'(B_0)]^2 J_1(\Omega, M_B),$$

where

$$J_1(\Omega, M_B) = \int_{-\infty}^{\infty} \frac{d\nu}{2\pi} \frac{1}{(\nu^2 + \Omega^2)(\nu^2 + M_B^2)} = \frac{1}{2\Omega M_B(\Omega + M_B)}.$$

Thus

$$\boxed{\delta c_{0,BX}^{(1)} = -\frac{c^2[W'(B_0)]^2}{2\Omega M_B(\Omega + M_B)}.}$$

VIII.C Plateau and crossover regimes

At the smooth endpoints,

$$W'(0) = W'(1) = 0,$$

so this particular one-loop bubble vanishes:

$$\delta c^{(1)}_{0,BX} = 0 \qquad (B_0 = 0 \text{ or } 1).$$

Through the crossover,

$$0 < B_0 < 1, \qquad W'(B_0) \neq 0,$$

and the contribution is generically nonzero if the carrier is quantized. At $B_0 = 1/2$,

$$W'(1/2) = \frac{3}{2}.$$

This is the shortest nontrivial loop already latent in the frozen architecture. It requires no arbitrary bath self-interaction, but it does require the missing B-mode propagator and normalization.

VIII.D Status

The varied world tube was required for the total Ward identity, but its coefficient-complete quantum action was never supplied. Treating B as a classical external profile deletes the bubble but also changes the quantum theory and must be stated. Quantizing B without its kinetic and boundary action leaves M_B and the loop measure undefined.

IX. Gravitational and composite-readout loops

IX.A Readout expansion

Around a background curvature state,

$$Q_\Delta[\bar{\mathcal{C}} + \delta\mathcal{C}] = \bar{Q}_\Delta + P^{\text{eff}}_A \delta\mathcal{C}^A + \frac{1}{2} H^{\text{cap}}_{AB} \delta\mathcal{C}^A \delta\mathcal{C}^B + \cdots.$$

The $Q_\Delta X_\alpha$ vertex therefore contains bilinear and higher interactions between the environment, retained curvature jets, and gravitational modes.

IX.B Missing propagator obstruction

The one-loop coefficient needs contractions such as

$$P^{\text{eff}}_A G^{AB}_{\text{grav+CMC}} P^{\text{eff}}_B,$$

and vertices involving H^{cap}_{AB}, higher readout derivatives, jet contacts, lapse and shift, CMC boundary data, and ghosts. The frozen record explicitly leaves the coefficient-complete gravitational propagator and full secondary algebra open.

The capacity Hessian cannot replace the propagator:

$$H^{\text{cap}}_{AB} \neq \Gamma_{QQ}, \qquad \chi^{\text{aux}}_{QQ} = 0.$$

Consequently, the gravitational component of $c_0^{(1)}$ is not calculable from the compact capacity tensor alone.

IX.C General decomposition

The most precise full-parent statement is

$$\delta c_0^{(1)} = 0_{\text{constrained readout}} + 0_{\text{isolated memory}} + 0_{\text{Gaussian bath}} + \delta c_{0,BX}^{(1)} + \delta c_{0,X-\text{int}}^{(1)} + \delta c_{0,\text{grav/jet/CMC}}^{(1)} + \delta c_{0,\text{bdy/state}}^{(1)}.$$

Only the first three terms are fixed. The remaining terms are not known to vanish and are not numerically specified.

X. Coefficient-Identifiability Theorem

Theorem (One-Loop Coefficient Non-Identifiability). The frozen v8.1/v8.2/v9.0 architecture does not determine a unique one-loop coefficient of the physical static operator $\widetilde{Q}_{\Delta,a}\widetilde{Q}_{\Delta,r}$.

Proof. The frozen data fix a finite Gaussian bath with frequencies Ω_α, linear couplings c_α, positive spectral density, and a once-subtracted tree contact. Completion A sets every bath self-interaction to zero and evaluates the fixed-base constrained readout plus isolated linear memory. Its relevant Hessians are independent of $\bar{Q}$, so $\delta c_0^{(1)} = 0$.

Completion B adds the covariant local interaction $uX^4/4!$, whose coefficient is not fixed or forbidden by the frozen architecture. It can be infrared matched to the same renormalized Ω and c. Its one-loop coefficient is $uc^2/(4\Omega^5)$ in the finite representative and is nonzero for $u \neq 0$. Alternatively, quantizing the already required varied world tube produces the mixed coefficient in Section VIII. Thus two completions satisfying the same frozen quadratic data give different one-loop answers. The coefficient is not identifiable from those data. □

X.A Consequence for the beta function

In the exactly quadratic subtheory,

$$\beta_{c_0} = 0$$

trivially because there are no interaction loops. This is not technical naturalness. In an interacting completion, the coefficient depends on new microscopic couplings, propagators, dimension, regulator, and subtraction scheme. No unique

$$\beta_{c_0}$$

can be extracted before those data are fixed.

X.B Consequence for tuning

At a chosen matching scale,

$$c_{\text{ct}}^{(1)} = -\delta c_0^{(1)}$$

remains the correct condition. The current calculation proves that the Gaussian portion costs nothing beyond its exact matched contact, while every interacting contribution must be computed and subtracted. It does not supply a numerical fine-tuning ratio because both the loop numerator and the observationally permitted residual remain unspecified.

XI. Ward, noise, and rank consequences

XI.A Total covariance

Every local counterterm can be inserted covariantly as

$$S_{\mathrm{ct}}^{(1)} \propto \int d^4x \sqrt{-g}\, W(B)^2 Q_\Delta^2.$$

When its metric, clock, readout, B, jet, and boundary variations are retained, it does not invalidate the conditional diagonal diffeomorphism identity. Omitting those variations would create a source-force defect.

XI.B No new protective identity

The Gaussian determinant zero does not add a Ward identity. The static operator remains symmetry allowed. Therefore the calculation does not close item 15 and does not prove item 16.

XI.C Noise

The local real counterterm does not change the positive spectral discontinuity or KMS noise directly. Interactions that renormalize the bath spectrum also renormalize noise and must satisfy the reduced advanced/noise identity. The current calculation does not assume that a real static match fixes those stochastic terms.

XI.D Constraint rank

The local static contact adds no new velocity by itself, so the $58/116$ primary structural subtotal is unchanged. Its coefficient can alter the secondary jet kernel and augmented CMC operator. No complete gravitational rank follows from either the Gaussian zero or the representative nonzero loops.

XII. Regime and boundary audit

REGIME	CALCULATED RESULT	STATUS
fixed base geometry	compact auxiliary susceptibility and independent loop vanish	exact within the constrained module
isolated linear memory	determinant is Q-independent; $K_{\mathrm{sel}}^R(0) = 0$	exact linear result
finite Gaussian bath	matched saddle has zero DC; determinant is Q-independent	exact quadratic-subtheory result
ideal Drude continuum	tree subtraction remains exact	loop result requires UV continuation and regulator
$B = 0$ plateau	$W' = 0$; mixed B-X bubble vanishes	exact for this bubble
$B = 1$ plateau	$W' = 0$; mixed B-X bubble vanishes	exact for this bubble
$0 < B < 1$ crossover	$W' \neq 0$; mixed bubble generically nonzero	coefficient conditional on B propagator

REGIME	CALCULATED RESULT	STATUS
$q_N = 0$ apex	Q_Δ and capacity derivatives remain finite for $\Delta > 0$	gravitational loop still needs full propagator
$\Delta \to 0$	compact Jacobian becomes singular at the apex	outside established constant-rank domain
zero bath self-coupling	quartic contribution vanishes	Gaussian special point
nonzero bath self-coupling	quartic contribution nonzero	allowed but coefficient unspecified
classical external B	no B-loop	changes quantum field content; must be declared
quantized B	mixed bubble present through crossover	needs S_{tube} and boundary state
finite transverse momentum	five physical static form factors may appear	transverse kernels absent
noninvariant regulator/state	additional Ward and boundary defects possible	not established

XIII. Graded claim ledger

CLAIM	EVIDENCE	GRADE	EFFECT
compact auxiliary alone generates a QQ loop	constrained measure and source functional	**false at fixed base**	capacity Hessian remains non-propagating
isolated linear memory generates a static one-loop contact	Q-independent determinant	**false**	exact transfer retained
finite Gaussian bath generates a one-loop static term	Q-independent Hessian	**false**	Gaussian subtheory has exact zero
specified quadratic core has $\delta c_0^{(1)} = 0$	determinant calculation	**theorem/exact**	no tuning inside fixed quadratic core
this zero is an all-loop protective Ward result	$Q_a Q_r$ remains allowed	**false**	items 15–16 remain open
quartic bath interaction produces a static one-loop term	explicit determinant/tadpole	**derived representative**	proves interaction sensitivity
dynamical world-tube crossover produces a mixed loop	explicit B-X determinant	**derived conditional**	identifies shortest latent nontrivial loop
endpoint plateaus remove that mixed bubble	$W'(0) = W'(1) = 0$	**theorem for this diagram**	does not remove other loops

CLAIM	EVIDENCE	GRADE	EFFECT
frozen data determine the full one-loop coefficient	two-completion counterexample	**false**	coefficient non-identifiable
frozen data determine β_{c_0}	missing interactions/regulator	**false**	no numerical running
a numerical tuning factor can be quoted	missing loop value and tolerance	**false**	tuning remains symbolic
total Ward identity is invalidated	covariant counterterm can be varied fully	**no**	conditional Ward grade unchanged
$58/116$ primary subtotal changes	no new velocity in static contact	**no**	subtotal unchanged
ledger item 35 closes	full coefficient still absent	**no**	item remains open
framework grade improves	G1/G3 and microscopic completion remain open	**no**	grade unchanged

XIV. Direct answer to the declared calculation

The answer has two levels and they must not be merged.

XIV.A What is actually calculable

$$\boxed{\delta c^{(1)}_{0,\text{constrained readout+linear memory+Gaussian bath}} = 0.}$$

This is exact and reproduced. It means the already specified finite quadratic realization does not create an additional one-loop subtraction cost.

XIV.B What the frozen theory predicts

$$\boxed{\delta c^{(1)}_{0,\text{full frozen architecture}} \text{ is not identifiable from the supplied action.}}$$

The missing value cannot be replaced by the Gaussian zero. Doing so would silently set every unspecified interaction and carrier fluctuation to zero.

XIV.C Ledger effect

- Item 15 remains open: no full physical-readout Ward identity exists.
- Item 16 remains open: interacting radiative stability is not proved.
- Item 35 remains open: this record proves non-identifiability and isolates the first missing diagrams but does not supply the coefficient-complete full-parent number.
- Gate G1 remains open: no full gravitational equation count or advanced/noise identity is produced.
- Zero withdrawals are preserved.

XV. Decisive next calculation

The shortest honest successor is the **varied world-tube crossover loop**, because its nonlinearity already exists in the frozen architecture. It requires:

1. a coefficient-complete quadratic $S^{(2)}_{\mathrm{tube}}[b]$;
2. the normalized retarded, advanced, and noise propagators of b;
3. the background crossover profile $B_0(x)$;
4. the microscopic $c_\alpha(\mathcal{I})$ normalization from Gate G2;
5. the mixed B-X loop in the doubled contour;
6. its covariant local subtraction and all carrier variations;
7. insertion into the jet and augmented CMC operators;
8. the reduced advanced/noise Ward test.

If B is deliberately classical, that must be declared and justified; the next loop then moves to the first derived interacting bath or gravitational composite vertex. No numerical-relativity simulation should precede this coefficient-complete local calculation.

XVI. Reproducibility

The accompanying NumPy checker verifies:

1. the frozen v9.0 hash when the baseline is available;
2. the finite Gaussian static cancellation;
3. exact zero DC of the once-subtracted finite-bath kernel;
4. Q-independence of the Gaussian determinant;
5. exact linear-memory zero DC and determinant independence;
6. the compact-readout Dirac determinant and constrained-measure cancellation;
7. vanishing fixed-base auxiliary susceptibility;
8. the background-field trace formula;
9. the $0+1$-dimensional tadpole integral;
10. $\delta c^{(1)}_{0,X^4} = uc^2/(4\Omega^5)$;
11. direct determinant reproduction of that coefficient;
12. the mixed B-X bubble integral;
13. the world-tube crossover coefficient;
14. endpoint vanishing from $W'(0) = W'(1) = 0$;
15. explicit four-dimensional cutoff dependence;
16. distinct one-loop answers with identical quadratic matching data.

The checker uses the Python standard library and NumPy only. Its finite representatives verify the algebra and non-identifiability proof; they are not substitutes for the missing microscopic parent.

XVII. Conclusion

The declared one-loop calculation does not yield a hidden naturalness success or a universal tuning number. It yields a sharper boundary.

The constrained readout, exact linear memory, and finite Gaussian bath are internally cleaner than the structural Gate G3 statement alone showed: their one-loop static coefficient is exactly zero. But the zero occurs because the specified core contains no interaction vertex capable of producing the loop. The moment the architecture is completed by an allowed bath self-interaction or by quantizing its already required varied world tube, a nonzero static coefficient appears and depends on parameters that have not been derived.

The correct scientific statement is therefore:

$$\boxed{\text{quadratic core: exact one-loop zero;}\qquad \text{full parent: coefficient not identifiable.}}$$

The framework remains:

$$\boxed{\text{STF is a coherent gravitational candidate — not a completed gravity theory.}}$$

References

1. *STF First Principles Paper v8.1*, publication and calculation baselines, 26 August 2026.
2. *STF First Principles Paper v8.2: Gravitational Candidate*, repaired release, 28 August 2026.
3. *STF First Principles Paper v9.0*, five-gate audit-layer release, 28 August 2026.
4. *STF v8.2 Open-Operator Deformed-Identity Classification Gate*, Version 1.0.
5. *STF v8.2 Covariant Q_Δ Environment Vertex and Horizon Spectral Gate*, Version 1.0.
6. *STF v8.2 All-Loop Zero-DC Protection and Quantum-Stability Gate*, Version 1.0.
7. *STF v9.0 Relative-Coordinate Stueckelberg Viability Gate*, Version 1.0.
8. P. A. M. Dirac, *Lectures on Quantum Mechanics*, Belfer Graduate School of Science, Yeshiva University (1964).
9. M. Henneaux and C. Teitelboim, *Quantization of Gauge Systems*, Princeton University Press (1992).

Appendix AD — Varied World-Tube Crossover Loop and Noise Gate

Frozen-consolidation record. Source file `STF_V9_0_Varied_World_Tube_Crossover_Loop_and_Noise_Gate_V1_0.md` *, SHA-256* `bb89b94d9f01f59e243069ba1cd57910924e632f1a776906c5ef79494fb9e5b7` *. The scientific body is carried in full; Markdown heading levels are adjusted for nesting and missing-backslash LaTeX quad transport defects are repaired in the consolidated rendering. Section numbers below are local to this appendix.*

Scope. This paper performs the calculation declared at the end of the one-loop static-coefficient audit: recover the varied world-tube carrier from the frozen corpus, derive its quadratic fluctuation operator, calculate the doubled B-X_α crossover loop and noise, and state the consequences for the Ward identity, rank ledger, and zero-static-response condition. It does not edit or import physics into v8.1, v8.2, or v9.0.

Baseline rule. The physics is graded against the frozen v8.1 publication and calculation baselines and the repaired v8.2 architecture. The v9.0 file is used only as the frozen audit-layer ledger that names the open gate. No version-9 proposal is used as a premise.

Result. The corpus does contain a definite representative carrier action,

$$S_B = -\int d^4x\sqrt{-g}\left[\frac{Z_B}{2}\nabla_\mu B\nabla^\mu B + V_B(B)\right], \qquad Z_B > 0,$$

with $W(B) = B^2(3-2B)$. Thus the preceding identifiability paper was too broad when it called the world-tube action absent. What remains absent is a derived V_B, a finite stable tube solution, its boundary state, the microscopic $c_\alpha(\mathcal{I})$, and the transverse/ultraviolet bath completion.

On a stationary local crossover patch, write

$$B = B_0 + \frac{b}{\sqrt{Z_B}}, \qquad m_B^2 = \frac{V_B''(B_0)}{Z_B}, \qquad g_\alpha = \frac{c_\alpha W'(B_0)}{\sqrt{Z_B}}.$$

For one finite oscillator of frequency Ω, the raw composite bX bubble is negative at zero external frequency. That is not the complete selected-channel answer. The frozen Gaussian construction also requires the zero-mode contact to contain the same $W(B)^2$. Fluctuating that contact generates a positive seagull. In a one-clock-line KMS representative their sum is

$$\boxed{\delta c^{(1)}_{0,BX} = g^2\mathcal{L}_\beta(m_B,\Omega) > 0,}$$

$$\mathcal{L}_\beta = \frac{1}{\Omega^2}\frac{\coth(\beta m_B/2)}{2m_B} - \frac{1}{\Omega^2 - m_B^2}\left[\frac{\coth(\beta m_B/2)}{2m_B} - \frac{\coth(\beta\Omega/2)}{2\Omega}\right].$$

At zero temperature,

$$\boxed{\mathcal{L}_\infty(m_B,\Omega) = \frac{1}{2\Omega^2(m_B+\Omega)}.}$$

The raw-bubble-only expression previously displayed is therefore superseded by the matched bubble-plus-seagull expression above. This supersession affects only that post-v9.0 exploratory calculation record. It withdraws no v8.1, v8.2, v9.0, or Gate G1–G5 result.

For the displayed independent-worldline bath in $3+1$ dimensions, the local zero-temperature matched coefficient is instead

$$\delta c^{(1)}_{0,BX}(\Lambda) = \frac{g^2}{4\pi^2\Omega^2}\int_0^\Lambda dp\,\frac{p^2}{\sqrt{p^2+m_B^2}+\Omega},$$

and grows quadratically with the spatial cutoff. The dissipative part has a positive composite spectral density and KMS-positive noise, but the real static residual must be subtracted again if exact zero DC is imposed. Its number is not fixed by the frozen corpus.

$$\boxed{\text{Gate G3 remains open and priced; ledger item 35 remains open.}}$$

$$\boxed{\text{Grade unchanged: coherent gravitational candidate, not a completed gravity theory.}}$$

I. Source control

I.A Frozen records

RECORD	ROLE	S
`STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md`	publication baseline	[illegible]
`STF_First_Principles_Paper_V8_1_fixed(1).md`	calculation baseline	[illegible]
`STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md`	repaired v8.2 architecture	[illegible]
`STF_First_Principles_Paper_V9_0_2026-08-28.md`	frozen audit-layer ledger only	[illegible]
`STF_V8_1_Covariant_Clock_World_Tube_Gaussian_Bath_and_Ward_Completion_V1_0.md`	canonical carrier source	[illegible]
`STF_V9_0_One_Loop_Static_QQ_Coefficient_Identifiability_Gate_V1_0.md`	immediately preceding calculation	[illegible]

No listed source is modified. The checker can verify all six hashes.

I.B Exact correction to the preceding record

The preceding calculation made two different statements about the varied carrier:

1. its main identifiability conclusion correctly said that a finite tube potential, background, normalization, state, and boundary fluctuation operator were not fixed; and
2. its Section VIII treated the quadratic carrier as merely hypothetical and retained only the raw mixed determinant.

The first statement survives after being narrowed. The second does not. The canonical Stage-4 source already supplied S_B and $Z_B > 0$, although it explicitly left the soliton and V_B unsolved. More importantly, the raw mixed determinant is not separately admissible once the matched contact $W(B)^2 Q_\Delta^2$ is retained. This paper therefore supersedes the raw formula

$$-\frac{c^2[W'(B_0)]^2}{2\Omega M_B(\Omega + M_B)}$$

as a claimed selected-channel coefficient. It remains the raw bubble in the unnormalized variable convention used there. The complete matched result is derived below.

I.C What this calculation can and cannot determine

The canonical source fixes:

- the Lorentz-scalar sign and derivative order of the B action;
- $Z_B > 0$;

- the smooth window $W(B) = B^2(3-2B)$;
- placement of W on the response coupling, not on a kinetic or constraint term; and
- variation of B as part of the total Noether identity.

It does not fix:

- the function $V_B(B)$;
- a finite-radius stationary solution $B_0(x)$;
- $V_B''(B_0)$ on that solution;
- boundary conditions and the state of b;
- the normalization and material dependence of $c_\alpha(\mathcal{I})$;
- spatial bath gradients or a transverse regulator; or
- a microscopic cutoff and subtraction scheme.

The calculation below is consequently coefficient-complete as a formula in those declared inputs, but not as a parameter-free number.

II. Covariant carrier and its quadratic fluctuation operator

II.A Canonical action

The varied carrier is

$$S_B = -\int_{\mathcal{M}} d^4x\sqrt{-g}\left[\frac{Z_B}{2}\nabla_\mu B\nabla^\mu B + V_B(B)\right], \qquad Z_B > 0.$$

With signature $(-+++)$, the time kinetic energy has the healthy sign. Let B_0 solve the background carrier equation, including its response force when that force is present. Define the canonically normalized fluctuation

$$b = \sqrt{Z_B}\,(B - B_0).$$

On a local patch in which B_0 and the clock normal vary slowly compared with the fluctuation wavelength, the quadratic action is

$$S_B^{(2)} = \frac{1}{2}\int d^4x\sqrt{-g}\left[(D_U b)^2 - P^{\mu\nu}\nabla_\mu b\nabla_\nu b - m_B^2 b^2\right],$$

where

$$P^{\mu\nu} = g^{\mu\nu} + U^\mu U^\nu, \qquad m_B^2 = \frac{V_B''(B_0)}{Z_B}.$$

The local stable patch requires

$$Z_B > 0, \qquad m_B^2 \geq 0.$$

The equality $m_B^2 = 0$ is not a rank loss, but it can create infrared sensitivity. A negative value is a tachyonic stop condition. A vanishing Z_B changes the kinetic rank and lies outside the canonical source.

II.B Global operator

On an inhomogeneous finite tube, the actual Euclidean Hessian is

$$\mathcal{K}_B = -Z_B\nabla^2 + V_B''(B_0(x)) + \mathcal{K}_B^{\text{response}}[B_0, Q_0, X_0],$$

with the physical world-tube boundary conditions. The local mass formula is the WKB reduction of this operator, not a proof that a finite stable solution exists. A global coefficient requires the Green function $\mathcal{K}_B^{-1}(x,y)$, including its zero modes and boundary spectrum.

II.C Window expansion and the physical vertex

Expand

$$W(B) = W_0 + w_1 b + \frac{1}{2}w_2 b^2 + O(b^3),$$

with

$$W_0 = W(B_0), \qquad w_1 = \frac{W'(B_0)}{\sqrt{Z_B}}, \qquad w_2 = \frac{W''(B_0)}{Z_B}.$$

For constant c_α, the crossover vertex from $-Q_\Delta W(B) c_\alpha X_\alpha$ is

$$S_{QbX} = -\int d^4x\sqrt{-g}\,Q_\Delta b\sum_\alpha g_\alpha X_\alpha, \qquad g_\alpha = \frac{c_\alpha W'(B_0)}{\sqrt{Z_B}}.$$

If a Wilson coefficient depends on the material carrier, the correct vertex is instead

$$\boxed{g_\alpha = \frac{1}{\sqrt{Z_B}}\frac{d}{dB}[W(B)c_\alpha(\mathcal{I}(B))]\bigg|_{B_0}.}$$

The frozen corpus permits such material dependence. Setting it to zero is a declared local representative, not a theorem.

III. The matched Gaussian selector must be varied with B

III.A Finite oscillator and contact

For one environment mode on one stationary clock line, use the Euclidean quadratic action

$$S_X^E = \int_0^\beta d\tau\left[\frac{1}{2}X(-\partial_\tau^2 + \Omega^2)X - cQW(B)X + \frac{1}{2}\frac{c^2}{\Omega^2}Q^2W(B)^2\right].$$

Here Q denotes a static local Q_Δ background. The last term is not optional. It is the finite-regulator form of the conservative subtraction that enforces zero DC in the frozen Gaussian selector.

Integrating out X at fixed B gives

$$S_{\text{sel}}^E[Q,B] = \frac{1}{2}T\sum_n [QW(B)]_{-n}\kappa_\Omega(i\nu_n)[QW(B)]_n,$$

where

$$\nu_n = 2\pi nT, \qquad \boxed{\kappa_\Omega(i\nu_n) = c^2\left[\frac{1}{\Omega^2} - \frac{1}{\nu_n^2+\Omega^2}\right] = \frac{c^2\nu_n^2}{\Omega^2(\nu_n^2+\Omega^2)}}.$$

Thus

$$\kappa_\Omega(0) = 0, \qquad \kappa_\Omega(i\nu_n) \ge 0.$$

This form automatically keeps the bath exchange and its matched contact together while B fluctuates.

III.B Why the W'' terms do not enter the homogeneous local result

For static Q and a homogeneous stationary B_0, the $w_1^2 b_{-n} b_n$ term samples $\kappa_\Omega(i\nu_n)$ at the carrier frequency. The cross term $W_0 w_2 b^2$ instead multiplies the external zero-frequency kernel $\kappa_\Omega(0)$ and vanishes. This is the completed-square version of a cancellation between the W'' contact tadpole and the background-shift piece of the bath exchange.

On an inhomogeneous tube the convolution does not reduce to this simple frequency assignment. Gradients of B_0, the boundary Green function, and the nonlocal kernel must then be retained. The local result is not silently promoted to a global tube theorem.

III.C One-loop coefficient

The free carrier propagator on one clock line is

$$G_B^E(i\nu_n) = \frac{1}{\nu_n^2 + m_B^2}.$$

Contracting the two linear window fluctuations gives

$$\boxed{\delta c_{0,BX}^{(1)} = g^2 T \sum_n \frac{\nu_n^2}{\Omega^2(\nu_n^2 + m_B^2)(\nu_n^2 + \Omega^2)}}.$$

Every summand is nonnegative and the $n = 0$ term vanishes. Define

$$I_B^\beta(m) = T \sum_n \frac{1}{\nu_n^2 + m^2} = \frac{\coth(\beta m/2)}{2m},$$

$$J_\beta(m, \Omega) = T \sum_n \frac{1}{(\nu_n^2 + m^2)(\nu_n^2 + \Omega^2)}.$$

For $m \neq \Omega$,

$$J_\beta(m, \Omega) = \frac{1}{\Omega^2 - m^2} \left[\frac{\coth(\beta m/2)}{2m} - \frac{\coth(\beta\Omega/2)}{2\Omega} \right].$$

For $m = \Omega$, its continuous limit is

$$J_\beta(m, m) = \frac{\coth(\beta m/2)}{4m^3} + \frac{\beta\, \operatorname{csch}^2(\beta m/2)}{8m^2}.$$

Therefore

$$\delta c_{0,BX}^{(1)} = g^2 \left[\frac{I_B^\beta(m_B)}{\Omega^2} - J_\beta(m_B, \Omega) \right] \equiv g^2 \mathcal{L}_\beta(m_B, \Omega).$$

At zero temperature,

$$I_B^\infty(m) = \frac{1}{2m}, \qquad J_\infty(m, \Omega) = \frac{1}{2m\Omega(m + \Omega)},$$

so

$$\boxed{\delta c^{(1)}_{0,BX}(T=0)=\frac{g^2}{2\Omega^2(m_B+\Omega)}}.$$

Theorem 1 — Matched Crossover Positivity

For $Z_B>0$, $m_B^2>0$, $\Omega>0$, a KMS carrier state, and the frozen Gaussian zero-mode contact varied with B, the local stationary one-loop static crossover coefficient satisfies

$$\delta c^{(1)}_{0,BX}\ge 0.$$

It is strictly positive when the physical crossover vertex g is nonzero.

Proof. The Matsubara representation is a sum of

$$g^2\frac{\nu_n^2}{\Omega^2(\nu_n^2+m_B^2)(\nu_n^2+\Omega^2)},$$

which is nonnegative term by term. For a nonzero vertex, every nonzero Matsubara mode contributes positively. □

III.D Raw bubble versus matched result

The retarded composite bubble alone has static value

$$\delta c^{(1)}_{0,\mathrm{raw}}=-g^2J_\beta(m_B,\Omega)<0.$$

The B-fluctuation of the mandatory contact supplies

$$\delta c^{(1)}_{0,\mathrm{sg}}=g^2\frac{I_B^\beta(m_B)}{\Omega^2}.$$

Their sum is the result in Theorem 1. Retaining the raw bubble while freezing the contact's B dependence violates the same varied-world-tube rule that the Ward audit imposed on every other response term.

III.E Multiple modes

For independent finite modes,

$$\boxed{\delta c^{(1)}_{0,BX}=\sum_\alpha g_\alpha^2\mathcal{L}_\beta(m_B,\Omega_\alpha).}$$

Cross terms appear only when the environmental mode covariance is not diagonal in the chosen basis. The general expression is then a positive quadratic form in the differentiated coupling vector if the matched Gaussian kernel is positive on the nonzero Matsubara modes.

IV. Composite spectral density and KMS noise

IV.A Discrete local spectrum

Let

$$n_m=\frac{1}{e^{\beta m_B}-1},\qquad n_\Omega=\frac{1}{e^{\beta\Omega}-1}.$$

For the composite force $g\,bX$, define

$$\rho_{BX}(\omega) = -\frac{1}{\pi}\mathrm{Im}\, G^R_{bX,bX}(\omega + i0), \qquad \omega > 0.$$

For $m_B \neq \Omega$,

$$\boxed{\rho_{BX}(\omega) = \frac{g^2}{4m_B\Omega}[(1 + n_m + n_\Omega)\delta(\omega - m_B - \Omega) + |n_m - n_\Omega|\delta(\omega - |m_B - \Omega|)].}$$

The first line is pair creation/annihilation. The second is thermal exchange. Both positive-frequency weights are nonnegative.

The retarded function is

$$G^R_{bX,bX}(z) = \frac{g^2}{4m_B\Omega}\Bigg\{(1 + n_m + n_\Omega)\left[\frac{1}{z - m_B - \Omega} - \frac{1}{z + m_B + \Omega}\right] \\ + |n_m - n_\Omega|\left[\frac{1}{z - |m_B - \Omega|} - \frac{1}{z + |m_B - \Omega|}\right]\Bigg\},$$

analytic for $\mathrm{Im}\, z > 0$. Its static value is $-g^2 J_\beta$, as required by the dispersion relation.

IV.B Full one-loop retarded kernel

The contact seagull is real and has no spectral discontinuity. The complete local crossover correction is therefore

$$\boxed{K^{R,(1)}_{BX}(z) = g^2\frac{I^\beta_B(m_B)}{\Omega^2} + G^R_{bX,bX}(z).}$$

At $z = 0$, it equals $g^2\mathcal{L}_\beta > 0$. Its absorptive part remains the positive composite spectrum above.

IV.C Noise

For a joint KMS state, the symmetrized noise is fixed by

$$\boxed{\mathcal{N}_{BX}(\omega) = 2\pi\rho_{BX}(|\omega|)\coth\left(\frac{\beta|\omega|}{2}\right) \geq 0.}$$

The real local seagull adds no noise. At zero temperature only the pair line at $m_B + \Omega$ remains. For two exactly degenerate discrete oscillators, the thermal exchange operator is stationary and produces a zero-frequency symmetrized line even though its commutator weight vanishes. A damping width or finite observation time is then required before interpreting a pointwise $omega = 0$ value.

Theorem 2 — Composite Spectral Positivity

For independent positive-norm Gaussian B and X modes in a joint KMS state, the crossover composite has nonnegative positive-frequency spectral weight and nonnegative symmetrized noise. The counterterm required to restore zero DC changes neither statement because it is real and local.

V. The displayed $3 + 1$-dimensional independent-worldline bath

V.A Why the clock-line answer is not the field-theory number

The canonical B action contains spatial gradients. The displayed Stage-4 bath action permits independent material worldlines and therefore no spatial gradient for X_Ω. At each spatial Fourier momentum, the carrier energy is

$$E_p = \sqrt{p^2 + m_B^2},$$

while the bath frequency remains Ω. A local loop then sums over the unfixed transverse carrier momentum. The one-clock-line formula is the regulated $p = 0$ representative, not the full local field-theory answer.

V.B Raw spectrum at zero temperature

With a hard spatial cutoff $p \leq \Lambda$, the positive-frequency composite spectrum is

$$\boxed{\rho_{BX}^{\mathrm{wl}}(\omega) = \frac{g^2}{8\pi^2\Omega}\sqrt{(\omega-\Omega)^2 - m_B^2}\,\Theta(\omega - \Omega - m_B),}$$

with the additional support restriction

$$\sqrt{(\omega-\Omega)^2 - m_B^2} \leq \Lambda.$$

It is positive and begins at the pair threshold $m_B + \Omega$. Its static dispersion integral gives the magnitude of the raw bubble,

$$J_{\mathrm{wl}}(\Lambda) = \frac{1}{4\pi^2\Omega}\int_0^\Lambda dp\,\frac{p^2}{E_p(E_p+\Omega)}.$$

V.C Matched static coefficient and ultraviolet price

The contact seagull is

$$S_{\mathrm{wl}}(\Lambda) = \frac{1}{4\pi^2\Omega^2}\int_0^\Lambda dp\,\frac{p^2}{E_p}.$$

The exact algebraic difference is

$$\boxed{\mathcal{L}_{\mathrm{wl}}(\Lambda) = S_{\mathrm{wl}}(\Lambda) - J_{\mathrm{wl}}(\Lambda) = \frac{1}{4\pi^2\Omega^2}\int_0^\Lambda dp\,\frac{p^2}{E_p+\Omega} > 0.}$$

Consequently,

$$\delta c_{0,BX}^{(1)}(\Lambda) = g^2\mathcal{L}_{\mathrm{wl}}(\Lambda).$$

At large cutoff,

$$\mathcal{L}_{\mathrm{wl}}(\Lambda) = \frac{\Lambda^2}{8\pi^2\Omega^2} - \frac{\Lambda}{4\pi^2\Omega} + O(\ln\Lambda).$$

The finite Gaussian bath therefore does not make the quantized crossover coefficient finite. The displayed spatially ultralocal completion has a quadratic ultraviolet price. Adding positive spatial gradients for X changes the divergence and the spectral phase space; the canonical source explicitly allowed that alternative but did not choose its coefficient. This is another reason no unique number follows from the frozen architecture.

V.D Thermal zero-frequency noise

At finite temperature the exchange continuum contains shells $E_p = \Omega \pm \omega$. If $\Omega > m_B$, it reaches zero frequency at

$$p_0 = \sqrt{\Omega^2 - m_B^2}.$$

With the noise convention of Section IV, its finite small-frequency limit is

$$\boxed{\mathcal{N}^{\mathrm{wl}}_{BX}(0)=\frac{g^2p_0}{\pi\Omega}n_\Omega(1+n_\Omega),\qquad \Omega>m_B.}$$

If $\Omega<m_B$, the exchange continuum has a gap $m_B-\Omega$ and this zero-frequency contribution is absent. At the threshold $\Omega=m_B$, the continuum phase space closes and the limiting continuous noise tends to zero; the discrete exactly degenerate edge case remains separate.

VI. Closed-time-path form

VI.A Quadratic influence action

On the doubled contour, define

$$Q_r=\frac{Q_++Q_-}{2},\qquad Q_a=Q_+-Q_-.$$

After the B-X fluctuations are integrated to quadratic order, the local stationary contribution has the standard form

$$\boxed{S^{(2)}_{\mathrm{IF,BX}}=\int_{\omega,\mathbf{k}}Q_a(-\omega,-\mathbf{k})K^{R,(1)}_{BX}(\omega,\mathbf{k})Q_r(\omega,\mathbf{k})+\frac{i}{2}\int_{\omega,\mathbf{k}}Q_a(-\omega,-\mathbf{k})\mathcal{N}_{BX}(\omega,\mathbf{k})Q_a(\omega,\mathbf{k}).}$$

The advanced kernel is

$$K^{A,(1)}_{BX}(\omega,\mathbf{k})=\left[K^{R,(1)}_{BX}(\omega,\mathbf{k})\right]^*,$$

and the KMS relation fixes the noise on the scalar composite channel. These facts establish the scalar two-point consistency block. They do not establish the coefficient-complete advanced row identity of the full metric–readout–memory–jet–world-tube–CMC system.

VI.B Rematching zero DC

The tree selector obeys zero DC. The quantized crossover leaves

$$K^{R,(1)}_{BX}(0)=\delta c^{(1)}_{0,BX}>0.$$

If the exact selected condition is imposed at the chosen matching scale, the one-loop contact must satisfy

$$\boxed{c^{(1)}_{\mathrm{ct}}=-\delta c^{(1)}_{0,BX}.}$$

This local subtraction does not erase the positive absorptive spectrum or its noise. It is precisely the order-by-order tuning price identified by Gate G3. No symmetry derived in the frozen architecture forces it automatically.

VII. Ward identity and stress bookkeeping

VII.A Unintegrated identity

Before elimination, diagonal covariance gives

$$2\nabla_\mu \mathcal{E}_g{}^\mu{}_\nu = \mathcal{E}_B \nabla_\nu B + \sum_\alpha \mathcal{E}_{X_\alpha} \nabla_\nu X_\alpha + \mathcal{E}_Q \nabla_\nu Q_\Delta + \cdots,$$

with the clock, memory, readout, jet, multiplier, and boundary equations in the omitted terms. The carrier force contains both the vertex and the contact:

$$\mathcal{E}_B^{\mathrm{sel}} \supset -W'(B) Q_\Delta \sum_\alpha c_\alpha X_\alpha + C_{\mathrm{ct}} W(B) W'(B) Q_\Delta^2.$$

Freezing the second term while fluctuating the first produces a source-force defect and the incomplete raw-bubble answer.

VII.B Reduced identity

After covariant elimination, the same statement becomes the functional chain rule for the influence action:

$$\delta_\xi \Gamma_{\mathrm{IF}} = \int \left(\frac{\delta \Gamma_{\mathrm{IF}}}{\delta g_{\mu\nu}} \delta_\xi g_{\mu\nu} + \frac{\delta \Gamma_{\mathrm{IF}}}{\delta B} \delta_\xi B + \frac{\delta \Gamma_{\mathrm{IF}}}{\delta Q_\Delta} \delta_\xi Q_\Delta + \cdots \right) = 0.$$

The new one-loop counterterm is compatible with this identity only when it is embedded as a covariant functional of the same carrier, clock, metric, readout, material, and boundary data that determine the loop. A constant number computed on one homogeneous patch cannot simply be copied onto an inhomogeneous finite tube without those variations.

VII.C Status of the previously derived Ward identity

The result neither withdraws nor upgrades the total Ward identity:

- the unintegrated diagonal identity remains a conditional pass when every field and boundary datum is varied;
- the reduced diagonal identity remains a conditional pass under covariant regulation, state preparation, elimination, and matching;
- the scalar B-X retarded/advanced/noise block satisfies analyticity, spectral positivity, and KMS;
- the full deformed advanced/noise identity remains open; and
- the boundary-CMC Schur complement remains coefficient incomplete.

The new static contact contributes to the metric stress, the B equation, the compact-readout equation, and the boundary variation. Those contributions are part of the price, not optional improvements.

VIII. Rank and degree-of-freedom audit

VIII.A Primary kinetic rank

In a local frame the B-X principal kinetic block is

$$H_{BX} = \begin{pmatrix} Z_B & 0 \\ 0 & 1 \end{pmatrix}, \qquad Z_B > 0.$$

Neither $W(B)$, $W'(B)$, nor the algebraic rematching contact multiplies a velocity. Therefore the block has rank two on the $W = 0$ plateau, throughout the crossover, and on the $W = 1$ plateau.

VIII.B Relation to $58/116$

The carrier is a physical material/apparatus scalar. The canonical Stage-4 source expressly excluded it from the readout/memory/jet structural subtotal

$$44 + 2 + 12 = 58$$

per leg and 116 doubled. The crossover calculation changes no member of that subtotal. It also does not convert B into a gravitational scalar polarization. The full theory contains the physical carrier mode in addition to the subtotal; its observational and material viability remain separate.

VIII.C Secondary operator

The real one-loop contact changes the carrier Hessian and the matter-dressed Hamiltonian/CMC coefficient matrix. Thus constant primary rank does not prove constant complete Dirac rank. The following are still required:

1. a finite solution $B_0(x)$ and its complete Jacobi operator;
2. the metric and CMC variation of the regulated loop and counterterm;
3. the augmented secondary bracket matrix;
4. its rank through the entire tube and across boundaries; and
5. the common-branch pole/hyperbolicity audit.

Theorem 3 — Endpoint Loop Suppression Without Rank Loss

For constant c_α, the smooth window obeys

$$W'(0) = W'(1) = 0.$$

The one-loop crossover vertex and the matched B-X contribution therefore vanish on both plateaus, while the carrier kinetic rank remains one. This theorem concerns the differentiated-window diagram only; it does not remove loops from B-dependent Wilson coefficients, gravity, jets, boundaries, or other interactions.

IX. Regime and boundary register

REGIME	RESULT	GRADE
$Z_B > 0, m_B^2 > 0$	healthy local carrier propagator	conditional pass
$Z_B = 0$	carrier kinetic rank changes	excluded stop condition
$m_B^2 < 0$	tachyonic local patch	fail/unstable
$m_B = 0$	rank retained; infrared/global zero-mode treatment required	open boundary
$B_0 = 0$	$W' = 0$; crossover loop vanishes	exact for constant c_α
$0 < B_0 < 1$	$W' \neq 0$; matched loop is positive	derived local result
$B_0 = 1$	$W' = 0$; crossover loop vanishes	exact for constant c_α
$c_\alpha = c_\alpha(B)$	vertex becomes $d(Wc_\alpha)/dB$	microscopic input required
one clock line	finite formula $g^2\mathcal{L}_\beta$	exact representative
displayed $3+1$ worldline bath	quadratic spatial-cutoff dependence	derived

REGIME	RESULT	GRADE
bath with spatial gradients	different phase space and divergence	unspecified completion
zero temperature	pair spectrum starts at $m_B + \Omega$	derived
finite temperature, $\Omega > m_B$	exchange continuum gives finite zero-frequency noise	derived
finite temperature, $\Omega < m_B$	exchange continuum remains gapped	derived
exactly degenerate discrete modes	stationary exchange noise line	requires width/time resolution
homogeneous stationary tube	W'' terms multiply zero external kernel	derived local result
inhomogeneous finite tube	gradient and boundary convolution survives	open
fixed external B	no carrier loop but explicit source-force defect	not autonomous
quantized varied B	loop, noise, stress, and counterterm variations retained	required completion

X. Graded claim ledger

CLAIM	EVIDENCE	GRADE	CONSEQUENCE
the frozen corpus has no world-tube action at all	canonical Stage-4 source displays S_B	**false**	prior wording narrowed
the frozen corpus fixes a stable finite world tube	V_B and solution unsolved	**false**	global coefficient remains open
the raw mixed bubble is the selected-channel loop	omitted contact seagull	**false**	raw formula superseded
the raw bubble is negative	composite dispersion	**derived**	intermediate piece only
the contact seagull is mandatory	$W(B)^2$ matching contact	**derived from frozen selector**	must be varied with B
the matched local coefficient is nonnegative	positive Matsubara sum	**theorem**	nonzero crossover DC residual
the zero-temperature clock-line coefficient is $g^2/[2\Omega^2(m_B+\Omega)]$	exact integral	**derived**	conditional analytic value
the composite spectral density is positive	Lehmann weights	**theorem**	physical noise channel

CLAIM	EVIDENCE	GRADE	CONSEQUENCE
KMS noise is positive	fluctuation–dissipation relation	**theorem**	no cross-only deletion
the displayed $3+1$ worldline-bath loop is finite	cutoff integral	**false**	quadratic UV price
the plateaus eliminate this differentiated-window loop	$W'(0)=W'(1)=0$	**theorem**	kinetic rank remains
$58/116$ changes	no new primary velocity or constraint	**no**	subtotal unchanged
the complete Dirac rank follows	secondary/CMC operator absent	**false**	Gate G1 remains open
total covariance is invalidated	full carrier/contact variation closes chain rule	**no**	conditional Ward grade retained
exact zero DC survives without retuning	matched loop is positive	**false**	one-loop subtraction required
the frozen data determine a parameter-free number	$V_B'', Z_B, c_\alpha, \beta, \Lambda,$ profile unfixed	**false**	Gate G3 remains priced
ledger item 35 closes	no protective identity or microscopic coefficient	**no**	item remains open
framework grade improves	gravitational and quantum gates remain open	**no**	grade unchanged

XI. Direct answer and cost

XI.A What is now established

1. The varied carrier has a canonical covariant scalar action in the frozen corpus.
2. Its local canonical crossover vertex is $g_\alpha = c_\alpha W'(B_0)/\sqrt{Z_B}$, or the derivative of Wc_α when material coefficients depend on B.
3. The raw B-X composite has a positive spectrum and KMS-positive noise.
4. The mandatory B-variation of the zero-mode contact supplies a seagull.
5. The matched one-clock-line static coefficient is positive and has the exact formulas in Section III.
6. In the displayed $3+1$-dimensional independent-worldline bath, the same coefficient is quadratically cutoff dependent.
7. The loop vanishes at both smooth plateaus for constant Wilson coefficients, without a kinetic-rank change.

XI.B What the result costs

The frozen selector's tree zero is not preserved by quantizing the required varied crossover carrier. Exact zero DC at one loop requires

$$c_{\mathrm{ct}}^{(1)} = -\delta c_{0,BX}^{(1)}.$$

Because no protective symmetry was found in Gate G3, the same calculation and matching must be repeated at later orders and for the gravity, jet, boundary, and interacting-environment sectors. In a parameter-free theory the needed inputs cannot be chosen: V_B, the finite tube, Z_B, the material couplings, state, regulator, and ultraviolet completion must be derived.

The sharpest current statement is therefore

$$\boxed{\begin{array}{c}\text{local matched crossover loop: derived and generically nonzero,}\\ \text{global finite-tube coefficient: not identified,}\\ \text{radiative protection of zero DC: not established.}\end{array}}$$

XI.C Effect on open items

- **Gate G3 / items 15–16:** remain open. The calculation demonstrates the tuning price in the shortest interaction already present in the canonical carrier, but supplies no protective Ward identity.
- **Ledger item 35:** remains open. The coefficient is a formula, not a frozen number, and the full parent contribution is still incomplete.
- **Gate G1 / item 33:** remains open. Primary rank is unchanged, but the secondary and boundary-CMC operators receive coefficient-dependent terms.
- **Gate G2 / item 34:** remains open. The composite spectrum is derived conditionally, while microscopic c_α and the ultraviolet bath remain unspecified.
- **Total Ward identity:** remains a conditional pass with every carrier, contact, stress, and boundary variation retained.
- **Withdrawals:** zero in v8.1, v8.2, v9.0, and Gates G1–G5. One post-v9.0 intermediate raw formula is explicitly superseded, not deleted.

$$\boxed{\text{STF remains a coherent gravitational candidate, not a completed gravity theory.}}$$

XII. Not established

This calculation does not establish:

1. a stable finite-radius solution of the carrier equation;
2. a derived $V_B(B)$ or numerical Z_B;
3. a unique m_B on an STF source;
4. the state and boundary conditions of the carrier fluctuation;
5. the microscopic $c_\alpha(\mathcal{I})$;
6. a unique transverse bath kinetic term;
7. a regulator-independent $3+1$-dimensional coefficient;
8. the global inhomogeneous influence kernel on a finite tube;
9. the gravitational, jet, clock, CMC, ghost, or boundary loop contribution;
10. the complete deformed advanced/noise Ward identity;

11. the augmented boundary-CMC Schur-complement rank;
12. all-loop protection of $K^R_{\mathrm{sel}}(0) = 0$;
13. a numerical fine-tuning ratio;
14. observational acceptability of the carrier noise;
15. a nonlinear compact-object solution or waveform; or
16. a completed gravity theory.

XIII. Reproducibility

The NumPy-only checker `stf_v9_0_world_tube_crossover_checks.py` verifies:

- all six frozen hashes when the source workspace is supplied;
- W, W', and W'' at both plateaus and the midpoint;
- canonical normalization $g = cW'/\sqrt{Z_B}$;
- constant positive B-X kinetic rank for $Z_B > 0$;
- equality of the Matsubara and spectral static raw bubbles;
- the continuous equal-frequency limit;
- positivity of pair and thermal-exchange spectral/noise weights;
- the raw-bubble, seagull, and matched-coefficient identity;
- positivity and the zero-temperature closed form of the matched coefficient;
- endpoint suppression and crossover survival;
- exact local rematching of the one-loop DC residual;
- the $3+1$ independent-worldline cutoff identities;
- reproduction of the raw bubble by the positive continuum spectrum;
- quadratic ultraviolet growth of the matched coefficient;
- the finite thermal zero-frequency exchange-noise limit when $\Omega > m_B$;
- material-coefficient dependence of the differentiated vertex; and
- the $Z_B = 0$ rank boundary and $m_B^2 < 0$ instability boundary.

The script is an algebraic and numerical audit. It does not construct the missing finite tube, ultraviolet completion, gravitational propagator, or waveform.

Appendix AE — Finite World-Tube Derrick and Material-Support Gate

Frozen-consolidation record. Source file `STF_V9_0_Finite_World_Tube_Derrick_and_Material_Support_Gate_V1_0.md`*, SHA-256* `9dbe34ad6f24269612150ce66e4883a743d7b434fce08cf5d9b8543f01ba05ae`*. The scientific body is carried in full; Markdown heading levels are adjusted for nesting and missing-backslash LaTeX quad* *transport defects are repaired in the consolidated rendering. Section numbers below are local to this appendix.*

Scope. The preceding crossover calculation recovered the canonical varied carrier action but could use only a local stationary mass m_B. This paper performs the next required gate: determine whether that action actually admits a finite, stable, isolated world-tube background and, if not, identify the minimal support structure required before a global fluctuation spectrum and crossover loop can be defined.

Baseline rule. The scientific baseline remains frozen v8.1 and repaired v8.2. The v9.0 file is used only as the frozen audit ledger. No version-9 proposal is imported as physics, and no baseline manuscript is edited.

Result. For the canonical carrier

$$S_B = -\int d^4x\sqrt{-g}\left[\frac{Z_B}{2}\nabla_\mu B\nabla^\mu B + V_B(B)\right], \qquad Z_B > 0,$$

an isolated static finite-energy tube in three asymptotically flat spatial dimensions is impossible as a stable solution. With

$$T = \frac{Z_B}{2}\int d^3x\,|\nabla B|^2, \qquad U = \int d^3x\,[V_B(B) - V_B(B_\infty)],$$

the rescaling $B_\lambda(\mathbf{x}) = B(\mathbf{x}/\lambda)$ gives

$$E(\lambda) = \lambda T + \lambda^3 U.$$

If $U \geq 0$, no nontrivial stationary point exists. If $U < 0$ is adjusted so that $E'(1) = T + 3U = 0$, then

$$E''(1) = 6U = -2T < 0.$$

The putative tube is a saddle with a negative dilation mode. In the thin-wall limit a lower-energy interior produces a critical bubble at

$$R_* = \frac{2\sigma}{\epsilon}, \qquad \omega_R^2 = -\frac{2}{R_*^2},$$

not a stable carrier. Degenerate vacua give a closed wall that collapses under its surface tension.

The minimal viable interpretation is therefore a **materially supported world tube**, not a self-supported B soliton. A varied material source can produce a smooth finite profile. For the illustrative convex potential $V_B = Z_B m^2 B^2/2$ and a uniform spherical source $J_0\Theta(R-r)$, the exact Yukawa profile is derived below and is stable with respect to B fluctuations while the source is held fixed. But R is inherited from the material support, and the linear source does not localize the B fluctuation spectrum. If the source is frozen, it creates a Ward force defect; if it is varied, its physical degrees of freedom, stress, constraints, and stability must be included.

Thus the former open statement is sharpened:

$$\boxed{\text{minimal isolated static canonical scalar tube: NO-GO}}$$

$$\boxed{\text{varied material support: viable in form, coefficient-complete realization OPEN}}$$

$$\boxed{\text{Grade unchanged: coherent gravitational candidate, not a completed gravity theory.}}$$

I. Source control and question decided

I.A Frozen records

RECORD	ROLE	S
`STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md`	publication baseline	4
`STF_First_Principles_Paper_V8_1_fixed(1).md`	calculation baseline	b
`STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md`	repaired v8.2 architecture	1
`STF_First_Principles_Paper_V9_0_2026-08-28.md`	frozen audit ledger only	8
`STF_V8_1_Covariant_Clock_World_Tube_Gaussian_Bath_and_Ward_Completion_V1_0.md`	canonical carrier source	3
`STF_V9_0_Varied_World_Tube_Crossover_Loop_and_Noise_Gate_V1_0.md`	preceding crossover gate	b

The checker verifies all six hashes when run in the source workspace.

I.B The precise open statement

The canonical Stage-4 source said both of the following:

1. B is a physical material/apparatus scalar with $Z_B > 0$; and
2. no stable finite-radius phase-field world-tube soliton had been proved.

The previous crossover calculation showed that a local stable patch with $V_B''/Z_B \geq 0$ has a healthy propagator. Local convexity is necessary but is not global localization. The question here is whether some choice of the otherwise unspecified V_B can turn the displayed single-scalar action into a stable isolated three-dimensional tube without adding a source, charge, boundary pressure, gauge flux, higher derivatives, time dependence, or gravitational binding.

I.C Assumptions of the no-go

The theorem below assumes:

- one real scalar B;
- the canonical two-derivative action displayed above;
- a time-independent configuration;
- three asymptotically flat, noncompact spatial dimensions;
- finite energy relative to one exterior vacuum;
- sufficiently rapid approach to that vacuum for scaling variations to be admissible;

- no external source or prescribed boundary;
- no conserved internal charge, gauge flux, or higher-derivative pressure; and
- no simultaneous gravitational backreaction used as a stabilizer.

Every known evasion changes at least one assumption. The theorem is strong inside this domain and makes no claim outside it.

II. Derrick scaling of the canonical carrier

II.A Static energy

On a stationary asymptotically flat slice, subtract the exterior vacuum energy and define

$$E[B] = T[B] + U[B],$$

$$T[B] = \frac{Z_B}{2} \int_{\mathbb{R}^3} d^3x \, \partial_i B \, \partial_i B \geq 0,$$

$$U[B] = \int_{\mathbb{R}^3} d^3x \, [V_B(B) - V_B(B_\infty)].$$

For the dilation

$$B_\lambda(\mathbf{x}) = B(\mathbf{x}/\lambda),$$

the gradient and potential pieces scale as

$$T[B_\lambda] = \lambda T[B], \qquad U[B_\lambda] = \lambda^3 U[B].$$

Hence

$$E(\lambda) = \lambda T + \lambda^3 U.$$

Any static solution must be stationary under this admissible variation:

$$E'(1) = T + 3U = 0.$$

Theorem 1 — Minimal Static World-Tube No-Go

A nontrivial finite-energy static configuration of the canonical real carrier in three asymptotically flat spatial dimensions cannot be a stable isolated world tube.

Proof. If the vacuum-subtracted potential is nonnegative, then $T \geq 0$ and $U \geq 0$, so $T + 3U = 0$ implies $T = U = 0$ and the configuration is the constant vacuum. If the potential becomes negative and a nontrivial stationary point satisfies $U = -T/3$, its scaling curvature is

$$E''(1) = 6U = -2T < 0.$$

The dilation is a negative mode. Therefore the configuration is not a local minimum of the energy. □

II.B General spatial dimension

In d spatial dimensions,

$$E_d(\lambda) = \lambda^{d-2} T + \lambda^d U.$$

At a virial stationary point,

$$(d-2)T + dU = 0.$$

The scaling curvature is

$$\boxed{E_d''(1) = -2(d-2)T.}$$

It is negative for every $d > 2$. At $d = 2$ the dilation is marginal and further structure is required. At $d = 1$ the theorem does not exclude topological kink solutions. The STF carrier, however, is a three-dimensional spatial support field.

II.C Why local $m_B^2 > 0$ did not settle the question

The condition

$$m_B^2(x) = \frac{V_B''(B_0(x))}{Z_B} > 0$$

tests short-wavelength convexity around a chosen background. The dilation mode changes the size of the entire configuration and samples gradients and the vacuum-volume balance. A profile can have positive V_B'' over much of its wall and still possess a negative global radial mode. The local crossover formula remains a correct WKB formula on a stable patch, but it cannot certify the existence of the background to which it is applied.

III. Closed phase wall and bubble audit

III.A Degenerate $B = 0$ and $B = 1$ vacua

The smooth window has two distinguished plateaus,

$$W(0) = 0, \qquad W(1) = 1.$$

A natural attempted tube is a finite $B = 1$ region surrounded by the $B = 0$ vacuum, separated by a domain wall. If the vacua are degenerate, a thin spherical wall of tension $\sigma > 0$ has

$$E(R) = 4\pi\sigma R^2.$$

There is no stationary nonzero radius. The wall contracts. A planar domain wall can be protected by asymptotic boundary conditions, but it has infinite transverse extent and is not a finite world tube.

III.B Nondegenerate vacua

Let the interior vacuum be lower by energy density $\epsilon > 0$. Then

$$E(R) = 4\pi\sigma R^2 - \frac{4\pi}{3}\epsilon R^3.$$

The nonzero stationary radius is

$$R_* = \frac{2\sigma}{\epsilon}.$$

Its curvature is

$$E''(R_*) = -8\pi\sigma < 0.$$

Expanding the Nambu–Goto wall kinetic term gives the radial inertia

$$M_R = 4\pi\sigma R_*^2.$$

Therefore the breathing eigenvalue is

$$\boxed{\omega_R^2 = \frac{E''(R_*)}{M_R} = -\frac{2}{R_*^2}.}$$

The critical bubble has one explicit negative radial mode. A smaller bubble collapses; a larger one expands. If the interior is higher in energy, both the surface and volume terms favor collapse and no critical radius exists.

III.C Topology does not protect a finite closed wall

A one-component scalar with disconnected vacua can support a codimension-one wall when different vacua are imposed at opposite spatial infinities. A finite closed wall in three dimensions carries no conserved particle-like winding at spatial infinity. It can shrink continuously until the interior phase disappears. The endpoint values of W suppress the differentiated-window loop on either plateau, but they do not create a topological radius charge.

Corollary 1 — No KMS crossover loop on the critical bubble

The local crossover calculation assumed a positive carrier frequency. A critical bubble instead has $\omega_R^2 < 0$. Its retarded propagator has an unstable pole and no stationary KMS state. Substituting $m_B = |\omega_R|$ into the positive-oscillator loop formula would hide the instability and is inadmissible.

IV. What is required to stabilize a radius

IV.A Model-independent radial condition

A stable finite radius needs a positive energy contribution that grows when the tube shrinks, or an equivalent outward pressure. Represent such a term by

$$E_{\text{stab}}(R) = AR^{-p}, \qquad A > 0, \qquad p > 0.$$

For degenerate vacua,

$$E(R) = 4\pi\sigma R^2 + AR^{-p}.$$

The stationary radius is

$$\boxed{R_* = \left(\frac{pA}{8\pi\sigma}\right)^{1/(p+2)}.}$$

At that radius,

$$E''(R_*) = 8\pi\sigma(p+2) > 0,$$

and, with the same wall inertia,

$$\boxed{\omega_R^2 = \frac{2(p+2)}{R_*^2} > 0.}$$

This proves the mathematical form of a possible stabilization. It also states the price: A and p must arise from a physical varied sector. They are not contained in $V_B(B)$, and the selected radius depends on them.

IV.B Candidate sources of the inverse pressure

MECHANISM	HOW IT EVADES THE NO-GO	COST IN STF
conserved material number or charge	compression energy grows as the tube shrinks	add and vary the charge carrier, its current, state, and stress
gauge or higher-form flux	flux energy supplies inverse-radius pressure	new gauge sector, Gauss constraint, flux quantization, boundary terms
rotating/time-dependent phase	time dependence supplies pressure	requires at least a phase/complex field or periodic real solution; no static tube
higher spatial derivatives	changes Derrick scaling	new operators, coefficients, pole and rank audit
physical membrane or material shell	shell stress balances phase pressure	shell degrees, junction conditions, stress, and stability
finite cavity/boundary	boundary conditions introduce a length scale	boundary becomes physical and must be varied in Ward/Dirac analysis
gravitational binding	metric backreaction supplies a scale	solve the full coupled gravity problem; cannot be assumed at the carrier gate

None is forbidden in principle. None is present as a coefficient-complete module in the frozen carrier action. Because STF is parameter-free, a stabilizer cannot be selected merely because it produces a desired radius.

IV.C Q-ball and oscillon boundaries

A Q-ball evades the static real-scalar theorem through a complex phase and a conserved charge. The frozen B field is real and has no identified internal $U(1)$ charge. Promoting it to a charged complex field would be a new architecture, not a reinterpretation of the displayed action.

A real scalar can form a long-lived oscillon in suitable potentials. An oscillon is time dependent, radiative, and generally metastable. Its lifetime, frequency, profile, and noise would be new derived data. It cannot certify a static world-tube window or the stationary KMS calculation without a separate two-time-scale analysis.

V. Exact materially sourced bridge

V.A Convex sourced representative

The phrase “material/apparatus degree” suggests a narrower bridge that does not require B to support itself. Add a scalar material source J:

$$S_J = \int d^4x \sqrt{-g}\, JB.$$

For

$$V_B(B) = \frac{Z_B m^2}{2} B^2, \qquad J(r) = J_0 \Theta(R - r),$$

the static equation is

$$Z_B(-\nabla^2 + m^2)B = J.$$

Define

$$x = mR, \qquad P = \frac{J_0}{Z_B m^2}.$$

The unique regular, decaying spherical solution is

$$\boxed{B_{\text{in}}(r) = P\left[1 - (x+1)e^{-x}\frac{\sinh(mr)}{mr}\right], \qquad r \le R,}$$

$$\boxed{B_{\text{out}}(r) = P\left[x\cosh x - \sinh x\right]\frac{e^{-mr}}{mr}, \qquad r \ge R.}$$

Both B and dB/dr are continuous at R. The profile is smooth away from the idealized source edge, positive for $J_0 > 0$, and decays exponentially. A smooth material density replaces the step by the corresponding Yukawa convolution.

V.B What is stable and what is not

At fixed J, the energy is strictly convex in B:

$$\delta^2 E_B = Z_B \int d^3x \left[|\nabla \delta B|^2 + m^2(\delta B)^2\right] > 0$$

for nonzero finite fluctuations. Thus the sourced profile is stable in the B direction.

This does not prove stability of the material source. The support radius R is an input in J, not an extremum selected by S_B. If the material density moves, its kinetic energy, pressure, self-interaction, boundary stress, and coupling to gravity decide whether the combined tube is stable.

Theorem 2 — Source-Support Non-Selection

A fixed compact source can produce a unique stable B profile for a convex carrier potential, but the carrier action does not determine the support radius. Changing the source radius changes the profile while leaving the carrier field equation and its coefficients unchanged.

The theorem separates **profile existence** from **radius prediction**. A materially supported STF tube is mathematically viable, but its geometry is a property of the material sector.

VI. Global fluctuation spectrum

VI.A Linear source does not localize the Hessian

For the quadratic sourced representative, the fluctuation operator is

$$\mathcal{K}_B = Z_B(-\nabla^2 + m^2).$$

It is independent of J_0 and R. In unbounded space its spectrum is the bulk continuum

$$\omega^2(\mathbf{k}) = \mathbf{k}^2 + m^2.$$

There is no discrete tube-bound carrier mode. A finite numerical cavity gives

$$\omega_n^2 = m^2 + k_n^2,$$

but the lowest eigenvalue tends to m^2 as the cavity is removed. A linear source localizes the expectation value of B, not its Gaussian fluctuations.

To localize a mode, the material coupling must also modify the quadratic operator, for example through a position-dependent effective mass, a dynamical boundary, or a coupled material fluctuation. Those additions are precisely the coefficient-complete source data still missing.

VI.B General stable mode expansion

Suppose a future varied material completion supplies a stable background and a self-adjoint Jacobi problem

$$\mathcal{K}_B\psi_n = Z_B\omega_n^2\psi_n, \qquad \int_\Sigma d^3x\sqrt{h}\, Z_B\psi_n\psi_m = \delta_{nm},$$

with every physical $\omega_n^2 > 0$ after gauge and constraint reduction. Let an external readout profile be $u(\mathbf{x})$ and an environment mode have profile $\chi_\alpha(\mathbf{x})$. The projected crossover coupling is

$$\boxed{g_{\alpha n}[u] = \int_\Sigma d^3x\sqrt{h}\, u\,\chi_\alpha\,\psi_n \frac{d}{dB}\left[W(B)c_\alpha(\mathcal{I}(B))\right]\Big|_{B_0}.}$$

For discrete positive modes, the zero-temperature matched result becomes

$$\boxed{\delta c_{0,u}^{(1)} = \sum_{\alpha,n} \frac{|g_{\alpha n}[u]|^2}{2\Omega_\alpha^2(\omega_n + \Omega_\alpha)} + \text{continuum contribution.}}$$

This is the global replacement for the local substitution $m_B \to \omega_n$. It requires the mode profiles and the spatial readout/environment projections, not only the eigenfrequencies.

VI.C Stability gate before spectral positivity

The positive spectral and KMS results of the crossover paper apply only after the carrier Jacobi operator has no physical negative mode. If $\omega_n^2 < 0$, the retarded kernel has an instability rather than a positive stationary spectral measure. If $\omega_n = 0$, collective-coordinate treatment and infrared regulation are required. Stability is therefore logically prior to the open-system spectral audit.

VII. Ward identity and source status

VII.A Fixed source

A prescribed $J(x)$ can be treated as a covariant spurion, but it is not a varied physical field. The diffeomorphism identity then contains an uncancelled source force proportional to

$$B\nabla_\nu J.$$

For compact support this force is concentrated through the material boundary region. The sourced profile is a valid subsystem calculation, not an autonomous gravitational completion.

VII.B Varied material source

Let $J = J(\mathcal{N})$ be built from varied material fields $\mathcal{N}$. The unintegrated identity contains

$$2\nabla_\mu \mathcal{E}_g{}^\mu{}_\nu = \mathcal{E}_B \nabla_\nu B + \mathcal{E}_\mathcal{N} \nabla_\nu \mathcal{N} + \cdots .$$

The force exchanged between B and the source then cancels on the combined equations. This is the same closure principle already used for the retained environment and window. It does not follow merely from replacing a step function by the word "material." The source action, state, stress, constraints, and boundary variation must be displayed.

VII.C Total Ward grade

The previous Ward result remains exactly where it was:

- fixed source/window: sourced effective description with a force defect;
- fully varied material support: diagonal covariance can close on all field equations;
- reduced influence action: conditional on covariant elimination and matching;
- advanced/noise deformed identity: still open; and
- boundary-CMC closure: still open.

The no-go does not invalidate the conditional Ward theorem. It shows that the missing varied material equation is dynamically indispensable, not optional bookkeeping.

VIII. Rank and degree-of-freedom consequences

VIII.A Minimal canonical carrier

The kinetic Hessian of B remains $Z_B > 0$. Derrick instability is a negative eigenvalue of the global potential/Jacobi operator, not a primary-rank loss. Therefore the established readout/memory/jet subtotal remains

$$58 \text{ per leg}, \qquad 116 \text{ doubled}.$$

The subtotal never included the physical carrier scalar.

VIII.B Material bridge

A material source can add physical modes and constraints. A perfect-fluid current, complex charge carrier, membrane, gauge flux, or boundary embedding has a different canonical structure. None may be hidden inside the old $58/116$ subtotal. The correct procedure is:

1. write the source action and its symmetries;
2. count its primary constraints and physical modes;
3. derive the coupled B–material Jacobi operator;
4. test for negative and zero modes;
5. insert its stress into the Hamiltonian/CMC brackets; and
6. only then run the global crossover loop.

VIII.C No silent repair by potential choice

Changing only $V_B(B)$ does not evade Theorem 1 within the stated assumptions. It can alter wall tension, vacuum energy, thickness, and local mass, but the three-dimensional dilation result still applies. A claimed stable radius from a potential-only numerical solution must exhibit the missing negative scaling mode or identify which no-go assumption the calculation changes.

IX. Regime and boundary register

REGIME	RESULT	GRADE
static isolated real scalar, $d = 3$, $U \geq 0$	only trivial vacuum stationary point	theorem/no-go
static isolated real scalar, $d = 3$, $U < 0$ at virial point	negative dilation mode	theorem/unstable
$d > 3$	negative dilation mode	theorem/unstable
$d = 2$	scaling direction marginal	not stabilized by theorem
$d = 1$	kink not excluded	boundary outside tube problem
degenerate $B = 0/1$ closed wall	surface-tension collapse	derived
lower-energy interior	critical radius with $\omega_R^2 < 0$	derived/unstable
higher-energy interior	collapse; no critical radius	derived
planar domain wall	boundary/topological support, infinite transverse extent	not a finite tube
critical bubble used in KMS loop	unstable pole	rejected
inverse-power pressure AR^{-p}	stable radius possible	conditional on new sector
Q-ball	charge stabilization possible	requires complex/charged field
oscillon	metastable time-dependent localization possible	not a static KMS tube
fixed compact source	stable B profile for convex potential	sourced subsystem only
varied material source	Ward-compatible support possible	coefficient-complete source open
linear Yukawa source	localizes mean profile, not fluctuation modes	theorem for representative
source-dependent Hessian	localized modes may occur	material coupling unspecified
finite cavity	discrete positive spectrum	boundary-dependent, not intrinsic
cavity removed	spectrum tends to bulk continuum	derived
$Z_B = 0$	primary rank changes	excluded boundary
$Z_B > 0$ with Jacobi negative mode	rank regular but dynamically unstable	fail

REGIME	RESULT	GRADE
Jacobi zero mode	collective coordinate/IR treatment required	open boundary
gravitational binding	possible evasion	full coupled solution required

X. Graded claim ledger

CLAIM	EVIDENCE	GRADE	EFFECT
some potential V_B alone can stabilize an isolated static finite tube	Derrick scaling	**false** under stated assumptions	minimal soliton route closed
nonnegative vacuum-subtracted potential has a nontrivial static tube	$T + 3U = 0$	**false**	only vacuum
negative potential can yield a stable static tube	$E'' = -2T$	**false**	any virial extremum is a saddle
closed degenerate phase wall has stable radius	$E = 4\pi\sigma R^2$	**false**	collapse
nondegenerate critical bubble is stable	$\omega_R^2 = -2/R_*^2$	**false**	one negative radial mode
local $m_B^2 > 0$ proves global stability	dilation mode	**false**	local loop remains conditional
inverse-radius pressure can stabilize a radius	exact radial minimum	**derived**	requires new varied physics
a compact source can produce a smooth finite B profile	exact Yukawa solution	**theorem for representative**	profile viable
S_B predicts the sourced radius	source-support non-selection	**false**	radius inherited from material support
a linear source localizes a Gaussian B mode	source-independent Hessian	**false**	continuum remains
a fixed source is autonomously Ward closed	source-force term	**false**	sourced effective layer
a varied material source can close total force exchange	Noether chain rule	**conditional theorem**	source action still required
Derrick instability changes primary rank	regular Z_B Hessian	**no**	instability is spectral
$58/116$ changes	physical source sector excluded from subtotal	**no**	subtotal retained

CLAIM	EVIDENCE	GRADE	EFFECT
complete Dirac/CMC rank follows	material and boundary blocks missing	**false**	Gate G1 remains open
Gate G3 closes	global coefficients and protection absent	**no**	tuning gate remains open
stable finite tube ledger item closes positively	minimal route fails; bridge incomplete	**no**	item narrowed, remains open generally
framework grade improves or collapses	one completion route ruled out, viable sourced class remains	**no**	grade unchanged

XI. Direct answer and next required calculation

XI.A Direct answer

The canonical B action does **not** admit the stable isolated static finite-radius soliton that the Stage-4 source left open. No choice of $V_B(B)$ alone repairs that within the theorem's domain. The local crossover mass m_B therefore cannot be promoted to a global isolated-tube eigenmode.

A finite tube remains possible only as a supported object. The narrowest bridge consistent with the existing interpretation of B is:

$$\boxed{\text{derive a covariant varied material current and let it source the phase field.}}$$

The source must determine the tube support, participate in the Ward identity, and supply a positive coupled Jacobi spectrum. A fixed support function is not enough.

XI.B Consequences for prior results

- The canonical action and positive primary kinetic rank are retained.
- The local matched crossover loop is retained as a conditional WKB result on any genuinely stable supported patch.
- The raw-bubble supersession by the contact seagull is unchanged.
- The global finite-tube loop is not yet defined because the material spectrum and projection are absent.
- The total diagonal Ward theorem remains a conditional pass for a fully varied source.
- The $58/116$ structural subtotal remains unchanged.
- No v8.1, v8.2, v9.0, or Gate G1–G5 claim is withdrawn.

XI.C Next calculation

The next coefficient-complete calculation is now uniquely identified:

1. choose the existing material/current variables that define the compact source world tube;
2. write a covariant action $S_{\mathrm{mat}}[\mathcal{N}, g, U]$ and scalar source $J(\mathcal{N})B$;
3. solve one finite stationary source profile;
4. derive the coupled B–material radial Jacobi matrix;
5. prove that its physical spectrum has no negative mode;

6. compute the normalized projection $g_{\alpha n}[u]$;
7. insert that spectrum into the matched crossover loop; and
8. repeat the Ward, primary/secondary rank, and boundary-CMC audit.

Until those steps are completed,

$$\boxed{\text{STF remains a coherent gravitational candidate, not a completed gravity theory.}}$$

XII. What is not established

This paper does not establish:

1. a coefficient-complete varied material source;
2. a parameter-free source radius or density;
3. a stable coupled B–material solution;
4. a localized positive carrier mode;
5. the global spatial readout projector $u(\mathbf{x})$;
6. the environment mode profiles $\chi_\alpha(\mathbf{x})$;
7. a finite global crossover coefficient;
8. radiative protection of zero DC;
9. stability of a Q-ball, oscillon, flux tube, membrane, cavity, or gravitationally bound alternative;
10. the source sector's complete primary and secondary constraint chains;
11. the augmented boundary-CMC Schur complement;
12. the complete advanced/noise deformed identity;
13. a nonlinear binary solution or waveform;
14. the production world tube or timing normalization; or
15. a completed gravity theory.

XIII. Reproducibility

The NumPy-only checker `stf_v9_0_finite_world_tube_checks.py` verifies:

- all six frozen hashes when the source workspace is supplied;
- the $d = 3$ Derrick virial relation and negative dilation mode;
- the $d > 2$, $d = 2$, and $d = 1$ scaling boundaries;
- direct Gaussian-profile energy scaling;
- the critical thin-wall radius, negative radial curvature, and $\omega_R^2 = -2/R_*^2$;
- collapse/expansion directions around the critical bubble;
- the exact stable radius and breathing frequency produced by a generic inverse-power stabilizer;
- dependence of that radius on the new microscopic coefficient;

- continuity and derivative matching of the exact sourced Yukawa profile;
- its positivity, decay, linear source scaling, and source-radius dependence;
- positivity and source independence of the linear-source fluctuation Hessian;
- convergence of the cavity spectrum to the bulk threshold;
- the stable-mode and negative-mode boundaries of the crossover loop;
- dependence of the global loop on the boundary spectrum;
- constant healthy canonical primary rank for $Z_B > 0$; and
- the nonzero boundary force density of a fixed compact source.

The checker is a theorem and representative-solution audit. It does not manufacture the missing varied material sector.

References

1. G. H. Derrick, “Comments on Nonlinear Wave Equations as Models for Elementary Particles,” *Journal of Mathematical Physics* **5**, 1252–1254 (1964), doi:10.1063/1.1704233.
2. S. Coleman, “The Fate of the False Vacuum: Semiclassical Theory,” *Physical Review D* **15**, 2929–2936 (1977), doi:10.1103/PhysRevD.15.2929; erratum **16**, 1248 (1977).
3. S. Coleman, “Q-balls,” *Nuclear Physics B* **262**, 263–283 (1985); doi:10.1016/0550-3213(85)90286-X; erratum **269**, 744 (1986).
4. *STF V8.1 Covariant Clock, World-Tube, Gaussian Bath, and Ward Completion*, Version 1.0, 27 August 2026.
5. *STF V9.0 Varied World-Tube Crossover Loop and Noise Gate*, Version 1.0, 28 August 2026.

Appendix AF — Varied Conserved-Material-Current Bridge Gate

Frozen-consolidation record. Source file `STF_V9_0_Varied_Conserved_Material_Current_Bridge_Gate_V1_0.md`*, SHA-256* `6f065043b78a37885ab4728c0cca43d2ef3c16a44d95e2ab4a52567e5a6e19c0`*. The scientific body is carried in full; Markdown heading levels are adjusted for nesting and missing-backslash LaTeX quad transport defects are repaired in the consolidated rendering. Section numbers below are local to this appendix.*

Scope. This paper carries out the calculation declared by the finite-world-tube record: choose a covariant varied material current, couple it to the already varied world-tube phase field B, determine whether the combined system can select a finite support radius, derive its radial Jacobi problem, and track the consequences for the environment, production, Ward, and rank ledgers. It does not modify the frozen v8.1, v8.2, or v9.0 manuscripts.

Baseline rule. Physics is graded against the frozen v8.1 publication and calculation baselines and the repaired v8.2 gravitational architecture. The v9.0 file is used only as the frozen audit ledger. No version-9 proposal is imported as a premise.

Result. A productive bridge exists, but only conditionally. The narrowest covariant completion is an isentropic Brown current with conserved particle number, an equation of state $\varepsilon(n, B)$, and the already retained canonical phase field B. A minimal representative reuses the frozen window

$$W(B) = B^2(3 - 2B)$$

as a material binding function:

$$\varepsilon(n, B) = mn + \frac{\kappa}{\gamma - 1}n^\gamma - gnW(B), \qquad 1 < \gamma \le 2.$$

At fixed conserved number N, a thin-wall configuration with surface tension $\sigma > 0$ has

$$E(R) = (m - g)N + 4\pi\sigma R^2 + AR^{-p}, \qquad p = 3(\gamma - 1),$$

$$A = \frac{\kappa N^\gamma}{\gamma - 1}\left(\frac{3}{4\pi}\right)^{\gamma - 1}.$$

It has the unique radius

$$\boxed{R_* = \left(\frac{pA}{8\pi\sigma}\right)^{1/(p+2)}, \qquad E''(R_*) = 8\pi\sigma(p + 2) > 0.}$$

This is not a self-supported B soliton and does not contradict the preceding Derrick theorem. Compression of a conserved material charge supplies the missing inverse-power term. For the explicit dimensionless verification point

$$\gamma = \frac{5}{3}, \quad \kappa = 0.8, \quad N = 10, \quad \sigma = 0.5, \quad m = 5, \quad g = 2.5,$$

the checker obtains

$$R_* = 1.3590504422, \qquad n_* = 0.9510528735,$$

and the droplet lies below the dispersed threshold:

$$E(R_*) - mN = -1.7896859680 < 0.$$

Its chemical no-leak condition and frozen-B sound-speed condition also pass. These numbers are an existence representative in arbitrary units, not STF predictions and not allowed inputs to a parameter-free release.

The full coupled radial quadratic form is

$$\delta^2 E = 4\pi \int dr\, r^2 \left[\frac{Z_B}{2}(b')^2 + \frac{\mathcal{A}}{2}b^2 - \mathcal{C}b\,\mathcal{D}\xi + \frac{\mathcal{K}}{2}(\mathcal{D}\xi)^2\right] + \delta^2 E_{\partial\Omega},$$

with

$$\mathcal{D}\xi = \frac{1}{r^2}\frac{d}{dr}(r^2 n_0 \xi), \quad \mathcal{A} = V_B'' + \varepsilon_{BB}, \quad \mathcal{C} = \varepsilon_{nB}, \quad \mathcal{K} = \varepsilon_{nn}.$$

A sufficient bulk positivity condition is

$$\boxed{Z_B > 0, \qquad \mathcal{K} > 0, \qquad \mathcal{A} - \frac{\mathcal{C}^2}{\mathcal{K}} > 0.}$$

The thin-wall breathing mode and all $\ell \geq 2$ capillary shape modes pass in the reduced representative; $\ell = 1$ gives the expected translational collective zero modes. The coefficient-complete smooth interface operator has not been solved, so a global all-mode stability claim is not made.

The same current supplies a covariant support, material rest frame, density, and normal-mode basis for Gate G2. It can generate a positive material contribution to ρ_{QQ} after microscopic couplings are supplied, but it fixes neither those couplings nor the required Drude continuum. It supplies the rest frame and support needed by Gate G5, but a single neutral barotrope contains no polarization-magnetization tensor and does not create a pre-merger charged current. Thus G2, G3, and ledger items 24–26 remain open. The unintegrated Ward source defect is repaired conditionally because the material current is varied; the advanced/noise identity and boundary-CMC algebra remain open. The structural $58/116$ subtotal is unchanged and must not absorb the material sound mode.

$$\boxed{\text{Grade unchanged: coherent gravitational candidate, not a completed gravity theory.}}$$

I. Source control and inherited question

I.A Frozen records

RECORD	ROLE
`STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md`	publicatio baseline
`STF_First_Principles_Paper_V8_1_fixed(1).md`	calculatio baseline
`STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md`	repaired v8.2 architectu
`STF_First_Principles_Paper_V9_0_2026-08-28.md`	frozen au ledger on
`STF_V8_1_Covariant_Clock_World_Tube_Gaussian_Bath_and_Ward_Completion_V1_0.md`	canonical carrier source
`STF_V9_0_Varied_World_Tube_Crossover_Loop_and_Noise_Gate_V1_0.md`	matched crossover calculatio
`STF_V9_0_Finite_World_Tube_Derrick_and_Material_Support_Gate_V1_0.md`	immediat preceding finite-tube gate
`STF_V8_2_Merger_Production_Activation_Timing_Surface_and_Visible_Vertex_Gate_V1_0.md`	productio support calculatio

The publication and calculation v8.1 baselines differ only by the already recorded pair-level-significance sentence. No source listed above is changed.

I.B What the preceding gate established

The finite-world-tube calculation closed one subclass negatively:

1. an isolated, static, finite-energy canonical real scalar in three spatial dimensions cannot support a stable tube under the stated Derrick assumptions;
2. a closed degenerate-vacuum wall collapses;
3. a nondegenerate critical bubble has a negative breathing mode;
4. a prescribed compact source gives a stable B profile at fixed source but does not select the source radius; and
5. a linear prescribed source does not localize the B Hessian.

It left one narrow route: make the source a fully varied material system whose conserved charge, pressure, stress, and fluctuations select the radius and enter the total Ward identity. That is the present calculation.

I.C Status of the covariant current action

The current action used below is the isentropic specialization of the standard covariant perfect-fluid action with a densitized particle flux. Brown’s action derives particle-number conservation, the perfect-fluid stress tensor, the Euler equation, and the canonical constraints from one varied parent. The STF-specific choice is not that formalism; it is the new equation of state and its coupling to the frozen B window. The distinction matters: covariance is standard, while the material coefficients remain new data.

II. Minimal covariant varied current

II.A Fields and action

Let J^μ be a contravariant vector density of weight one. Define

$$|J| = \sqrt{-g_{\mu\nu}J^\mu J^\nu}, \qquad n = \frac{|J|}{\sqrt{-g}}, \qquad u^\mu = \frac{J^\mu}{\sqrt{-g}\,n}, \qquad u^\mu u_\mu = -1.$$

For an isentropic fluid with possible vorticity, take

$$\boxed{S_{\rm mat} = \int d^4x \left[-\sqrt{-g}\,\varepsilon(n,B) + J^\mu\left(\partial_\mu\vartheta + \alpha\,\partial_\mu\beta\right)\right]}.$$

The scalars ϑ, α, β are Clebsch variables. The irrotational sector follows by setting the advected pair α, β to a trivial configuration. Keeping the pair is safer for the full theory because merger plasma need not be potential flow.

Variation of ϑ gives the exact conservation law

$$\boxed{\partial_\mu J^\mu = 0} \qquad \Longleftrightarrow \qquad \boxed{\nabla_\mu(nu^\mu) = 0.}$$

Variation of J^μ gives the Taub-current relation

$$\mu u_\mu + \partial_\mu\vartheta + \alpha\partial_\mu\beta = 0, \qquad \mu = \frac{\partial\varepsilon}{\partial n}.$$

The remaining Clebsch equations advect α and β along u^μ. No prescribed support function appears.

II.B Stress and thermodynamics

Metric variation gives

$$T^{\mu\nu}_{\text{mat}} = (\varepsilon + p)u^\mu u^\nu + pg^{\mu\nu}, \qquad p = n\varepsilon_n - \varepsilon.$$

The B-dependent first law is

$$d\varepsilon = \mu\, dn + \varepsilon_B\, dB.$$

On the material equations,

$$\nabla_\mu T^{\mu}_{\text{mat}\,\nu} = -\varepsilon_B \nabla_\nu B.$$

Thus the material system can exchange force with B without creating an external Ward defect.

II.C Minimal STF-compatible equation of state

The narrowest representative that reuses an existing STF function is

$$\boxed{\varepsilon(n,B) = mn + \frac{\kappa}{\gamma-1}n^\gamma - gnW(B), \quad W(B) = B^2(3-2B), \quad 1 < \gamma \le 2.}$$

Here $m > 0$ is the outside one-particle energy, $\kappa > 0$ is the polytropic coefficient, and $g > 0$ is the material binding gap between $W = 0$ and $W = 1$. The pressure is

$$\boxed{p = \kappa n^\gamma.}$$

The linear-in-n binding term changes the chemical potential but not the pressure:

$$\mu = m + \frac{\kappa\gamma}{\gamma-1}n^{\gamma-1} - gW(B).$$

The frozen window has

$$W(0) = 0, \quad W(1) = 1, \quad W'(0) = W'(1) = 0,$$

so the coupling does not push either bulk phase away from its endpoint. Its derivatives are

$$W'(B) = 6B(1-B), \qquad W''(B) = 6 - 12B.$$

Consequently

$$\varepsilon_B = -gnW', \qquad \varepsilon_{BB} = -gnW'', \qquad \varepsilon_{nB} = -gW', \qquad \varepsilon_{nn} = \kappa\gamma n^{\gamma-2} > 0.$$

This form is minimal, not unique. The numbers m, κ, γ, g are not fixed by v8.1 or v8.2. They must ultimately be calculated from a named material sector. Treating them as adjustable STF coefficients would violate baseline control and the parameter-free claim.

II.D A definite phase potential for the existence representative

The canonical corpus left V_B open. To perform an existence calculation, choose the symmetric quartic

$$\boxed{V_B(B) = \lambda_B B^2(1-B)^2, \qquad \lambda_B > 0.}$$

It has degenerate vacua at $B = 0, 1$. In the planar thin-wall limit its tension is

$$\boxed{\sigma = \int_0^1 dB\sqrt{2Z_B V_B(B)} = \frac{\sqrt{2Z_B\lambda_B}}{6}.}$$

Choosing this potential adds λ_B; it does not derive it. Its purpose is to make every coefficient in the representative explicit enough to test.

III. Coupled equations and total Ward identity

III.A B equation

Add $S_{\rm mat}$ to the canonical varied parent while retaining the existing B action and windowed readout. The phase-field equation becomes

$$\boxed{Z_B\Box B - V_B'(B) - \varepsilon_B(n,B) + W'(B)Q_\Delta\mathcal{E}^{\rm env}_{\widetilde{Q}} = 0.}$$

For the minimal equation of state, the material force is $+gnW'(B)$ in this equation. The final term is the already derived environment, counterterm, and memory force. It must not be dropped in a global STF solution; it is omitted only in the decoupled stationary support diagnostic below.

III.B Material Euler equation

Projecting the current equation orthogonal to u^μ gives

$$(\varepsilon + p)a_\nu + P_\nu{}^\mu\nabla_\mu p = -\varepsilon_B P_\nu{}^\mu\nabla_\mu B,$$

where

$$a_\nu = u^\mu\nabla_\mu u_\nu, \qquad P_{\mu\nu} = g_{\mu\nu} + u_\mu u_\nu.$$

The phase gradient is a physical confining force. It is carried by the varied material equation rather than by a frozen source.

III.C Exact force cancellation

On the B equation with the other STF response forces temporarily suppressed,

$$\nabla_\mu T^\mu_{B\,\nu} = +\varepsilon_B\nabla_\nu B,$$

while the material equation gives the opposite term. Therefore

$$\boxed{\nabla_\mu\left(T^\mu_{B\,\nu} + T^\mu_{{\rm mat}\,\nu}\right) = 0}$$

on their coupled equations. Restoring the clock, readout, memory, bath, metric, visible fields, and multipliers extends this cancellation into the already derived diagonal identity.

Theorem 1 — Varied-Source Ward Repair

If the compact source is generated by the varied fields $J^\mu, \vartheta, \alpha, \beta$ through $\varepsilon(n,B)$, the fixed-source defect $B\nabla_\nu J$ of the preceding record is replaced by internal force exchange and vanishes on the combined equations.

The theorem is unintegrated and conditional on varying all fields. It does not establish the reduced advanced/noise identity, the boundary contribution, or the CMC bracket algebra.

IV. Finite supported equilibrium

IV.A Controlled regime

Use the weak-gravity, static, spherical, thin-wall regime as an existence test. Let $B \simeq 1$ and $n \simeq n_*$ inside $r < R$, and $B \simeq 0$, $n = 0$ outside. The wall thickness must be small compared with R, the response force must be subleading in the background, and the total particle number

$$N = 4\pi \int_0^\infty dr\, r^2 n(r)$$

is held fixed. These assumptions define a controlled representative, not a binary-merger solution.

IV.B Energy and selected radius

For a uniform interior,

$$n(R) = \frac{3N}{4\pi R^3}.$$

The rest and binding energies are $(m - g)N$ and do not select R. The compression energy is

$$E_{\rm comp}(R) = \frac{\kappa}{\gamma - 1} n(R)^\gamma \frac{4\pi R^3}{3} = AR^{-p},$$

with

$$p = 3(\gamma - 1) > 0, \qquad A = \frac{\kappa N^\gamma}{\gamma - 1}\left(\frac{3}{4\pi}\right)^{\gamma-1}.$$

The total thin-wall energy is

$$\boxed{E(R) = (m - g)N + 4\pi\sigma R^2 + AR^{-p}.}$$

It diverges as $R \to 0$ because of compression and as $R \to \infty$ because of surface area. Its unique stationary point satisfies

$$8\pi\sigma R_* - pAR_*^{-p-1} = 0,$$

or

$$\boxed{R_*^{p+2} = \frac{pA}{8\pi\sigma}.}$$

At the solution,

$$\boxed{E''(R_*) = 8\pi\sigma(p + 2) > 0.}$$

The equivalent Young–Laplace equation is

$$\boxed{p_{\rm in} = \kappa n_*^\gamma = \frac{2\sigma}{R_*}.}$$

Theorem 2 — Conserved-Current Radius Selection

For $\sigma > 0$, $\kappa > 0$, fixed $N > 0$, and $\gamma > 1$, the thin-wall energy has exactly one finite positive radius and it is a strict global minimum in the radial collective coordinate.

This theorem changes the status of the narrow material subclass: its radius is selected by the varied material coefficients and conserved number, not inserted as a source radius. It does not assert that those coefficients or N are fixed by STF.

IV.C Binding and leakage conditions

A radial minimum is not enough. The droplet must lie below the energy of N widely dispersed exterior particles:

$$\boxed{E(R_*) < mN.}$$

Equivalently,

$$gN > E_{\mathrm{comp}}(R_*) + 4\pi\sigma R_*^2.$$

Local particle leakage is absent when the interior chemical potential is below the exterior one-particle threshold:

$$\boxed{\mu_{\mathrm{in}} = m - g + \frac{\kappa\gamma}{\gamma - 1} n_*^{\gamma-1} < m.}$$

Thus

$$\boxed{g > \frac{\kappa\gamma}{\gamma - 1} n_*^{\gamma-1}.}$$

The frozen-B sound speed is

$$c_s^2 = \left.\frac{dp}{d\varepsilon}\right|_B = \frac{\kappa\gamma n^{\gamma-1}}{m - gW + \frac{\kappa\gamma}{\gamma-1} n^{\gamma-1}}.$$

The material representative must satisfy

$$0 < c_s^2 \leq 1, \qquad \varepsilon + p > 0.$$

The choice $1 < \gamma \leq 2$ gives a causal high-density limit, but finite-density causality and positive chemical potential must still be checked.

IV.D Explicit existence point

Take arbitrary dimensionless units and

$$Z_B = 1, \quad \lambda_B = 4.5, \quad \sigma = \frac{\sqrt{2 Z_B \lambda_B}}{6} = 0.5,$$

$$\gamma = \frac{5}{3}, \quad \kappa = 0.8, \quad N = 10, \quad m = 5, \quad g = 2.5.$$

The analytic formulas give

$$R_* = 1.3590504422, \qquad n_* = 0.9510528735,$$

$$E_{\mathrm{comp}} = 11.6051570160, \qquad E_{\mathrm{wall}} = 11.6051570160,$$

$$E(R_*) - mN = -1.7896859680,$$

$$\frac{\kappa\gamma}{\gamma - 1} n_*^{\gamma-1} = 1.9341928360 < g, \qquad c_s^2 = 0.2907996874.$$

The equality $E_{\mathrm{comp}} = E_{\mathrm{wall}}$ is specific to $\gamma = 5/3$, for which $p = 2$. The checker reproduces every value from the declared coefficients. Again, this is an existence point and no numerical parameter is transferred into the STF baseline.

V. Radial Jacobi problem

V.A Coupled perturbations

Let

$$B(t,r)=B_0(r)+b(t,r),$$

and describe the material perturbation by a radial Lagrangian displacement $\xi(t,r)$. Linearized number conservation gives

$$\boxed{\delta n=-\mathcal{D}\xi,\qquad \mathcal{D}\xi=\frac{1}{r^2}\frac{d}{dr}\left(r^2n_0\xi\right).}$$

Suppressing the already declared metric, readout, environment, and boundary-CMC blocks, the radial potential quadratic form is

$$\boxed{\delta^2E=4\pi\int_0^\infty dr\,r^2\left[\frac{Z_B}{2}(b')^2+\frac{\mathcal{A}}{2}b^2-\mathcal{C}b\mathcal{D}\xi+\frac{\mathcal{K}}{2}(\mathcal{D}\xi)^2\right]+\delta^2E_{\partial\Omega}.}$$

Here

$$\mathcal{A}(r)=V_B''(B_0)+\varepsilon_{BB}(n_0,B_0),$$

$$\mathcal{C}(r)=\varepsilon_{nB}(n_0,B_0),\qquad \mathcal{K}(r)=\varepsilon_{nn}(n_0,B_0).$$

For the minimal representative,

$$\boxed{\mathcal{A}=V_B''-gn_0W'',\qquad \mathcal{C}=-gW',\qquad \mathcal{K}=\kappa\gamma n_0^{\gamma-2}.}$$

V.B Jacobi matrix

With the radial inner product

$$\langle f,g\rangle=4\pi\int dr\,r^2fg,$$

the operator form is

$$\boxed{\mathbb{J}_{B\mathrm{m}}=\begin{pmatrix}-Z_Br^{-2}\partial_r(r^2\partial_r)+\mathcal{A} & -\mathcal{C}\mathcal{D}\\ -\mathcal{D}^\dagger\mathcal{C} & \mathcal{D}^\dagger\mathcal{K}\mathcal{D}\end{pmatrix}+\mathbb{J}_{\partial\Omega}.}$$

The generalized normal-mode equation is

$$\mathbb{J}_{B\mathrm{m}}\Psi_a=\omega_a^2\mathbb{M}_{B\mathrm{m}}\Psi_a,$$

where the kinetic metric contains $Z_B>0$ for b and the positive fluid enthalpy density $w_0=\varepsilon_0+p_0$ for ξ. Exact coefficients in the fluid kinetic block depend on the chosen radial variable, but its sign does not.

V.C Bulk Schur condition

The local nondifferential part completes the square:

$$\frac{\mathcal{K}}{2}\left(\mathcal{D}\xi-\frac{\mathcal{C}}{\mathcal{K}}b\right)^2+\frac{1}{2}\left(\mathcal{A}-\frac{\mathcal{C}^2}{\mathcal{K}}\right)b^2.$$

Therefore a sufficient bulk condition is

$$\boxed{Z_B > 0, \qquad \mathcal{K} > 0, \qquad \mathcal{S}(r) \equiv \mathcal{A} - \frac{\mathcal{C}^2}{\mathcal{K}} > 0.}$$

It is sufficient, not necessary, because a domain-wall profile can have locally negative V_B'' while its full gradient operator remains nonnegative. The coefficient-complete acceptance test is the spectrum of $\mathbb{J}_{B\mathrm{m}}$ with the actual smooth background and boundary conditions.

V.D Collective breathing and shape modes

For the thin-wall radial collective coordinate, the effective inertia is

$$\mathcal{M}_R = 4\pi\sigma R_*^2 + \mathcal{M}_{\mathrm{fluid}} > 0.$$

For a homogeneous nonrelativistic radial flow,

$$\mathcal{M}_{\mathrm{fluid}} = \frac{3}{5}(\varepsilon_* + p_*)\frac{4\pi R_*^3}{3}.$$

Hence

$$\boxed{\omega_R^2 = \frac{8\pi\sigma(p+2)}{\mathcal{M}_R} > 0.}$$

If fluid inertia is neglected, this reduces to

$$\omega_R^2 = \frac{2(p+2)}{R_*^2}.$$

For surface deformations expanded in spherical harmonics, the fixed-volume capillary part is proportional to

$$(\ell - 1)(\ell + 2).$$

Thus $\ell \geq 2$ surface modes are positive, $\ell = 1$ are the three translations, and $\ell = 0$ is the breathing mode stabilized above. These statements do not replace the smooth coupled-interface spectrum.

Theorem 3 — Reduced Stability Pass

Under the thin-wall, homogeneous-interior, weak-gravity assumptions, with the binding, causality, and positive-inertia inequalities satisfied, the unique radius R_* has a positive breathing eigenvalue; capillary modes with $\ell \geq 2$ are positive; and $\ell = 1$ contains only translational collective zero modes.

V.E Exact remaining stability test

The reduced pass does not determine whether a mixed phase/material eigenmode is negative in the smooth interface. Completion requires:

1. solve the coupled stationary equations for $B_0(r)$ and $n_0(r)$ at fixed N with the response background included;
2. impose regularity at $r = 0$, decay at infinity, and the varied boundary data;
3. construct $\mathbb{J}_{B\mathrm{m}}$ without thin-wall replacement;
4. remove only genuine collective and gauge zero modes;
5. require every remaining physical eigenvalue to obey $\omega_a^2 > 0$; and
6. repeat after metric, clock, readout, jet, and CMC mixing is restored.

The present calculation narrows the obstruction to this explicit spectral problem.

VI. Normalized projections and Gate G2

VI.A Material normal modes

Let the stable physical modes be

$$\Psi_a = (\psi_{B,a}, \xi_a), \qquad \langle \Psi_a, \mathbb{M}_{B\mathrm{m}} \Psi_b \rangle = \delta_{ab}.$$

Their density component is

$$\psi_{n,a} = -\mathcal{D}\xi_a.$$

If an environment coefficient depends on material scalars through $c_\alpha(n, B)$, then the fluctuation of the selected coupling is

$$\delta[Wc_\alpha] + \partial_B(Wc_\alpha)\,\delta B + \partial_n(Wc_\alpha)\,\delta n,$$

where the B-component of each global mode is normalized with the Z_B kinetic weight already included in $\mathbb{M}_{B\mathrm{m}}$. For spatial readout $u(x)$ and environment profile $\chi_\alpha(x)$, the normalized overlap is

$$\boxed{G_{\alpha a}[u] = \int_\Sigma d^3x \sqrt{h}\, u \chi_\alpha [\partial_B(Wc_\alpha)\psi_{B,a} + \partial_n(Wc_\alpha)\psi_{n,a}]_0.}$$

Equivalently, if one instead expands a canonically normalized local field $b_c = \sqrt{Z_B}\,\delta B$, its coefficient is $\partial_B(Wc_\alpha)/\sqrt{Z_B}$. The two conventions must not be mixed.

This replaces the local $m_B \to \omega_a$ substitution by an actual mode projection.

VI.B Positive material contribution to ρ_{QQ}

For stable discrete Gaussian modes at zero temperature, the material/phase sector contributes

$$\boxed{\rho_{QQ}^{\mathrm{mat}}(\omega; u) = \sum_a \frac{|G_a[u]|^2}{2\omega_a} \delta(\omega - \omega_a) + \rho_{QQ}^{\mathrm{cont}}(\omega; u), \qquad \omega > 0.}$$

Every displayed weight is nonnegative. In a KMS state, the corresponding symmetrized noise is nonnegative by the fluctuation–dissipation relation.

This supplies a **form** for a material contribution to the previously open spectral density. It does not supply a number because the frozen corpus fixes neither $c_\alpha(n, B)$ nor the smooth mode functions. It also does not yield the Drude continuum automatically: an isolated finite droplet gives discrete lines until damping, many-body continua, or an exterior bath is derived.

VI.C Consequence for the static loop price

Once positive modes and overlaps are known, the matched zero-temperature crossover result becomes

$$\boxed{\delta c_{0,u}^{(1)} = \sum_{\alpha,a} \frac{|G_{\alpha a}[u]|^2}{2\Omega_\alpha^2(\omega_a + \Omega_\alpha)} + \text{continuum contribution} \geq 0.}$$

The varied current does not protect $K_{\mathrm{sel}}^R(0) = 0$. Unless every physical overlap vanishes, it adds positive radiative support that must be included in the same subtraction already priced by Gate G3. No new Ward identity forbids the static $Q_a Q_r$ operator.

Gate G3 remains open and priced.

VI.D G2 disposition

The current supplies:

1. a covariant support $\{n > 0\}$;
2. a material four-velocity u^μ and projector $P_{\mu\nu} = g_{\mu\nu} + u_\mu u_\nu$;
3. positive normalized material/phase modes if the Jacobi gate passes; and
4. a positive spectral sum once microscopic overlaps are supplied.

It does not supply:

1. the microscopic c_α;
2. the bath frequency measure and ultraviolet completion;
3. a Drude continuum with the frozen ω_c;
4. a lower or upper numerical bound on ρ_{QQ}; or
5. the horizon-sourced environment coefficient considered in the earlier G2 audit.

Gate G2 is narrowed, not closed.

VII. Production sector and Gate G5

VII.A What the current supplies

The varied current provides a covariant material world tube, its rest frame, density, enthalpy, and boundary. These are precisely the variables that were missing when the production gate warned against a prescribed W_i, fixed disk surface, or frozen coherence length.

The support of a possible production channel is now defined by

$$\Omega_{\rm mat} = \{x \mid n(x) > 0\},$$

not by an externally drawn coordinate tube.

VII.B What a neutral barotrope does not supply

The visible existence vertex requires a varied antisymmetric material tensor

$$\mathcal{M}^{\mu\nu} = 2u^{[\mu}\mathcal{P}^{\nu]} + \epsilon^{\mu\nu\rho\sigma}u_\rho\mathcal{M}_\sigma.$$

The polarization $\mathcal{P}^\mu$ and magnetization $\mathcal{M}^\mu$ are not contained in a single neutral perfect-fluid current. Consequently the minimal bridge cannot by itself source

$$J^\mu_{\rm prod} = \nabla_\nu\left[\frac{Q_\Delta}{\Lambda_i^4}\mathcal{G}_i(\Upsilon_Z)W_i\mathcal{M}_i^{\nu\mu}\right].$$

A charged multi-fluid or kinetic plasma completion is required. It must add and vary the charged species currents, electromagnetic field, polarization response, composition, and dissipative state. Current conservation alone does not derive that response.

VII.C Timing support

Even after a charged extension, the production-support theorem remains: multiplication by the STF gate cannot create matter or polarization where the varied material solution has none. To carry the timing anchors, the completed pre-merger solution must have nonzero charged support on the covariant surfaces corresponding to $1466R_S$, $730R_S$, and $360R_S$ for the reference system.

The present static droplet is not such a compact-binary magnetosphere. It derives no 3.32-year, 71-day, or 0.1-year support boundary and no channel-threshold ratio. Ledger items 24–26 remain open.

VII.D Productive reuse rule

The next charged calculation should extend this current rather than introduce an unrelated frozen plasma profile. That preserves the following chain:

$$\text{varied number current} \longrightarrow \text{varied world tube} \longrightarrow \text{material normal modes} \longrightarrow \rho_{QQ}^{\text{mat}}$$

and, after adding charged response,

$$\text{varied polarization} \longrightarrow J^{\mu}_{\text{prod}} \longrightarrow \text{pre-merger support test.}$$

This is the scientific value of the bridge even though it does not yet close a gate.

VIII. Rank, constraints, and gravitational status

VIII.A Structural subtotal

The established number

$$58 \text{ per leg}, \qquad 116 \text{ doubled}$$

is the readout–memory–jet structural subtotal. It did not include the physical B scalar and does not include the material current.

VIII.B New material degrees and constraints

The Brown action is first order in the Clebsch variables and has its own primary constraints. In the isentropic irrotational sector it carries one longitudinal sound degree of freedom. The vortical Clebsch completion also carries advected material data. Neither may be counted as a hidden second-class partner of B.

No new total rank is quoted because the coupled primary and secondary chains have not been inserted into the full metric–clock–readout–memory–jet–boundary Dirac matrix. Writing ``59/118'' or any other simple increment would repeat the unsupported counting error rejected in the earlier Stueckelberg audit.

VIII.C CMC and hyperbolicity conditions

Before gravitational closure, the material block must satisfy:

1. positive enthalpy and causal sound cone;
2. no negative physical eigenvalue of the smooth coupled Jacobi operator;
3. no rank change where $n \to 0$ at the free boundary;
4. a well-posed moving-boundary variational problem;
5. insertion of $T^{\mu\nu}_{\text{mat}}$ and its canonical variables into the Hamiltonian and momentum constraints; and
6. a nonsingular boundary-CMC Schur complement on the same branch.

The total diagonal Ward identity is necessary but does not prove any of these. Gate G1 remains open.

IX. Acceptance and stop conditions

IX.A Acceptance conditions for this bridge class

A coefficient-complete material bridge would require all of the following:

1. derive m, κ, γ, g and V_B from a named material or compactification sector rather than fit them to an STF anchor;
2. solve the smooth coupled B_0, n_0 background at fixed conserved charges;
3. prove energetic binding against particle leakage, fission, and dispersion;
4. show $0 < c_s^2 \leq 1$ and positive enthalpy throughout the support;
5. show the full physical Jacobi spectrum is positive after collective modes are separated;
6. compute normalized $G_{\alpha a}$ and the full ρ_{QQ};
7. include the resulting matched loop and noise in the G3 subtraction ledger;
8. close the unintegrated Ward identity including the moving boundary;
9. pass the complete Dirac and boundary-CMC rank audit; and
10. for production, extend to a varied charged plasma and demonstrate nonzero pre-merger support without using the timing anchors as inputs.

IX.B Hard stops

The route fails for a proposed material sector if any of the following occurs:

1. $\kappa \leq 0$, $\gamma \leq 1$, negative enthalpy, or superluminal sound;
2. $E(R_*) \geq mN$ or $\mu_{\text{in}} \geq m$, allowing dispersion or leakage;
3. a negative radial, interface, fission, or nonradial Jacobi eigenvalue;
4. a frozen density profile or boundary is required to hold the tube;
5. the density support switches the kinetic or constraint rank;
6. the full CMC/Dirac matrix bifurcates;
7. the computed material overlap makes the G3 tuning inconsistent with the declared subtraction prescription;
8. a charged extension violates gauge invariance or the sequestering constraints;
9. the pre-merger material polarization vanishes at the timing surfaces; or
10. the coefficients are selected from the desired R_*, 3.32-year, 71-day, or 0.1-year outputs.

X. Graded claim ledger

CLAIM	BASIS	GRADE	LEDGER EFFECT
an isolated canonical real B scalar self-supports a finite tube	preceding Derrick theorem	false in stated subclass	unchanged
a varied conserved current can supply the	fixed-N polytropic scaling	derived	productive bridge identified

CLAIM	BASIS	GRADE	LEDGER EFFECT
missing inverse-power energy			
the thin-wall current–B model has a unique stable radial minimum	Theorem 2	derived in controlled representative	narrows finite-tube gap
the displayed dimensionless point is bound and causal	analytic formulas and checker	reproduced existence point	not an STF prediction
every smooth coupled B–material mode is stable	interface operator unsolved	not established	stability gate remains open
the varied current repairs the fixed-source Ward defect	Noether force cancellation	conditional theorem	diagonal Ward level preserved
the advanced/noise identity is thereby closed	reduced influence identity still absent	false	remains open
the material current fixes ρ_{QQ} numerically	microscopic overlaps absent	false	G2 remains open
stable modes contribute nonnegative spectral weight	normalized spectral sum	conditional derived	G2 narrowed
the material bridge protects zero DC	static operator still allowed and loop positive	false	G3 remains open and priced
a neutral barotrope supplies the visible polarization tensor	no charged response fields	false	item 24 remains open
the current alone supplies the timing anchors or ratio	no binary solution or thresholds	false	items 25–26 remain open
$58/116$ becomes a total rank after adding matter	subtotal excludes physical material fields	false	G1 unchanged
the framework grade improves	full gates remain open	no	grade unchanged

No v8.1, v8.2, v9.0, or Gate G1–G5 claim is withdrawn. No post-v9.0 calculation formula is superseded by this record.

XI. Regime and boundary register

ID	REGIME OR BOUNDARY	RESULT
M1	$N = 0$	returns to isolated-B Derrick obstruction

ID	REGIME OR BOUNDARY	RESULT
M2	$\gamma \leq 1$	compression fails to diverge as $R \to 0$
M3	$\kappa > 0, \gamma > 1, N > 0, \sigma > 0$	unique thin-wall radius
M4	$E(R_*) \geq mN$	radial minimum is metastable or unbound to dispersion
M5	$\mu_{\text{in}} \geq m$	particle leakage allowed
M6	$0 < c_s^2 \leq 1$	causal frozen-B sound sector
M7	$\mathcal{S} > 0$	sufficient local bulk Jacobi positivity
M8	$\mathcal{S} < 0$ locally in a wall	full gradient operator required; no automatic failure
M9	$\omega_R^2 > 0$	breathing mode passes
M10	$\ell = 1$ surface mode	translational collective zero mode
M11	$\ell \geq 2$ capillary mode	positive in thin-wall representative
M12	negative smooth-interface mode	material bridge fails for that coefficient set
M13	stable discrete material modes	positive line contribution to ρ_{QQ}
M14	no microscopic overlap	spectral normalization undetermined
M15	finite isolated spectrum only	no Drude continuum follows
M16	nonzero crossover overlap	positive static loop residual; G3 subtraction priced
M17	fully varied material current	fixed-source Ward defect cancels on shell
M18	fixed n, u, or boundary	uncancelled material force defect
M19	neutral one-current fluid	no polarization-magnetization production tensor
M20	charged varied extension	visible current possible, still conditional
M21	material support absent at pre-merger rungs	gated production exactly zero
M22	rank changes at $n = 0$ boundary	gravitational completion fails

XII. What is not established

This calculation does not establish:

1. a derivation of the material equation of state from the STF compactification;

2. a value of m, κ, γ, g, or λ_B;
3. that the dimensionless existence point describes any physical object;
4. a smooth self-consistent $B_0(r), n_0(r)$ solution with the full STF response;
5. all-mode stability of that smooth solution;
6. stability against fission, fragmentation, rotation, or relativistic collapse;
7. a self-gravitating Tolman–Oppenheimer–Volkoff completion;
8. a moving-boundary Hamiltonian and complete primary/secondary chain;
9. the boundary-CMC Schur complement;
10. a new total rank count;
11. a microscopic environment spectrum;
12. a numerical ρ_{QQ} or bound on it;
13. a Drude continuum from the finite material object;
14. radiative protection of $K^R_{\mathrm{sel}}(0) = 0$;
15. the coefficient-complete advanced/noise identity;
16. a charged plasma polarization tensor;
17. a pre-merger magnetosphere at the STF timing surfaces;
18. a UHECR or GRB production rate;
19. the channel-threshold ratio;
20. the 0.1-year lower boundary;
21. simultaneous passage of the four G4 emission bounds; or
22. a completed gravity theory.

XIII. Decisive next calculation

The next calculation is now smaller than the generic material problem:

1. retain the action of Section II with the coefficients treated as outputs of one named microscopic matter sector;
2. solve the smooth stationary fixed-N equations for $B_0(r), n_0(r)$;
3. construct the full radial and nonradial $\mathbb{J}_{B\mathrm{m}}$;
4. require positivity after translations and any gauge modes are removed;
5. compute the normalized $G_{\alpha a}$;
6. compare the resulting discrete/continuum spectrum with the retained Drude environment and calculate the matched G3 residual;
7. extend the same current to charged species only if the stable neutral support survives; and
8. evaluate that charged solution on the covariant pre-merger rungs.

The route should be abandoned for any microscopic sector that fails binding, causality, interface stability, rank continuity, or pre-merger support.

XIV. Reproducibility

The accompanying NumPy-only checker independently verifies:

1. every frozen source hash when the source workspace is supplied;
2. the frozen window values and derivatives;
3. the quartic-wall tension formula;
4. the fixed-N compression exponent and coefficient;
5. the analytic equilibrium radius;
6. the Young–Laplace relation;
7. the positive radial curvature;
8. the virial relation;
9. the bound-state and chemical no-leak inequalities;
10. the causal sound speed at the existence point;
11. the positive breathing frequency with wall and material inertia;
12. capillary-mode signs for $\ell = 0, 1, 2, 3, 4$;
13. a finite-dimensional coupled Jacobi representative and its Schur condition;
14. generalized-mode normalization;
15. nonnegative material spectral weights;
16. positive matched crossover terms;
17. current conservation in a homologous spherical flow;
18. antisymmetric visible-current divergence in a finite representative;
19. unchanged gate and grade strings; and
20. the declared absence of any simple total-rank increment.

Successful execution ends with

`ALL ASSERTIONS PASSED`.

XV. Final verdict

The conserved-material-current route is productive. It supplies the precise physical ingredient that the Derrick audit found missing and proves that a finite radial support can exist in a controlled current–wall representative. It also provides the correct covariant variables for the G2 spectral projector and the G5 material support.

It is not a completion. The displayed coefficients are not derived from the frozen corpus; the smooth coupled interface spectrum is not solved; the material spectrum does not automatically reproduce the retained environment; a neutral current does not supply a visible polarization; and the gravitational Dirac/CMC and advanced/noise gates remain open.

$$\boxed{\text{Coherent gravitational candidate — not a completed gravity theory.}}$$

References

1. J. D. Brown, “Action functionals for relativistic perfect fluids,” *Classical and Quantum Gravity* **10** (1993) 1579–1606, arXiv:gr-qc/9304026.
2. G. H. Derrick, “Comments on nonlinear wave equations as models for elementary particles,” *Journal of Mathematical Physics* **5** (1964) 1252–1254.
3. Z. Paz, *The Selective Transient Field from First Principles*, v8.1 frozen publication and calculation baselines, 26 August 2026.
4. Z. Paz, *The Selective Transient Field from First Principles*, repaired v8.2 gravitational candidate, 28 August 2026.
5. *STF V8.1 Covariant Clock, World-Tube, Gaussian Bath, and Ward Completion*, Version 1.0, project calculation record.
6. *STF V9.0 Varied World-Tube Crossover Loop and Noise Gate*, Version 1.0, project calculation record.
7. *STF V9.0 Finite World-Tube Derrick and Material-Support Gate*, Version 1.0, project calculation record.
8. *STF v8.2 Merger-Production Activation Gate*, Version 1.0, project calculation record.

Appendix AG — Microscopic-Current Identifiability and Real-Scalar Floquet Gate

Frozen-consolidation record. Source file `STF_V9_0_Microscopic_Current_Identifiability_and_Real_Scalar_Floquet_Gate_V1_0.md`*, SHA-256* `de2ed85fa1bb39594e9fecabd1f713748a2f825fc83cc48bc3cc9b1cb9799a11`*. The scientific body is carried in full; Markdown heading levels are adjusted for nesting and missing-backslash LaTeX quad transport defects are repaired in the consolidated rendering. Section numbers below are local to this appendix.*

Scope. This record executes the next calculation declared by the varied conserved-material-current bridge: determine whether the frozen STF corpus actually contains a microscopic sector that supplies the bridge’s conserved charge, equation of state, and coupling to the varied world-tube field B. Where the closest candidate is the retained ultralight scalar, the record derives the conditional nonrelativistic support formula and identifies the exact relativistic stability problem. It does not modify the frozen v8.1, v8.2, or v9.0 manuscripts.

Baseline rule. Physics is graded against the frozen v8.1 publication and calculation baselines and the repaired v8.2 gravitational architecture. The v9.0 file is used only as the frozen audit ledger. No version-9 proposal is imported as a premise.

Result. The frozen corpus does not contain a displayed field sector that simultaneously supplies

1. an exact localized conserved material charge;
2. a coefficient-complete compressional or gradient energy; and
3. a derived coupling that binds that charge to the B world tube.

The closest candidate is the canonical real scalar ϕ. Its weak-field, nonrelativistic rotating-wave limit is described by a complex envelope ψ and an emergent Schrödinger–Poisson continuity equation. That emergent $U(1)$ is not an exact internal symmetry of the relativistic real-scalar parent. Its canonical mass sector has at most the discrete map $\phi \mapsto -\phi$, and the displayed linear curvature source need not preserve even that map. The fixed-N material bridge is therefore not an exact STF consequence.

If a new binding vertex were independently derived,

$$\Delta\mathcal{L}_{\mathrm{bind}} = g_B W(B)|\psi|^2, \qquad W(B) = B^2(3-2B),$$

then a normalized Gaussian envelope would give

$$E(R) = 4\pi\sigma R^2 + \frac{3N}{4m_s R^2} - g_B N,$$

and hence the unique conditional radius

$$\boxed{R_*^4 = \frac{3N}{16\pi m_s \sigma}, \qquad E''(R_*) = 32\pi\sigma > 0.}$$

This formula moves the support problem from a generic barotropic completion to the corpus's actual ultralight sector, but g_B is absent from the frozen action, N is only approximately conserved, and σ is not fixed because V_B is unspecified. It is a conditional envelope result, not a parameter-free STF prediction.

The exact real-scalar background is periodic. Its stress contains a $2\omega_s$ harmonic, and the retained zero-mode-subtracted kernel obeys

$$|K(2\omega_s)| = \frac{2}{\sqrt{5}} \simeq 0.894427.$$

The response therefore cannot be removed merely by cycle averaging. The exact linear stability gate is a constrained open-system Floquet problem,

$$\partial_t \Xi = \mathbb{A}(t)\Xi, \qquad \mathbb{A}(t+T_s) = \mathbb{A}(t), \qquad \mathbb{M}_F = \mathcal{T}\exp\left(\int_0^{T_s} \mathbb{A}(t)dt\right),$$

with stability decided by the physical, constraint-projected multipliers of $\mathbb{M}_F$, together with retarded analyticity and positive Schwinger–Keldysh noise. The frozen corpus lacks the B binding coefficient and smooth background needed to construct $\mathbb{A}(t)$, so no multiplier spectrum is claimed.

The preceding Brown-current bridge remains a correct external existence construction; this record narrows its status from "candidate STF microscopic completion" to "coherent added matter sector not derived from frozen STF." Gate G2 remains open, Gate G3 remains open and priced, Gate G5 remains open, Gate G1 is unchanged, and no ledger item is closed or withdrawn.

$$\boxed{\text{Grade unchanged: coherent gravitational candidate, not a completed gravity theory.}}$$

I. Source control and the identification question

I.A Frozen records

RECORD	ROLE	S
`STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md`	publication baseline	[illegible]
`STF_First_Principles_Paper_V8_1_fixed(1).md`	calculation baseline	[illegible]
`STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md`	repaired v8.2 architecture	[illegible]
`STF_First_Principles_Paper_V9_0_2026-08-28.md`	frozen audit ledger only	[illegible]
`STF_V8_1_Covariant_Clock_World_Tube_Gaussian_Bath_and_Ward_Completion_V1_0.md`	canonical world-tube parent	[illegible]
`STF_Galactic_Sector_Rederivation_V2_0.md`	retained real-scalar condensate audit	[illegible]
`STF_V9_0_Finite_World_Tube_Derrick_and_Material_Support_Gate_V1_0.md`	finite-tube obstruction	[illegible]
`STF_V9_0_Varied_Conserved_Material_Current_Bridge_Gate_V1_0.md`	immediately preceding current bridge	[illegible]

The two v8.1 baselines differ only by the previously recorded pair-level-significance sentence. No file in this table is changed.

I.B What must be identified

The preceding record introduced a covariant Brown current and proved that a conserved compressible material charge can stabilize a thin-wall B tube. That was an existence theorem for an added matter sector. To turn it into an STF derivation, one displayed frozen-corpus sector must meet the following three conditions.

C1 — exact charge. There is a local current j^μ whose conservation follows from a non-anomalous symmetry of the unapproximated parent,

$$\nabla_\mu j^\mu = 0, \qquad N_\Sigma = \int_\Sigma d\Sigma_\mu j^\mu,$$

with N_Σ independent of the Cauchy surface under the stated boundary conditions.

C2 — coefficient-complete support. The same parent fixes the energy functional or equation of state that produces a positive term under compression. Merely naming a material sector does not fix this term.

C3 — derived tube binding. The frozen parent contains a coupling between that sector and B, or derives one from its compactification. The window $W(B)$ alone is not a material coupling; in v8.2 it windows the compact curvature readout $\widetilde{Q}_\Delta = W(B)Q_\Delta$.

A sector that misses any one condition cannot instantiate the previously proved fixed-charge radius as an STF prediction.

II. Exhaustive frozen-corpus sector audit

II.A Result table

FROZEN OR PROPOSED SECTOR	EXACT LOCALIZED CHARGE	SUPPORT ENERGY FIXED	DERIVED B E
canonical real scalar ϕ	no continuous exact charge	canonical gradient/mass terms	
internal phase $\Theta_I \in S^1$	not an independent field current	no independent EOS	
axionic partner ϑ	only in exact shift limit	kinetic term only in the candidate limit	
generic $S_{\mathrm{matter}}[g]$	unspecified	unspecified	
electromagnetic charge	exact gauge charge in charged matter	not a neutral compressional EOS	
retained environment X_α and memory	no compact material number	Gaussian response fixed after spectral data	no static
Brown current of the preceding gate	yes	yes after m, κ, γ are supplied	yes a

II.B The real scalar has no exact $U(1)$ charge

The relevant part of the frozen action is a canonical **real** scalar,

$$S_\phi = \int d^4x\sqrt{-g}\left[-\frac{1}{2}(\nabla\phi)^2 - \frac{1}{2}m_s^2\phi^2 + \kappa\phi D_U \mathcal{R}_{\mathrm{STF}} + \cdots\right].$$

For a single real component the mass term is invariant under the discrete transformation $\phi \mapsto -\phi$ when the linear curvature source is absent; it does not define a continuous internal rotation. With the displayed linear source, even that discrete symmetry is not a symmetry of the complete sourced sector unless the source transforms as well. There is no independent second real component with which ϕ could form a complex field and no exact Noether particle-number current in the displayed action.

The retained galactic audit correctly derives the nonrelativistic decomposition

$$\phi(\mathbf{x},t)=\frac{1}{\sqrt{2m_s}}\left[\psi(\mathbf{x},t)e^{-im_st}+\psi^*(\mathbf{x},t)e^{+im_st}\right].$$

After assuming slow envelopes and dropping the $e^{\pm 2im_st}$ harmonics, the canonical sector becomes

$$i\partial_t\psi=-\frac{\nabla^2}{2m_s}\psi+m_s\Phi\psi,\qquad \nabla^2\Phi=4\pi G(m_s|\psi|^2+\rho_b).$$

This reduced system is invariant under $\psi\mapsto e^{i\alpha}\psi$ and has

$$n_\psi=|\psi|^2,\qquad \mathbf{j}_\psi=\frac{1}{m_s}\mathrm{Im}(\psi^*\nabla\psi),\qquad \partial_t n_\psi+\nabla\cdot\mathbf{j}_\psi=0.$$

The conservation law is exact **inside the reduced equation**, but the reduction created the complex envelope by separating positive- and negative-frequency pieces and discarding fast harmonics. It did not add an exact continuous symmetry to the real relativistic parent. Number-changing and radiative effects are therefore allowed beyond the approximation. This is the standard relation between a real relativistic scalar and its complex nonrelativistic effective field, and it is also why self-gravitating real-scalar oscillatons may be extremely long lived without being exact charge-supported boson stars.

The fixed-number approximation is controlled only if a computed leakage rate Γ_N obeys

$$\boxed{\Gamma_N T_{\text{support}}\ll 1.}$$

The frozen STF corpus does not calculate Γ_N in the coupled metric–readout–memory–jet–world-tube parent.

II.C The internal phase is not an independent material current

The frozen relation

$$\phi=A\cos\Theta_I,\qquad \Theta_I\in S^1,$$

identifies oscillator phase. It does not display a kinetic action for an independent compact scalar Θ_I with a conjugate charge. Treating a phase coordinate reconstructed from $(\phi,\dot\phi/m_s)$ as an autonomous charged field would double the scalar phase space unless a new constrained parent and its Dirac algebra were supplied.

Nor can winding of Θ_I stabilize a finite spherical material tube in three spatial dimensions. Since

$$\pi_2(S^1)=0,\qquad \pi_3(S^1)=0,$$

neither a map from the enclosing two-sphere nor a compactified three-dimensional bulk carries a protecting winding number. The existing one-cycle closure rule is a temporal recurrence statement, not a spatial soliton charge.

II.D The axionic/shift candidate does not close the bridge

For an ideal shift field with

$$\mathcal{L}_\vartheta=-\frac{f^2}{2}\nabla_\mu\vartheta\nabla^\mu\vartheta-U(\vartheta),\qquad j^\mu_\vartheta=-f^2\nabla^\mu\vartheta,$$

one finds

$$\nabla_\mu j^\mu_\vartheta=-U'(\vartheta).$$

An exact charge exists only when $U' = 0$ and the quantum theory preserves the continuous shift. The frozen candidate audit records both shift-charge dilution for the homogeneous mode and compactification periodicity; it retains the phase only as a finite-epoch local reference, not as the global carrier. More directly for the present problem, no frozen action couples this candidate charge to B.

Even in the idealized exact-shift limit, a uniform charge Q confined to a sphere would contribute

$$E_Q(R) = \frac{Q^2}{2f^2V} = \frac{3Q^2}{8\pi f^2 R^3}.$$

Together with a separately supplied wall tension it would select

$$\boxed{R_*^5 = \frac{9Q^2}{64\pi^2 f^2 \sigma}, \qquad E''(R_*) = 40\pi\sigma > 0.}$$

This is another valid conditional support mechanism, but it requires the exact shift symmetry, its decay constant, a confining B coupling, and the wall tension. None is coefficient-complete in the frozen parent.

II.E Generic matter and electric charge

The baseline writes $S_{\text{matter}}[g]$. This states minimal metric coupling; it does not select a material species, an equation of state, a conserved number, or a coupling to B. Standard-model electric current is conserved when the charged matter sector is specified, but a macroscopically charged sphere pays a Coulomb energy and is not the neutral material support assumed by the bridge. Baryon and lepton numbers are not supplied as exact non-anomalous symmetries by the symbol $S_{\text{matter}}[g]$. Importing a neutron-star or plasma equation of state would be phenomenological input, not a parameter-free deduction from STF.

II.F Environment and memory do not provide static support

The retained bath variables are Gaussian environment coordinates coupled to the compact readout. They are not a compact material-number sector. More decisively, the selected retarded kernel satisfies

$$K^R_{\text{sel}}(0) = 0.$$

It is a causal high-pass response. It cannot generate a nonzero static binding potential by itself. A static material pressure or quantum-pressure term must come from a separate varied sector. Reusing the bath as that sector would also change its spectral interpretation and require a new positivity, KMS, and rank audit.

II.G Microscopic Current Non-Identifiability Theorem

Theorem. Within the displayed frozen v8.1/v8.2 action and its verified calculation corpus, no field sector satisfies C1–C3 simultaneously.

Proof. The displayed candidates are exhausted by the table in II.A. The real scalar supplies canonical gradient energy but no exact continuous charge and no B binding. The internal compact phase is not independent and has no relevant spatial homotopy charge. The axionic candidate has an exact charge only in an unrealized exact-shift limit and has no B binding. Generic matter is not coefficient-complete. Electric charge is not a neutral compressional sector and has no B binding. The Gaussian bath has no localized material number and its retarded response has zero static limit. The Brown current meets the conditions only after adding new matter coefficients and a new binding coefficient. Thus no displayed frozen sector meets all three conditions. □

Corollary — static fixed-N inadmissibility. A smooth static solution $(B_0(r), n_0(r))$ at exact fixed N cannot presently be advertised as an STF prediction. Writing its equations requires choosing a new microscopic matter parent or explicitly accepting a phenomenological extension.

III. The closest admissible conditional reduction

III.A Gaussian real-scalar envelope

The nonrelativistic scalar remains scientifically useful as a controlled conditional approximation. Normalize a spherically symmetric Gaussian envelope by

$$\psi_R(r) = \left(\frac{N}{\pi^{3/2}R^3}\right)^{1/2} \exp\left(-\frac{r^2}{2R^2}\right), \qquad \int d^3x\,|\psi_R|^2 = N.$$

Its canonical gradient energy is

$$E_{\mathrm{q}}(R) = \frac{1}{2m_s}\int d^3x\,|\nabla\psi_R|^2 = \frac{3N}{4m_sR^2}.$$

Suppose, only conditionally, that a microscopic derivation produces

$$\Delta\mathcal{L}_{\mathrm{bind}} = g_B W(B)|\psi|^2$$

and that the B sector produces a thin wall of tension $\sigma > 0$. Then the radius-dependent energy relative to the free rest energy is

$$\Delta E(R) = 4\pi\sigma R^2 + \frac{3N}{4m_sR^2} - g_B N.$$

The first and second derivatives are

$$\Delta E'(R) = 8\pi\sigma R - \frac{3N}{2m_sR^3},$$

$$\Delta E''(R) = 8\pi\sigma + \frac{9N}{2m_sR^4}.$$

There is one positive stationary radius,

$$R_*^4 = \frac{3N}{16\pi m_s\sigma},$$

and at that radius

$$E_{\mathrm{q}}(R_*) = E_{\mathrm{wall}}(R_*), \qquad \Delta E''(R_*) = 32\pi\sigma > 0.$$

The localized state lies below the dispersed threshold only if

$$\boxed{g_B N > 2E_{\mathrm{wall}}(R_*) = 8\pi\sigma R_*^2.}$$

The checker uses the dimensionless illustration

$$N = 10, \qquad m_s = 2, \qquad \sigma = 0.5, \qquad g_B = 1.5,$$

for which

$$R_* = 0.8789473272, \qquad \Delta E(R_*) = -5.2918704372.$$

These are arbitrary verification units. They demonstrate the algebra and nothing about STF's physical scale.

III.B What the reduction does and does not buy

The real-scalar envelope is narrower than the generic barotrope because its support term and mass are inherited from the canonical scalar. It therefore makes two genuine advances:

1. it identifies quantum pressure as a concrete compression term already latent in the retained condensate sector; and
2. it gives an analytic radius and strict radial curvature if a B binding vertex and wall tension are independently derived.

It does not supply the missing vertex, make particle number exact, derive V_B, or establish a smooth all-mode solution. The quantities g_B, σ, and the abundance N cannot be chosen from the desired radius without converting the construction into a fit.

III.C Control conditions for using fixed N

The static envelope approximation requires all of

$$\epsilon_t = rac|\partial_t\psi|m_s|\psi| \ll 1, \qquad \epsilon_x = \frac{|\nabla\psi|}{m_s|\psi|} \ll 1, \qquad \Gamma_N T_{\rm support} \ll 1,$$

plus weak gravity and a separation between the wall thickness and R_*. In the full STF parent there is an additional response-control parameter. Schematically,

$$\epsilon_{\rm resp} = \frac{\|\mathbb{C}_{\rm resp}(2\omega_s)\|}{\Delta_{\rm NR}}|K(2\omega_s)|,$$

where $\Delta_{\rm NR}$ is the relevant reduced spectral gap and $\mathbb{C}_{\rm resp}$ is the coefficient-complete coupling block. The kernel factor is order unity, not small. The frozen corpus does not supply the complete block, so $\epsilon_{\rm resp} \ll 1$ is an obligation, not a result.

IV. Exact replacement: the constrained open Floquet problem

IV.A Why a static Jacobi operator is insufficient

For the real scalar,

$$\phi_0(t,r) = A_0(r)\cos(\omega_s t) + \cdots.$$

Even when the averaged density is stationary, the pressure and trace curvature contain $2\omega_s$. The retained galactic calculation gives

$$R_\phi(t,r) = \frac{m_s^2 A_0(r)^2}{2M_{\rm Pl}^2}[1 + 3\cos(2\omega_s t)]$$

in its WKB normalization. With $\omega_c = \omega_s$,

$$K(\omega) = \frac{-i\omega}{\omega_c - i\omega}, \qquad |K(2\omega_s)| = \frac{2}{\sqrt{5}}.$$

The exact background of the coupled theory is therefore periodic rather than static whenever this response is retained. Some quadratic coefficients may have period $T_s/2$, but $T_s = 2\pi/\omega_s$ is always a valid common period.

IV.B Constraint-projected first-order system

Let Ξ collect the physical perturbations after solving or projecting the linearized lapse, shift, compact-alignment, jet, and boundary constraints. Before projection the collection includes

$$\Xi_{\text{raw}} = (\delta g, \delta\pi_g, \delta\phi, \delta\pi_\phi, \delta B, \delta\pi_B, \delta Q, \delta X_\alpha, \delta y, \delta Z, \ldots)^T.$$

On a coefficient-complete periodic background, the physical system takes the form

$$\boxed{\partial_t \Xi = \mathbb{A}(t)\Xi, \qquad \mathbb{A}(t+T_s) = \mathbb{A}(t).}$$

The monodromy operator is

$$\boxed{\mathbb{M}_F = \mathcal{T}\exp\left(\int_0^{T_s} \mathbb{A}(t)dt\right).}$$

For a closed conservative physical block, symplecticity produces reciprocal Floquet pairs. Stability requires every nongauge multiplier to lie on the unit circle and requires the unit multipliers associated with collective coordinates to be semisimple after quotienting gauge directions. For a passive open block, damping may place physical multipliers strictly inside the unit disk. A multiplier outside the disk is an instability in either case.

The acceptance condition is therefore

$$\boxed{|\lambda_a(\mathbb{M}_F)| \leq 1 \quad \text{for every physical multiplier,}}$$

with equality interpreted using the constraint and collective-mode quotient.

IV.C Open-system additions

Floquet multipliers alone are not enough for the doubled parent. The retarded block must remain analytic in the upper-half frequency plane, the noise kernel must be positive semidefinite on physical test functions, and the matched fluctuation relation must hold in any thermal stationary limit. In a periodic background these are naturally expressed in Floquet sidebands,

$$\omega \longrightarrow \omega + n\omega_s.$$

The exact gate therefore requires:

1. the periodic background and its constraint projector;
2. the retarded Floquet Green function with no upper-half-plane poles;
3. physical multipliers within the unit disk;
4. a positive sideband noise matrix; and
5. the already derived total diffeomorphism/Ward identity with no fixed-source defect.

The NumPy checker verifies the Floquet mechanics on conservative and damped two-dimensional representatives, including Liouville's determinant identity. It does not substitute those representatives for the missing STF operator.

IV.D Data missing before the exact spectrum can be run

The frozen corpus does not fix:

- a microscopic B binding vertex;
- $V_B(B)$ and hence the physical wall tension and wall thickness;
- the exact localized real-scalar background in the doubled open parent;
- the number-leakage rate Γ_N;
- the complete constraint projector on that background;
- the response and bath sideband matrices; or
- boundary conditions compatible with the selected CMC world tube.

Consequently it would be false precision to publish numerical STF Floquet multipliers now. The present result specifies the operator and acceptance test that the next microscopic completion must make calculable.

V. Ward identity, ranks, and gate consequences

V.A No new exact material Ward identity

The emergent envelope phase symmetry gives a continuity equation inside the nonrelativistic reduced model. It does not add an exact $U(1)$ Ward identity to the relativistic doubled parent. The total diffeomorphism identity retains the structure already derived for the varied fields,

$$\nabla_\mu \mathcal{E}_g{}^\mu{}_\nu = \mathcal{E}_\phi \nabla_\nu \phi + \mathcal{E}_B \nabla_\nu B + \mathcal{E}_U \nabla_\nu T_U + \sum_A \mathcal{E}_A \, \delta_\nu \Phi^A + \mathcal{B}_\nu,$$

where the sum denotes the retained readout, alignment, memory, jet, and environment variables in their appropriate tensor representations, and $\mathcal{B}_\nu$ denotes the varied world-tube/boundary contribution. On the full equations of motion the right-hand side vanishes subject to the established boundary conditions. No extra exact charge term can be deleted by invoking the approximate ψ phase.

If the Brown current is added as a genuinely varied matter sector, its Euler equations enter this identity and the prior fixed-source defect is conditionally repaired, exactly as the preceding gate states. The present audit does not undo that result. It shows that the repair is not supplied by the frozen real scalar at exact fixed N.

V.B Structural rank

No new field is added in this audit, so the reported 58 per-leg/116 doubled structural subtotal is unchanged. The nonrelativistic envelope is a change of description of the low-frequency real-scalar modes, not an additional complex field. If one instead promotes ψ or an axionic partner to an independent exactly charged field, its canonical variables and constraints must be added to a new Dirac audit; they cannot be hidden inside the existing subtotal.

V.C Gate-by-gate status

GATE OR LEDGER SECTOR	CONSEQUENCE OF THIS CALCULATION	STATUS
G1 — gravitational/Dirac completion	no new field and no completed background; existing algebra untouched	open, unchanged

GATE OR LEDGER SECTOR	CONSEQUENCE OF THIS CALCULATION	STATUS
G2 — environment spectral realization	microscopic material support is not identifiable in the frozen corpus; real-scalar sidebands give a concrete future spectral target	open, narrowed
G3 — zero-static-response quantum protection	$K(0) = 0$ cannot bind the tube; adding $g_B W(B)\|\psi\|^2$ introduces a new local coupling and new loop obligations	open and priced
G4 — gravitational-wave emission	no change to the direct-local or analytic-parent emission audit	conditional/open as previously recorded
G5 — production and visible current	the neutral real scalar supplies no polarization-magnetization tensor or charged pre-merger current	open
items 24–26	no covariant production surface, visible vertex, or threshold ratio is derived here	open
item 29 and world-tube support	approximate quantum-pressure subclass identified; exact microscopic support and smooth Floquet stability not established	open, narrowed

V.D No supersession and no withdrawals

This calculation does not supersede the finite-world-tube Derrick theorem. It does not supersede the Brown-current existence result. It distinguishes three levels that must remain separate:

1. **proved obstruction:** the isolated canonical B field does not select a stable finite tube under the stated Derrick assumptions;
2. **proved extension existence:** an added exact conserved material current can stabilize a thin-wall subclass; and
3. **present identifiability result:** the frozen STF corpus does not derive that exact current and its B coupling, while its real scalar supplies only an approximate quantum-pressure analogue.

No formula is withdrawn and no deletion is made.

VI. Productive paths from the obstruction

The result is negative about identification, not about all future completions. It leaves three scientifically distinct routes.

VI.A Derive an exact complex sector from compactification

The clean parameter-free route is to derive a second real component or complex modulus, its non-anomalous $U(1)$, and its coupling to B from the ten-dimensional parent. This requires more than renaming the breathing mode: the frozen block-diagonal reduction gives a real modulus and no Kaluza–Klein vector. The derivation must fix the charge normalization, potential, B vertex, and anomaly status and must repeat the Dirac and Ward audits.

VI.B Accept a controlled phenomenological extension

One may add a complex scalar Ψ with

$$S_\Psi = -\int d^4x\sqrt{-g}\left[g^{\mu\nu}(D_\mu\Psi)^* D_\nu\Psi + U(|\Psi|^2) - g_B W(B)|\Psi|^2\right].$$

This supplies an exact current when its $U(1)$ is non-anomalous, but U, g_B, and any gauge coupling are new theory data. It is a legitimate EFT extension, not a parameter-free derivation. The grade cannot change until its constraint, loop, Floquet, emission, and production gates pass.

VI.C Use the real scalar as a metastable effective material

The least invasive route keeps the frozen real scalar and treats N as an adiabatic invariant. It can be predictive only after the coupled theory computes Γ_N, g_B, V_B, and the exact Floquet spectrum and shows that the support lifetime exceeds the required astrophysical interval. This route may be adequate for a long-lived effective world tube, but it cannot be sold as exact charge protection.

VI.D Declared next calculation

The next useful calculation is a **minimal exact-complex-sector cost gate**:

1. introduce the smallest independent complex field consistent with the frozen clock and CMC structure;
2. enumerate every new coefficient and determine which, if any, compactification data fix them;
3. compute the enlarged primary and secondary constraint chains;
4. derive the exact current and total Ward identity;
5. solve the smooth periodic B–matter background;
6. compute the physical Floquet multipliers, retarded sidebands, and noise matrix;
7. propagate the same sector through G3 and G5.

The pass condition is not merely a stable radius. It is one coefficient-complete parent that supplies exact charge, tube binding, all-mode stability, passive open response, and the visible production current without fitting the target phenomenology.

VII. Verification summary

The companion NumPy checker verifies:

- all available frozen-record hashes;
- the exact high-pass kernel limits and the $2\omega_s$ magnitude;
- Gaussian normalization and gradient energy by numerical quadrature;
- the conditional quantum-pressure radius, virial equality, curvature, and bound criterion;
- the ideal shift-charge radius and curvature;
- the absence of a frozen sector satisfying C1–C3 in the explicit audit matrix;
- the presence of the controlling frozen-corpus statements;
- conservative Floquet reciprocal pairing and Liouville determinant;
- damped Floquet contraction and Liouville determinant; and
- the document’s scope, grade, zero-withdrawal, and open-gate language.

Numerical verification cannot prove the corpus-exhaustion theorem by itself; that result follows from the field-content audit in Section II. The checker protects the algebra and release claims against transcription drift.

VIII. Conclusion

The post-v9.0 work has moved the framework one rung forward by replacing a vague request for "material support" with a sharp microscopic identifiability test. The test fails for the frozen corpus: no displayed field supplies exact charge, support energy, and B binding together.

The retained real scalar nevertheless provides a useful conditional direction. Its quantum pressure selects a stable thin-wall radius if a microscopic binding vertex is derived. But its conserved number is emergent, not exact, and the retained response sees its $2\omega_s$ harmonic with order-unity gain. The honest next problem is therefore a constrained open Floquet calculation on a coefficient-complete periodic background, not a static fixed-N stability claim.

The cause has advanced in diagnostic precision and in a narrower constructive formula. It has not advanced in completion grade.

$$\boxed{\text{STF remains a coherent gravitational candidate, not a completed gravity theory.}}$$

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Internal STF corpus

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3. Z. Paz, *STF Galactic Sector Re-Derivation*, Version 2.0, 2026.
4. Z. Paz, *STF Covariant Clock, World Tube, Gaussian Bath, and Ward Completion*, Version 1.0, 2026.
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6. Z. Paz, *STF Varied Conserved-Material-Current Bridge Gate*, Version 1.0, 2026.
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External primary literature

8. E. Braaten, A. Mohapatra, and H. Zhang, "Nonrelativistic Effective Field Theory for Axions," *Physical Review D* **94**, 076004 (2016), arXiv:1604.00669.
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10. D. N. Page, "Classical and Quantum Decay of Oscillatons: Oscillating Self-Gravitating Real Scalar Field Solitons," *Physical Review D* **70**, 023002 (2004), arXiv:gr-qc/0310006.
11. G. Fodor, P. Forgács, and M. Mezei, "Mass Loss and Longevity of Gravitationally Bound Oscillating Scalar Lumps (Oscillatons) in D Dimensions," *Physical Review D* **81**, 064029 (2010), arXiv:0912.5351.

Appendix AH — Compactification Exact-Charge and World-Tube Binding Stop Gate

Frozen-consolidation record. Source file `STF_V9_0_Compactification_Exact_Charge_and_World_Tube_Binding_Stop_Gate_V1_0.md` *, SHA-256* `93633e12578c8153b890186947087296 87f56306e830587e7c83312e6395a19c` *. The scientific body is carried in full; Markdown heading levels are adjusted for nesting and missing-backslash LaTeX quad transport defects are repaired in the consolidated rendering. Section numbers below are local to this appendix.*

Scope. This record executes the bounded decision announced by the Microscopic-Current Identifiability Gate. It tests whether the frozen STF compactification supplies an exact complex or axionic charge together with a derived coupling to the varied world-tube scalar $B_{\rm wt}$. The agreed stop rule is applied before any enlarged Dirac or Floquet calculation: if the parent does not derive both ingredients with fixed coefficients, no downstream simulation is allowed to manufacture them.

Baseline rule. Physics is graded against the frozen v8.1 publication and calculation baselines and the repaired v8.2 gravitational architecture. The v9.0 manuscript is used only as the audit ledger. No version-9 proposal is imported as a premise.

Executive result

The parameter-free frozen-compactification route **fails at this gate**.

The failure has four independent parts.

1. The displayed ten-dimensional parent is a block-diagonal, metric-only reduction. It produces $g_{\mu\nu}$ and one real breathing mode σ; it does not contain the higher-form field whose reduction would produce an axion. Writing $T=\tau+i\vartheta$ is a possible supersymmetric completion, not a field derived by the displayed metric ansatz.

2. Even if that completion is supplied, the Kähler metric

$$K=-3\ln(T+\bar{T}),\qquad T=\tau+i\vartheta,$$

gives a shift coordinate ϑ, not an $O(2)$ rotation of the real STF oscillator. The corrected relation $\tau=e^{4\sigma}$ reproduces the canonical breathing normalization, but does not create a charged complex plane.

3. Promoting the real STF scalar to

$$\Psi=\frac{\phi+i\chi}{\sqrt{2}}$$

does not preserve an exact $U(1)$ while retaining the frozen linear activation $\kappa\phi\mathcal{S}$, where $\mathcal{S}=D_U\mathcal{R}_{\rm STF}$ or its compact post-memory representative. With the stated current convention,

$$\boxed{\nabla_\mu j^\mu=-\kappa\chi\mathcal{S}.}$$

The activation itself breaks the desired charge.

4. The world-tube window

$$W(B_{\rm wt}) = B_{\rm wt}^2(3-2B_{\rm wt})$$

is neither the ten-dimensional Kalb–Ramond two-form nor a periodic axion. It obeys $W(0)=0$ and $W(1)=1$, so identifying $B_{\rm wt}$ with an axion angle violates large-shift periodicity. No frozen compactification calculation produces the required invariant binding vertex

$$g_B W(B_{\rm wt})|\Psi|^2.$$

The type-IIB/KKLT escape does not repair the result. A one-modulus KKLT superpotential,

$$W_{\rm KKLT} = W_0 + Ae^{-aT},$$

generates

$$V(\tau,\vartheta) = \frac{aAe^{-a\tau}}{6\tau^2}\left[Ae^{-a\tau}(a\tau+3) + 3W_0\cos(a\vartheta)\right],$$

and therefore breaks the continuous shift to a discrete periodicity whenever $AW_0 \neq 0$. Moreover, the selected CICY #7447/$\mathbb{Z}_{10}$ corpus is a heterotic $SU(4)$-monad construction, not the required type-IIB orientifold; the audited ambient O3/O7 realization fails its holomorphic-form parity gate.

An exact charged completion can still be written as a new EFT, but it costs at least: a new real field, replacement of the linear STF activation by an invariant operator, a new vacuum/normalization if the linear response is to be recovered, a coefficient-complete V_B, and a new binding coefficient g_B. Gauging the charge adds a vector, gauge coupling, charge spectrum, and new constraints. This is not a repair within frozen STF.

Accordingly, the agreed stop rule fires:

$$\boxed{\begin{aligned}&\text{Existing compactification} \;\Rightarrow\; \text{exact charged material bridge: FAIL,}\\ &\text{Existing compactification} \;\Rightarrow\; \text{derived } B_{\rm wt} \text{ binding: FAIL.}\end{aligned}}$$

No enlarged Dirac rank, Ward identity, or Floquet spectrum is computed, because there is no coefficient-complete enlarged parent to evaluate. G1, G2, G3, G5, and ledger items 24–26 and 29 remain open. No established formula is withdrawn.

$$\boxed{\text{Grade unchanged: coherent gravitational candidate, not a completed gravity theory.}}$$

I. Source control and binary acceptance rule

I.A Frozen and inherited records

RECORD	ROLE
`STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md`	publication baseline
`STF_First_Principles_Paper_V8_1_fixed(1).md`	calculation baseline
`STF_First_Principles_Paper_V8_2_Gravitational_Candidate_FINAL_2026-08-28.md`	repaired gravitational architecture

RECORD	ROLE
`STF_First_Principles_Paper_V9_0_2026-08-28.md`	frozen audit ledger only
`STF_V8_1_Covariant_Clock_World_Tube_Gaussian_Bath_and_Ward_Completion_V1_0.md`	varied world-tube parent
`STF_V9_0_Microscopic_Current_Identifiability_and_Real_Scalar_Floquet_Gate_V1_0.md`	immediately preceding identifiability gate
`STF_Carrier_Dynamics_and_2pi_Derivation_Attempt_V1_0_1.md`	prior complex modulus calculation
`STF_CICY7447_to_D3_Translation_Feasibility_Audit_V1_0.md`	compactificat branch audit
`STF_CICY7447_Z10_O3O7_Equivariance_Obstruction_V1_0.md`	exact IIB-orientifold obstruction

The v8.1 baseline already carries the corrected $\tau = e^{4\sigma}$ convention. This record does not revive the earlier $e^{2\sigma}$ normalization.

I.B Pass conditions

The existing compactification route passes only if one and the same frozen UV construction derives all of the following:

1. an independent second scalar component or axion;
2. an exact non-anomalous localized charge in the full activated parent;
3. the normalization of that charge;
4. a coefficient-complete B_{wt} potential with stable finite support;
5. a symmetry-compatible binding vertex between the charge carrier and B_{wt}; and
6. all coefficients without fitting the desired radius, lifetime, or production threshold.

Failure of either the exact-charge condition or the binding condition stops the calculation before downstream constraint and stability work.

II. What the displayed ten-dimensional reduction actually contains

II.A Metric field content

The frozen reduction begins with

$$ds_{10}^2 = e^{-6\sigma(x)} g_{\mu\nu}(x) dx^\mu dx^\nu + e^{2\sigma(x)} \hat{g}_{mn}(y) dy^m dy^n, \qquad G_{\mu m} = 0.$$

This ansatz varies the four-dimensional metric and one overall internal-volume coordinate. Its massless metric sector is

$$\{g_{\mu\nu}, \sigma\}.$$

The block-diagonal condition removes Kaluza–Klein vectors. A pseudoscalar axion would descend from a higher-form field, such as the NS two-form or an RR form, not from the metric breathing coordinate. No such higher-form field appears in the displayed ten-dimensional parent.

> **Metric-Only Axion Non-Production Theorem.** A truncation whose only ten-dimensional field is the block-diagonal metric and whose internal deformation is one real scale factor cannot produce an independent four-dimensional pseudoscalar. A claimed axion requires adding a higher-form sector or other independent ten-dimensional field.

This is a field-content statement, not an assertion that string compactifications never contain axions. Full type-IIB orientifold reductions do contain complex Kähler variables and axionic partners. They contain them because their UV parent includes the required form fields and orientifold data.

II.B The CICY modules do not automatically supply the missing parent

The selected CICY #7447/$\mathbb{Z}_{10}$ flavour construction is heterotic and uses an $SU(4)$ monad bundle. Its bundle cohomology and quotient data do not make it a type-IIB O3/O7 compactification. The prior translation audit found no automatic heterotic-to-D3 charge-lattice map. The subsequent exact equivariance audit sharpened the selected ambient O3/O7 attempt to a failure: every compatible nondegenerate quotient branch preserves the holomorphic three-form rather than having the O3/O7 sign.

Thus three objects must not be merged:

$$\text{metric EGB reduction} \neq \text{heterotic monad model} \neq \text{type-IIB orientifold/KKLT parent}.$$

Any one could motivate a future completion, but the frozen corpus has not built one UV action containing all three sets of fields and couplings.

III. The complex Kähler-modulus route

III.A Corrected kinetic normalization

Assume, as an added four-dimensional supergravity completion,

$$T = \tau + i\vartheta, \qquad K = -3\ln(T+\bar{T}).$$

Then

$$K_{T\bar{T}} = \frac{3}{(T+\bar{T})^2} = \frac{3}{4\tau^2},$$

and

$$\mathcal{L}_{\rm kin} = -\frac{3M_{\rm Pl}^2}{4\tau^2}\left[(\nabla\tau)^2 + (\nabla\vartheta)^2\right].$$

Using the corrected frozen relation

$$\tau = e^{4\sigma}$$

gives

$$\mathcal{L}_{\sigma,\text{kin}} = -12M_{\text{Pl}}^2(\nabla\sigma)^2 = -\frac{1}{2}\left[\nabla(\sqrt{24}M_{\text{Pl}}\sigma)\right]^2,$$

exactly matching the real breathing-mode normalization. The normalization problem identified in the earlier carrier attempt has therefore been repaired in the frozen baseline.

III.B Shift coordinate is not oscillator angle

The field-space metric is conformally flat,

$$ds^2_{\text{field}} = \frac{3M_{\text{Pl}}^2}{2\tau^2}(d\tau^2 + d\vartheta^2).$$

It is invariant under $\vartheta \mapsto \vartheta + c$ when the potential is independent of ϑ. It is not invariant under ordinary rotations mixing τ and ϑ, because the conformal factor depends on τ. Therefore $T = \tau + i\vartheta$ does not imply the flat complex-scalar symmetry

$$\Psi \mapsto e^{i\alpha}\Psi.$$

The possible current is the axionic shift current. With

$$F(\tau) = \frac{3M_{\text{Pl}}^2}{2\tau^2}, \qquad \mathcal{L}_\vartheta = -\frac{1}{2}F(\tau)(\nabla\vartheta)^2 - V(\tau,\vartheta),$$

choose

$$j^\mu_\vartheta = -F(\tau)\nabla^\mu\vartheta.$$

The field equation gives

$$\boxed{\nabla_\mu j^\mu_\vartheta = -\partial_\vartheta V.}$$

It is exactly conserved only if the full potential and every interaction are shift independent.

III.C Radial-only stabilization is incomplete, while KKLT breaks the shift

The STF carrier calculation records a displayed stabilization ansatz depending only on σ. If an axion is appended while keeping that ansatz, the axion is a massless shift direction. The ansatz supplies neither an axion mass equal to m_s nor a rotating solution with $\dot{\vartheta} = m_s$. It also supplies no B_{wt} binding.

A standard type-IIB nonperturbative completion instead takes

$$W = W_0 + Ae^{-aT}.$$

With the no-scale Kähler potential above, the F-term potential reduces to

$$\boxed{V(\tau,\vartheta) = \frac{aAe^{-a\tau}}{6\tau^2}\left[Ae^{-a\tau}(a\tau+3) + 3W_0\cos(a\vartheta)\right].}$$

Therefore

$$\partial_\vartheta V = -\frac{a^2AW_0e^{-a\tau}}{2\tau^2}\sin(a\vartheta),$$

which is generically nonzero. The nonperturbative term stabilizes the axion by breaking its continuous shift to the discrete periodicity $\vartheta \mapsto \vartheta + 2\pi/a$. The two desired properties cannot be claimed simultaneously from this one-modulus model:

$$\text{exact continuous charge} \quad \text{and} \quad \text{nonperturbative axion stabilization.}$$

An aligned multi-axion or gauged construction could change the conclusion, but that is a new compactification with additional fields, charges, instantons, and coefficients.

IV. Exact charge versus the frozen STF activation

IV.A Minimal two-component promotion

To test the most favorable possible embedding, introduce one new real field χ and set

$$\Psi = \frac{\phi + i\chi}{\sqrt{2}}.$$

Let

$$\mathcal{L}_0 = -\frac{1}{2}(\nabla\phi)^2 - \frac{1}{2}(\nabla\chi)^2 - \frac{1}{2}m_s^2(\phi^2 + \chi^2).$$

This sector is invariant under

$$\delta\phi = -\epsilon\chi, \qquad \delta\chi = +\epsilon\phi.$$

Using the current convention

$$j^\mu = \chi\nabla^\mu\phi - \phi\nabla^\mu\chi,$$

$\mathcal{L}_0$ gives $\nabla_\mu j^\mu = 0$.

IV.B The linear activation breaks the charge

Retain the frozen interaction in schematic notation,

$$\mathcal{L}_{\mathrm{act}} = \kappa\phi\mathcal{S}, \qquad \mathcal{S} = D_U\mathcal{R}_{\mathrm{STF}}$$

or the coefficient-matched compact readout that reduces to it in the relevant regime. Under the rotation,

$$\delta\mathcal{L}_{\mathrm{act}} = -\epsilon\kappa\chi\mathcal{S}.$$

The two field equations imply

$$\boxed{\nabla_\mu j^\mu = -\kappa\chi\mathcal{S}.}$$

This is a classical breaking already present before anomalies or quantum-gravity effects are discussed.

> **Linear-Activation Charge Obstruction.** Adding an imaginary partner to the real STF scalar does not produce an exact $U(1)$ charge while the frozen interaction remains linear in the original real component. Exact charge and byte-faithful retention of that activation cannot both hold.

IV.C The invariant replacement is a new theory

A symmetry-preserving interaction could be

$$\mathcal{L}_{\mathrm{act}}^{U(1)} = \kappa_2|\Psi|^2\mathcal{S} = \frac{\kappa_2}{2}(\phi^2 + \chi^2)\mathcal{S}.$$

Its variation vanishes. But it is quadratic, has a different mass dimension and harmonic selection, and is not the frozen v8.1 operator. Recovering an apparently linear radial response requires a symmetry-breaking background,

$$\Psi = \frac{v+\rho}{\sqrt{2}} e^{i\theta},$$

for which

$$\kappa_2 |\Psi|^2 \mathcal{S} = \frac{\kappa_2 v^2}{2}\mathcal{S} + \kappa_2 v \rho \mathcal{S} + \frac{\kappa_2}{2}\rho^2 \mathcal{S}.$$

Matching the frozen linear coefficient requires

$$\kappa = \kappa_2 v.$$

This introduces a vacuum scale v, a new coefficient κ_2, a constant background source term, a radial potential selecting v, and a Goldstone mode. Gauging the symmetry removes the physical Goldstone only by adding a gauge field, gauge coupling, charge spectrum, Gauss constraint, and anomaly/completeness obligations.

Thus the exact-charge repair is not a notational completion. It replaces the activation sector and changes the degree-of-freedom and constraint audits.

V. Why the world-tube field cannot be borrowed from the axion

V.A Three distinct objects called “B”

The following must be kept separate:

1. the ten-dimensional Kalb–Ramond two-form $B^{(2)}_{MN}$;
2. a four-dimensional axion $b(x) = \int_{\Sigma_2} B^{(2)}$; and
3. the v8.2 material/apparatus scalar $B_{\rm wt}(x)$ used to window the compact readout.

The world-tube field has the canonical action

$$S_{B_{\rm wt}} = -\int d^4x \sqrt{-g}\left[\frac{Z_B}{2}(\nabla B_{\rm wt})^2 + V_B(B_{\rm wt})\right]$$

and the interpolation

$$W(B_{\rm wt}) = B_{\rm wt}^2(3-2B_{\rm wt}), \qquad 0 \le B_{\rm wt} \le 1.$$

Its source paper explicitly leaves a stable finite-radius solution of V_B unproved.

V.B Periodicity obstruction

If $B_{\rm wt}$ were an axion normalized so that a large shift is $B_{\rm wt} \mapsto B_{\rm wt}+1$, every local function in the action would have to respect that identification, up to allowed topological terms. But

$$W(0) = 0, \qquad W(1) = 1,$$

and generally

$$W(B+1) - W(B) = 1 - 6B^2 \neq 0.$$

Therefore the frozen window is not a well-defined function on the axion circle. Periodicizing it would alter the endpoint values or introduce a new function and new harmonics. Identifying the fields is not available.

V.C Missing binding vertex

The previous support calculation requires a static invariant such as

$$\mathcal{L}_{\text{bind}} = g_B W(B_{\text{wt}})|\Psi|^2.$$

This coupling respects a complex-scalar $U(1)$ because it depends on $|\Psi|^2$. Nothing in the metric reduction, the heterotic monad data, the CICY quotient intersection number, or the failed O3/O7 branch fixes g_B or produces this operator. Nor does the zero-mode-subtracted environment help: $K_{\text{sel}}^R(0) = 0$ removes a static response rather than generating binding.

The binding condition therefore fails independently of the exact-charge condition.

VI. Minimum cost ledger for continuing as a new theory

The smallest coherent extension has the following obligations.

NEW INGREDIENT	WHY REQUIRED	FROZEN DERIVATION
second real field χ or explicit form-field axion	make a charge coordinate possible	absent from metric-only parent
exact symmetry choice	global shift, global $U(1)$, or gauged $U(1)$	not selected
invariant activation $\kappa_2|\Psi|^2\mathcal{S}$	prevent the frozen linear operator from violating charge	replaces v8.1 operator
vacuum scale v and radial potential, if linear response is recovered	obtain $\kappa = \kappa_2 v$	new data
coefficient-complete $V_B(B_{\text{wt}})$	produce a finite wall and tension	open
binding coefficient g_B	localize charge inside the wall	absent
gauge field and charge spectrum, if gauged	make exact charge compatible with a UV gauge symmetry	optional but adds modes and constraints
visible polarization/current vertex	pass G5	absent

This is a lower-bound ledger. It does not count every counterterm, boundary term, or environment overlap that the new fields would generate.

VI.A Why no enlarged rank is quoted

The field content depends on the unresolved symmetry choice:

- a global complex scalar adds one real configuration variable per leg;
- a gauged scalar adds a vector, gauge redundancy, Gauss constraint, and possibly Higgsed degrees of freedom;

- an axion from a higher form inherits gauge identifications and topological couplings; and
- changing the activation to $|\Psi|^2\mathcal{S}$ changes its Hessian and constraint mixing.

There is consequently no unique enlarged Dirac matrix. Quoting a revised $59/118$, $60/120$, or any other total before selecting the parent would repeat the rank error already rejected in the post-v9.0 Stueckelberg audit.

VI.B Why no Floquet spectrum is quoted

The periodic background depends on $V(|\Psi|^2)$, V_B, g_B, the choice of global or gauged charge, and the invariant activation. Until those are fixed, the coefficient matrix $\mathbb{A}(t)$ and its constraint projector are undefined. The Floquet acceptance criterion from the preceding gate remains correct; it is not numerically executable for a nonexistent parent.

VII. Gate and ledger consequences

GATE OR ITEM	CONSEQUENCE	STATUS
G1 — gravitational/Dirac completion	no derived enlarged parent; no new rank claim	open, unchanged
G2 — environment realization	no compactification-derived material support or normalized overlaps	open
G3 — quantum zero-static protection	invariant quadratic activation and g_B would create a new counterterm problem	open and priced
G4 — emission	no change to the existing direct-local and analytic-parent audit	unchanged
G5 — production	no visible charged or polarization current follows from the modulus	open
items 24–26	production surface, visible vertex, and threshold ratio remain underived	open
item 29	finite tube has conditional external support constructions but no frozen microscopic completion	open, narrowed previously

The total diffeomorphism Ward identity of the varied frozen parent is not altered by this negative branch result. An exact new internal-current identity is not added because the exact symmetry is not present. The $58/116$ number remains only the previously reported structural subtotal; it is neither upgraded nor recomputed.

VII.A Supersession and withdrawal ledger

No established formula is superseded. The following earlier statements remain unchanged:

- the isolated canonical B_{wt} tube fails under the stated Derrick assumptions;
- an externally added Brown current can stabilize a thin-wall subclass;

- the real scalar provides a conditional nonrelativistic quantum-pressure radius if a binding vertex is added; and
- the exact real-scalar stability problem is Floquet.

The only branch closure is the proposal that the **existing frozen compactification** might automatically supply the missing exact complex sector and B_{wt} coupling. It does not. This is a resolved construction fork, not a withdrawal of an established STF result.

VIII. Decision and research boundary

The agreed stop condition is met twice: the exact charged field is not derived, and the B_{wt} binding is not derived. Downstream computation cannot cure either missing term.

The scientifically disciplined outcome is therefore:

$$\boxed{\text{Stop the parameter-free gravitational-completion push at the frozen compactification boundary.}}$$

This does **not** mean that all STF research must stop. It separates two future programs:

1. **Frozen STF programme.** Consolidate and test the coherent gravitational candidate exactly at its present grade. Do not claim a completed theory.
2. **New-theory programme.** Choose an explicit heterotic higher-form or type-IIB orientifold parent, derive its axions and charges, replace the activation by a symmetry-compatible operator, and derive V_B and g_B. Version and grade it as a new branch, not as a parameter-free consequence of v8.1/v8.2.

The second programme can be worthwhile, but it abandons the premise tested here. It should begin only by an explicit choice to change the theory.

$$\boxed{\text{STF remains a coherent gravitational candidate, not a completed gravity theory.}}$$

IX. Reproducibility summary

The companion NumPy checker verifies:

- all locally available frozen-record hashes;
- the corrected $\tau = e^{4\sigma}$ canonical normalization;
- the Kähler shift metric and its failure to possess flat $O(2)$ rotations;
- the KKLT potential against the full supergravity expression at multiple points;
- its axion derivative and discrete periodicity;
- the nonconservation of the complex current under the frozen linear activation;
- exact invariance of the quadratic replacement;
- the symmetry-breaking-background coefficient matching;
- the nonperiodicity of the world-tube window;
- the compactification branch acceptance matrix; and

- every scope, grade, open-gate, no-rank, and zero-withdrawal statement in this paper.

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Appendix E′ — Master Claim and Dependency Matrix

CLAIM	DEPENDS ON	DOES NOT ESTABLISH	GRADE
two clocks	periodic amplitude plus scalar universal ordering	carrier dynamics	theorem
q_N selection	N^μ, Weyl superenergy	full parent projection	derived/open
direct local metric action	nonlinear curvature norm	framework-wide no-go	closed generically

CLAIM	DEPENDS ON	DOES NOT ESTABLISH	GRADE
Q_Δ	compact alignment, $\Delta > 0$	origin of Δ	theorem/open
rank $44/88$	invertible J	full gravitational rank	theorem
exact memory	first-order retained pair	microscopic bath	derived
rank $58/116$	jet weak-coupling bound	lapse/shift/secondary algebra	conditional
CMC two-tensor count	augmented Jacobi invertibility, Ward closure	global foliation	conditional pass
SK architecture	doubled covariance, $N \succeq 0$	contact matching	pass/open
Drude bath	selected positive spectral parent	unique UV environment	existence pass
$H^{\mathrm{cap}} = M_*^2 J^{-1}$	compact geometry	QQ propagator	theorem
$\chi_{QQ}^{\mathrm{aux}} = 0$	fixed base source variation	full physical correlator	theorem
r	one independent bath diagonal	derivation from alignment	open
Peters hierarchy	GR plus declared temporal anchors	threshold selection	calculation
54-yr anchor	closure profile plus τ_-	derivation of τ_-	conditional
m_s	3.32-yr phase	production mechanism	derived conditional
flyby capacity	rotating observation carrier	unit utilization	theorem/open
scalar–GB c_T	regime-limited parent	completed-parent tensor cone	calculation
full gravity completion	all acceptance gates	—	open

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