

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: what is proved, what is derived, what is conditional, and what is open

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ARCHIVE NOTICE — 29 August 2026. This is Version 9.0 (28 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 It is superseded by [the current edition of First Principles](#), whose version history lists all editions.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. V9.0 carries the repaired v8.2 revision byte-intact plus the five-gate audit layer (§X, Appendices W–AA).

The Two-Clock Theory and Its Conditional Gravitational Completion

Version 9.0 — 28 August 2026

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Version record. Version 9.0 = the repaired v8.2 release (SHA-256

2cd54dae8fdb2ab1eb6372029459ac76583e936b88c8b4f3a4fcfff6808f6c0 , 28 August 2026) with the five-gate audit layer integrated additively: §X, Appendices W–AA, ledger items 33–37 and annotations to items 15, 16, 24–26, the §V.G acceptance gates, and the audit-layer reference block. Beyond that layer, the carried v8.2 content is modified only by a version-identity voice pass (four sentences renaming the document's self-references from v8.2 to v9.0) and one dated conclusion note — every change is listed in the integration map, and no physics statement is touched. Version 8.2 supersedes [v8.1](#) (frozen baseline, 26 August 2026); version 9.0 supersedes v8.2. A distinct earlier draft also bearing the label “V9.0”, produced by a separate session and architecturally departing from the STF primary construction, was excluded from the entire v8.2 derivation and audit program (ledger item 29) and is not this document and not part of its lineage; it remains quarantined in the project record. The five gates were frozen against the pre-repair v8.2 manuscript; the repair restored appendices and corpus wording without altering the audited physics (repair review record, deviations D1–D7). **[version record; 28 August 2026]**

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

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

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 $\mathbb{R} \rightarrow S^1$; that is a completion, not the theorem. **[theorem/entailment; corpus provenance restored]**

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

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

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 $\tau_- = 0.1$ 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, $\langle T \rangle = 3.31$ yr, and the direct timing, 3.32 ± 0.89 yr, converge on the same central value, with $m_s = h/(c^2 T) = 3.94 \times 10^{-23}$ eV/ c^2 . **[calculation/conditional convergence; reproduced]**

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 $\nabla \times (\omega \times \mathbf{r}) = 2\omega$; 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; reproduced]**

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

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

followed by exact first-order memory

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

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:

$$H_{AB}^{\text{cap}} = M_*^2 J_{AB}^{-1} \neq \Gamma_{QQ}, \quad \chi_{QQ}^{\text{aux}} = 0$$

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:

STF v9.0 is a coherent gravitational candidate, not acompleted 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

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, $\rho_{QQ}^D(\Omega) = (g_Q^2/\pi) \Omega \omega_c/(\Omega^2 + \omega_c^2)$, 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. **[audit layer; additive; 28 August 2026]**

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. **[historical provenance/corpus dependency; restored]**

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. **[dependency rule; restored and retained]**

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 with corpus provenance; restored]**

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, $\mathbb{R} \rightarrow S^1$, 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 $T_U \rightarrow f(T_U)$. 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; reproduced]**

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

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

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 $\nabla \times (\omega \times \mathbf{r}) = 2\omega$. 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,

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

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

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

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

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

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

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

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

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

The alignment equation

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

has the unique solution

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

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,

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

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

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

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

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; reproduced]**

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; reproduced]

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; reproduced]**

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 $\text{Re } T = e^{4\sigma}$, the Kähler normalization gives the canonical field $\phi_c = \sqrt{24}M_{\text{Pl}}\sigma$. The compactification scale used in the existing calculation is $L_* = 3.64 \times 10^{-30} \text{ m}$, with $M_* = L_*^{-1}$.

The saturated low-frequency response coefficient is

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

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
$q_N^2 = R^2 + 8\mathcal{W}_N$	intended positive clock-relative curvature state	derived selection; parent projection open
Q_Δ	smooth bounded readout	theorem for $\Delta > 0$; regulator origin open

OBJECT	ROLE	V8.2 STATUS
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 $A(k)$, 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

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

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 ,

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

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:

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

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

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

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

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

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

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

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

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

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,

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

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

The tangent response is

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

and

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

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

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

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

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

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 $R \oplus E_{ij}^{\text{TF}}$ 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

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

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

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

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

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

A sufficient constant-rank condition is

$$\boxed{|\epsilon_{\text{STF}}| \|\mathbf{A}(k)\|_2 < 1}$$

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

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

The combined one-leg structural rank is therefore

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

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

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

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

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

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

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

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

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

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,

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

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,

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

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

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

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

$$\Sigma_{ij}^R = g_i g_j K_{\text{sel}}^R, \quad N_{ij} = g_i g_j N_D \succeq 0.$$

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

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

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

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

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

$$\det J_x^R = \det J_0 [1 + \alpha K_{\text{sel}}^R \ell^T J_0^{-1} \ell], \quad \alpha \geq 0,$$

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 $j_Q Q_{\text{aux}}$ leaves $p^*(\mathcal{C})$ unchanged and shifts only a multiplier. At fixed base geometry,

$$W_{\text{aux}}[j_Q] = \int j_Q Q_{\Delta}, \quad \boxed{\chi_{QQ}^{\text{aux}} = \frac{\delta^2 W_{\text{aux}}}{\delta j_Q \delta j_Q} = 0.}$$

The physical tree response is instead composite,

$$\chi_{QQ}^{R,\text{tree}} = L_a G_{\text{grav}+\text{CMC}}^{R,ab} L_b,$$

plus contact and environmental terms. Since $[H^{\text{cap}}] = 0$, $[\Gamma_{QQ}] = -4$, 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 $|\hat{\gamma}_{\times}| = 1.6295 \times 10^{30}$, 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

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

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 $\tau_- = 0.1 \text{ yr}$; Peters translated them into separations. The central period gives

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

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

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

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

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	$3.94 \times 10^{-23} \text{ eV}/c^2$	phase conversion from T_s
ζ/Λ	$1.35 \times 10^{11} \text{ m}^2$	conditional parent/matching datum
L_*	$3.64 \times 10^{-30} \text{ m}$	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
ω_c	memory bandwidth	matched near the internal scale; UV derivation open
44/88	readout/alignment ranks	theorem for $\Delta > 0$

QUANTITY	VALUE OR DEFINITION	STATUS
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
$A(k), \delta\mathbb{J}$	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 $\det J_{\text{jet}} = 0$; 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. **[dependency rule; restored and extended without status change]**

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 $(\zeta/\Lambda)_{\text{SI}}$ 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 $\hat{B}$ by the Anderson match, because it is

an identity rather than a prediction; the Ulysses ephemeris discrepancy read as a direct 955.6 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 $10^{-20}\text{--}10^{-14}\text{ rad}$, 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; v8.1 wording restored]**

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. **[gravitational revision; retained]**

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 χQQ	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
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 $\lambda_{\text{res}} \simeq 2.04$ pc. Hubble damping requires a suppression $\eta_{\text{cos}} \lesssim 3.23 \times 10^{-20}$ at the declared benchmark. This closes the unsuppressed realization, not STF. Whether η_{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

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

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; post-v8.1 recalculation]**

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. $\det(I_6 + \epsilon_{\text{STF}} \mathbf{A}) = 0$ 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 $|\delta c_T|_{\text{envelope}} \simeq 3.6 \times 10^{-30}$ and its cross-messenger residual at $z = 1$ is $|\mathcal{R}_{2C}| \sim 2.6 \times 10^{-37} \text{ s}^{-1}$. “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. **[falsification scope; judgment recorded]**

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

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

- 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). **[acceptance gates; added in v9.0]**

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

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

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; Floquet gate retained]**

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; non-supersession judgment]**

Ultralight scalar and galactic sector. The mass $m_s \simeq 3.94 \times 10^{-23}$ 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; condensate sector retained]**

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; restored]**

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 $V_{\text{local}} = (c\tau_c)^3 = (2\pi)^3\bar{\lambda}_C^3$ 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; corrected arithmetic restored]**

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; non-supersession judgment]**

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; V7.9 Appendix J pointer restored]**

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. **[delegated record; exact V7.9 sector pointers restored]**

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; retained]**

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; restored]**

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 $\Gamma_{\text{UHECR}}(\tau)$ or $\Gamma_{\text{GRB}}(\tau)$. 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; name and content restored]**

The named missing inputs are the covariant production surface Σ_{prod} , self-field treatment, sequestering-consistent visible-sector vertices, the channel-threshold ratio, and the inner boundary $\tau_- = 0.1 \text{ yr}$. 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; restored]**

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. **[companion result; retained]**

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; restored]**

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:

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

The response-matched recalculation gives

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

in the tracking regime and

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

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

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

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; corrected]**

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 $A(k)$
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

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 9.0 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; the regulated curvature apex and the material window obstruct the naive realization, and compatibility of the full action, measure, state, regulator, boundaries, and anomaly structure remains unproved; open, priced (§X.C, Appendix Y);

16. quantum or radiative stability — Gate G3: conditional on the unrealized symmetry and its anomaly freedom; without it, one static $Q_a Q_r$ counterterm per order in the selected channel (two homogeneous, five finite-momentum in the full response); open, priced (§X.C, Appendix Y);
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: remains open; narrowed only to an antisymmetric material-polarization existence-construction class with a structurally conserved production current, while microscopic matching, plasma projection, sequestering compatibility, and pre-merger support remain unproved (§X.E, Appendix AA);
25. the 71-day production-threshold ratio — Gate G5: remains an independently normalized ratio target, $\mathfrak{R}_{\text{ch}} \simeq 2.41 \times 10^3$ (§X.E);
26. the 0.1-yr inner production boundary — Gate G5: wholly unsupplied (§X.E);
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”; the present document reclaims the version number without importing any of that draft’s content (Version record).
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 (Gate G2 eight-condition list, Appendix X §X);
35. a realized, anomaly-free protective translation symmetry of the full parent, or the one-loop c_{QQ} coefficient quantifying the unprotected subtraction cost (Gate G3, Appendix Y §§XII–XIII);
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).

VIII.G Exact next calculation

The immediate scientific frontier is finite:

1. choose covariant world-tube/environment fields X_α ;

2. derive the uneliminated vertex $Q_{\Delta}X_{\alpha}$;
3. compute

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

4. derive its retarded self-energy, conservative subtractions, noise, stress, and window force;
5. test the rank-one equality $\Sigma_{\phi Q}^2 = \Sigma_{\phi\phi}\Sigma_{QQ}$ or the positive-semidefinite inequality for a higher-rank bath;
6. insert the result into the coefficient-complete boundary-CMC Schur complement;
7. run the full primary/secondary Dirac, Ward, positivity, and pole audit.

IX. Conclusion

STF v9.0 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:

coherent gravitational candidate — not a completed gravitytheory.

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. **[v9.0 note: 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.]**

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

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. **[record; additive; 28 August 2026]**

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.i a78576364bc446ee5e6b77e8e3c778ef49e4f17b3a0cb60a4152d72b7ab01ac7
G5 — Merger-production activation and timing gate	STF_V8_2_Merger_Production_Activation_Timing_Surface_and_Visible_Vertex_Gate_V1_0 3571f0b8e1cc22b5d044b00425ecb19d77e47ff6b810ab146b36e9c5302c7d64

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. **[classification; new obligation; grade unchanged]**

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 $S_{QX} = -\sum_s s \int d^4x \sqrt{-g_s} \tilde{Q}_{\Delta,s} \mathcal{F}_{Q,s}$ 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 $\Sigma_{QQ}^R(z) = g_Q^2(-iz)/(\omega_c - iz)$ fixes the positive ideal continuum uniquely through the retarded discontinuity:

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

The warm-horizon environment of the linked decoherence papers supplies, conditionally, an additive Ohmic slope only after a covariant world-tube projection $\mathcal{F}_H = \lambda_H P_A \delta \mathcal{C}_H^A$ 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. **[derivation/theorem; conditional horizon supply; grade unchanged]**

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, $\delta \tilde{Q}_{\Delta,\pm} = \epsilon$, $\delta X_{\alpha,\pm} = \lambda_\alpha \epsilon$, $D_U \epsilon = 0$, yields a 1PI Ward identity forbidding an undifferentiated static $Q_a Q_r$ 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 $X_\alpha - \lambda_\alpha \tilde{Q}_\Delta$ 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. **[sufficient condition identified; blocked in the frozen architecture; open, priced]**

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 $m_{\text{gh}}^2 = M_{\text{Pl}}^2 q_N / (2\kappa|A|)$ 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 resumes 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. **[direct action doubly closed; parent conditionally ghost-free; observational gates open]**

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: $\mathfrak{R}_{\text{ch}} = (3.3 \text{ yr}/71 \text{ d})^{11/4} \simeq 2.41 \times 10^3$ is a requirement on independent canonical matching. Items 24, 25, and 26 remain open as stated. Ledger item 37. **[theorem; post-merger channels closed for pre-merger anchors; item 24 narrowed]**

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. **[context]**

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:

coherent gravitational candidate — not a completed gravitytheory.

*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.

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 , $M = m_1 + m_2$, $\mu = m_1 m_2 / M$, the Peters time to merger from separation a is $t_{\text{merge}}(a) = (5/256) c^5 a^4 / (G^3 \mu M^2)$. **[standard]**

A.2 Direct evaluation, 30+30 M_⊙. $R_{\text{S}} = 2GM/c^2 = 1.772 \times 10^5 \text{ m}$. $t(1466 R_{\text{S}}) = 54.07 \text{ yr}$; $t(730 R_{\text{S}}) = 3.324 \text{ yr}$; $t(360 R_{\text{S}}) = 71.82 \text{ d}$. **[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: $54/3.3 = 16.36$; $3.3 \text{ yr}/71 \text{ d} = 16.98$. 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 $\rightarrow$ {3.3 yr, 71 d}; STF Lagrangian $\rightarrow$ 54 yr (via the closure theorem, A.6); Peters = the common translator. Using the Lagrangian-forced 54-yr anchor at $\approx 1466 R_{\text{S}}$: $a(3.3 \text{ yr}) = 1466(3.3/54)^{1/4} = 728.9 R_{\text{S}}$ and $a(71 \text{ d}) = 1466((71/365.25)/54)^{1/4} = 359.1 R_{\text{S}}$ — 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 , $\sqrt{K} = \sqrt{48 GM/(c^2 r^3)} = 2.8 \times 10^{-19} \text{ m}^{-2}$, Peters $\dot{r} = 0.31 \text{ m/s}$, and $\mathcal{Q}_{GR} \approx 3\sqrt{K} \dot{r} \approx 2 \times 10^{-27} \text{ m}^{-2}\text{s}^{-1}$ — the scale V7.9 quoted as $\mathcal{Q}_{crit}$ (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 $\sqrt{K}_{ext} = 1.42 \times 10^{-19} \text{ m}^{-2}$ and $\mathcal{Q}_{ext} = 1.01 \times 10^{-27} \text{ m}^{-2}\text{s}^{-1}$. 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 $n = 11/8$, $\bar{\tau}_I = 3.31 \text{ yr}$, $\tau_- = 0.1 \text{ yr}$: **$\tau_+ = 53.8804 \text{ yr} \approx 54 \text{ yr}$** (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.* $\tau_- = 0.1 \text{ yr}$ entered silently: the published Test-40a table's uniform-profile entry is $(0.1+54)/2 = 27.05 \text{ yr}$, exactly the reported value, which reconstructs the boundary. The result is highly sensitive to it: $\tau_- = 0.05 \rightarrow \tau_+ = 85.10 \text{ yr}$; $0.1 \rightarrow 53.88$; $0.2 \rightarrow 33.48$; $0.5 \rightarrow 17.12$. **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,

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

For $30 + 30M_\odot$, $R_S = 1.772 \times 10^5 \text{ m}$, and direct evaluation gives 54.07 yr, 3.324 yr, and 71.82 d at $1466R_S$, $730R_S$, and $360R_S$. 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 $53.88 \simeq 54 \text{ yr}$ conditional on $\tau_- = 0.1 \text{ yr}$; 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 $730R_S$, a one-hole curvature proxy gives $q \sim 2.8 \times 10^{-19} \text{ m}^{-2}$ and $|Dq| \sim 2 \times 10^{-27} \text{ m}^{-2}\text{s}^{-1}$. 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 $1085R_S$ 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 $n^\mu q_\mu = s\nabla^\mu q_\mu / \sqrt{(-\nabla q \cdot \nabla q)}$, $s = \pm 1$. 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 $\varphi = A \cos \Theta_I$: $n^\mu \varphi_\mu$ 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 $-a^3\gamma\varphi \operatorname{sgn}(\dot{\varphi})\dot{R}$, non-differentiable at turning points; varying it produces $\delta(\varphi)$ terms. [reproduced] V7.9’s use of $n^\mu \varphi_\mu$ 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 $\Theta_I \simeq m_{ST}T_U + \delta \pmod{2\pi}$ 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 $\mathbb{R} \rightarrow S^1$, $T_U \mapsto e^{im_{ST}T_U}$. 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. $d\varphi/dT_U = -Am_s \sin \Theta_I = 0$ 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 $\dot{\varphi}^2 + (v_\varphi/m_s)^2 = A^2$ and $\Theta_I = \operatorname{atan2}(-v_\varphi/(Am_s), \varphi/A)$ 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. $\operatorname{atan2}$ gives an S^1 phase; the $\mathbb{R}$ lift is B.3. [reproduced]

B.5 Clock-Rate Invisibility (lemma). $T_U \rightarrow f(T_U)$, $f' > 0$: $\nabla f = f'\nabla T_U$, 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 $J_O = dT_U/dt_O$. [reproduced]

B.5b Spatial Clock-Gradient Invariance (theorem). The refinement the invisibility lemma admits: although the absolute relative rate $J_C = dT_U/dt_C$ 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 $h_\mu{}^\nu N_\nu = 0$: $D^\mu \perp_\mu \ln J_C \equiv h_\mu{}^\nu \nabla_\nu \ln J_C$ 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, $\alpha^{\wedge}\{(C)\}_{\mu} = c^2 D^{\wedge} \perp_{\mu} \ln J_{\text{C}}$, whose c^2 is the lapse $\leftrightarrow$ potential normalization ($J_{\text{C}} \approx 1 - \Phi/c^2 \Rightarrow c^2 \nabla \ln J_{\text{C}} \approx -\nabla \Phi$), 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 $4\pi^2$ firewall. $\mathcal{O}_{\text{crit}}$'s $4\pi^2$ is the cup product of the retarded and advanced Green-function sectors on the Hopf torus, $\int_{\{T^2\}} \omega_R \wedge \omega_A = 4\pi^2$ (Topological Closure V6.3, Heegaard transgression) — not internal $\times$ 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 $([\omega_R/2\pi i] - [\omega_A/(-2\pi i)], [T^2]) = \mathbf{1}$; the raw $4\pi^2$ is that integer expressed in canonical unnormalized angular coordinates ($\int d\theta \wedge d\bar{\theta} = (2\pi)^2$). Canonical once $e^{\wedge}\{i\theta\}$ 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 $n^{\wedge}_{\mu} \varphi$ by $N^{\wedge}_{\mu}$ inside the action changes the Euler–Lagrange equation, $T_{\mu\nu}$, 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 $S_U = \int \sqrt{-g} \lambda_U (\nabla T_U \cdot \nabla T_U + 1)$ enforces $\nabla T_U \cdot \nabla T_U = -1$ and gives $\nabla_{\mu}(\lambda_U N^{\wedge}_{\mu}) = 0$; 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 $N_{\mu} = -\alpha \nabla_{\mu} T_U$ with $\alpha = q^{-1}$, $q = \sqrt{-\nabla T_U \cdot \nabla T_U}$, the flow acceleration is $A^{\wedge}\{(N)\}_{\mu} = D^{\wedge} \perp_{\mu} \ln \alpha$ — not generically zero — but the minimal form's constraint $q = 1$ forces $A^{\wedge}\{(N)\}_{\mu} = 0$, 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 $\theta \propto a^{-3}$, $\rho \propto a^{-6}$, 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 $\mathbb{R} \rightarrow S^1$ 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. $[\varphi] = 1$, $[l_4] = 4$, $[\sqrt{l_4}] = 2$, $[N] = 0$, $[\nabla] = 1$. $\varphi N \cdot \nabla l_4$ has dimension $6 \rightarrow$ coefficient $M^{-2} \checkmark$ for ζ/Λ ; $\varphi N \cdot \nabla \sqrt{l_4}$ has dimension $4 \rightarrow$ coefficient dimensionless. $\gamma \varphi \mathcal{G}$ has dimension $5 \rightarrow [\gamma] = M^{-1}$; retarded

matching $\zeta/\Lambda = \gamma\tau_{\text{eff}}$ has dimension M^{-2} and multiplies $N \cdot \nabla \mathcal{G}$. $g(\mathcal{R}) = 2\mathcal{R}$ gives $2\mathcal{R}N \cdot \nabla \mathcal{R} = N \cdot \nabla I_4$ (chain rule) — Branch B collapses to A. [reproduced] V7.9's boxed action attached ζ/Λ to $N \cdot \nabla I_4$; withdrawn.

C.2 The kernel. V7.9 App. O used the normalized $L_R = \omega_c e^{\{-\omega_{ct}\}\Theta(t)}$, $\int L_R = 1$, whose expansion $(L_R * I) = I - \dot{I}/\omega_c + \dots$ generates a rate only as a correction to a nonzero static response — contradicting $K_R(0) = 0$. Repair: zero-mode subtraction $K^R_{\text{sel}} = \delta(t) - \omega_c e^{\{-\omega_{ct}\}\Theta(t)}$, $\int K = 0$, $(K * I) = \dot{I}/\omega_c - \ddot{I}/\omega_c^2 + \dots$, $\tau_{\text{eff}} = 1/\omega_c$, $C_{\text{match}} = m_s/\omega_c$. Frequency response $K(\omega) = -i\omega/(\omega_c - i\omega) \approx -i\omega/\omega_c$ ($\omega \ll \omega_c$, the rate operator); $O(1)$ at $\omega \sim \omega_c$; $\rightarrow 1$ for $\omega \gg \omega_c$. Since $\omega_c \sim m_s$, 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 $10\times$ radius Branch A is suppressed by $\sim 10^{-3}$ 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 $\Gamma_{\text{STF}} = S_{\text{parent}}[\Phi_+] - S_{\text{parent}}[\Phi_-] + \gamma \int \varphi_a K^R_{\text{sel}}(x, y; \mathfrak{o}_U) \mathcal{J}_r(y) + (i/2) \int \varphi_a N \varphi_a + \dots$, 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:

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

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

$$K_{\text{sel}}^R(t) = \delta(t) - \omega_c e^{-\omega_c t} \Theta(t)$$

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

$$\Gamma = S[+] - S[-] + \int \phi_a K_{\text{sel}}^R Q_r + \frac{i}{2} \int \phi_a N \phi_a + \dots$$

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 $\mathcal{C}^A$, positive clock-relative metric $h_{AB}(N)$, $q_N = \sqrt{(h_{AB} \mathcal{C}^A \mathcal{C}^B)}$ ($[q_N] = L^{-2}$). Response covector P_A .

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

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

D.4 The coefficient. $\kappa = \gamma_{\text{eff}} M^2 = (\zeta/\Lambda) M^2 = (\zeta/\Lambda)/L^{*2} = 1.35 \times 10^{11} \text{ m}^2 / (3.64 \times 10^{-30} \text{ m})^2 = 1.02 \times 10^{70}$, dimensionless — the conversion $\sqrt{7.9}$'s cosmological calculation already used. No new scale. [reproduced]

D.5 Auxiliary-field action. $S_B \supset \int \sqrt{-g} [\kappa \phi N^\mu \mu \nabla_\mu \chi + \lambda(\chi^2 - \mathcal{J}_N)]$; $\delta\lambda \Rightarrow \chi = q_N$; integration by parts shows χ has no kinetic term — zero propagating dof. $\sqrt{7.9}$ used essentially this in vacuum with $\lambda(\chi^2 - \mathcal{G})$; what was missing was why $\chi = \sqrt{\mathcal{G}}$ is the channel variable — capacity saturation supplies it. [reproduced]

D.6 The transverse polarization. Decompose $\mathcal{C}^A = q \mathcal{C}^A$: $D \mathcal{C}^A = \mathcal{C}^A Dq + q D \mathcal{C}^A$. Aligned $P \propto \mathcal{C}$ projects out the angular term (Branch B, radial). A rotating source needs $P_A = M^2(\cos \alpha \mathcal{C}_A + \sin \alpha \mathcal{F}_A)$ with $\mathcal{F}$ tangent to the curvature-state orbit: $P \cdot D \mathcal{C} = M^2[\cos \alpha Dq + \sin \alpha q Q_C]$. Radial polarization $\rightarrow$ Branch B; transverse $\rightarrow$ 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 $N^\mu \mu$. *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 $L^{*-2} \sqrt{\mathcal{J}_N}$. 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. $D_N q_N$ is a curvature-amplitude production rate, not a Lyapunov exponent; the fractional/Lyapunov-like rate is $D_N \ln q_N = D_N q_N / q_N$. [recorded]

Gravitational revision (v8.2). For

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

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

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

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

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 $M_*^2 J^{-1}$ is finite at the apex, where it equals $M_*^2 I/\Delta$. 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 $\mathcal{G}$ is indefinite. With $S_{\mu\nu} = R_{\mu\nu} - \frac{1}{4} R g_{\mu\nu}$, $\mathcal{G} = C^2 - 2S_{\mu\nu} S^{\mu\nu} + R^2/6$ (verified against $\mathcal{G} = R^2_{\mu\nu\rho\sigma} - 4R^2_{\mu\nu} + R^2$ 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 : $\dot{H} = -(3/2)(1+w)H^2$, $R = 3(1-3w)H^2$, $\mathcal{G} = -12(1+3w)H^4$. de Sitter: $R = 12H^2$, $\mathcal{G} = +24H^4$; matter: $3H^2$, $-12H^4$; radiation: 0 , $-24H^4$. $\sqrt{\mathcal{G}}$ is imaginary through matter and radiation domination and cannot reproduce the real $\kappa\phi\dot{R}$. 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. $E_{\mu\nu} = C_{\mu\alpha\nu\beta}N^{\alpha}N^{\beta}$, $B_{\mu\nu} = *C_{\mu\alpha\nu\beta}N^{\alpha}N^{\beta}$; $\mathcal{W}_N = E^2 + B^2 \geq 0$ (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 $\mathcal{W}_N > 0$. [standard; reproduced numerically]

E.4 $\mathcal{R}_{\text{STF}}(N) = \sqrt{(R^2 + 8\mathcal{W}_N)}$. 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. $R^2 + 8\mathcal{W}_N \neq \mathcal{G}$. The map $\mathcal{G} \rightarrow R^2 + 8\mathcal{W}_N$ 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 $I_4 = aR^2 + bR_{\mu\nu}R^{\mu\nu}$; $q_{\text{cos}} = \sqrt{(aR^2 + bR^2_{\mu\nu})}$; the replacement $q_{\text{cos}} \rightarrow |R|$ 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 ,

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

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 $q_N = \sqrt{C^2}$ is continuous but not differentiable at $C = 0$; 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 $L_{\text{int}} = A_i v^i - A_0$; Euler–Lagrange $F_i = -\partial_i A_0 - \partial_t A_i + v^j F_{ij}$, $F_{ij} = \partial_i A_j - \partial_j A_i = -F_{ji}$. Stationary pure-vector part: $F_i = v^j F_{ij} \Rightarrow F_i v^i = v^i v^j F_{ij} = 0$. 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 $\Delta V = (\zeta/\Lambda)[\dot{\mathcal{R}}_{\text{out}} - \dot{\mathcal{R}}_{\text{in}}]$ 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 $E = -\tilde{g}_{\mu\nu} \xi^{\mu} v^{\nu}$ conserved; asymptotic $E \leftrightarrow V_{\infty}$ relation the same at both ends $\Rightarrow V_{\infty, \text{out}} = V_{\infty, \text{in}}$. 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 $\phi_0(r, \theta, \phi - \omega t)$ with helical Killing vector $k = \partial_t + \omega \partial_{\phi}$ conserves $E - \omega L_z$, so $\Delta E = \omega \Delta L_z$; Anderson would require $\Delta L_z/m = (2RV_{\infty}^2/c)(\cos \delta_{\text{in}} - \cos \delta_{\text{out}})$ — 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 $\omega \rightarrow -\omega$. Verified: coefficient of a^1 in C^2 and in $\mathcal{W}_N$ is zero; $I_2 \propto E \cdot B$ has a^1 coefficient $E_0 b_1 \neq 0$. Hence $D\sqrt{C^2}$ and $D\sqrt{8\mathcal{W}_N}$ 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 ($I_2/\mathcal{C}$ — 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 $H^{\wedge} X D_{\mu\nu} = \hat{B}(\nabla_{\mu} \sigma \nabla_{\nu} q + \dots)$ has no intrinsic $O(a)$ carrier — “ $\nabla \phi_0$ 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 $D_{\perp} I$: 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 $\neq$ curvature sampling. [reproduced]

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

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

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, $E_{ij} = E^{(0)}_{ij} + O(a^2)$ 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 $u_{sc} \cdot \nabla q \neq 0$. [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 $\mathfrak{J} = 48m^2/(r - ia \cos \theta)^6 = C^2 + iP$ (P the Pontryagin C^*C). Writing $z = r - ia \cos \theta = \rho e^{-i\chi}$, $\rho = \sqrt{r^2 + a^2 \cos^2 \theta}$, $\chi = \arctan(a \cos \theta/r)$: $\mathfrak{J} = q^2 e^{2i\vartheta_C}$ with $q = 4\sqrt{3} m/\rho^3$ and $\vartheta_C = 3 \arctan(a \cos \theta/r)$. Verified: $|\mathfrak{J}| = q^2$, $\arg \mathfrak{J} = 2\vartheta_C$ 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). $C^2 = 48m^2/r^6 + O(a^2)$; $P = 288m^2 a \cos \theta/r^7 + O(a^3)$; $P/C^2 \approx 6a \cos \theta/r$. The first-order rotational information absent from $\sqrt{K}$ is entirely in ϑ_C . [reproduced, exact]

G.2 The curvature-phase connection. $\mathcal{A}_C = q d\vartheta_C$; $\mathcal{F}_C = d\mathcal{A}_C = dq \wedge d\vartheta_C = 36\sqrt{3} ma \sin \theta/\rho^5 dr \wedge d\theta$ (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 $r_{\mathcal{C}} = 3q/\sqrt{Y_N} = r$ — no explicit M, G, R or coordinate. $\Xi_\mu = r_{\mathcal{C}} h_\mu^{\nu} \nabla_\nu \vartheta_C$; slow Kerr $\Xi_{\hat{r}} \approx -(3a/r) \cos \theta$, $\Xi_{\hat{\theta}} \approx -(3a/r) \sin \theta = -(3a/r) \cos \delta$; $d\Xi = -(3a \sin \theta/r) dr \wedge d\theta \neq 0$ — cannot be removed by redefining one clock. [reproduced]

G.4 The surface scale. At $r = R$, $-\partial\vartheta_C/\partial\theta \approx (3a/R) \cos \delta$ per leg; $a = J/(Mc) = I\omega/(Mc) = k_I R^2 \omega/c \Rightarrow K_{\text{phase}} = 6k_I \omega R/c$; $K_{\text{phase}}/K_{\text{Anderson}} = 3k_I$. Earth $k_I = 0.3307 \Rightarrow 0.992$ ($K_{\text{phase}} = 3.075 \times 10^{-6}$ vs 3.099×10^{-6}); Venus $0.337 \pm 0.024 \Rightarrow 1.01$ (sign-reversing, $\omega < 0$); Jupiter $0.263 \Rightarrow 0.79$ ($K \approx 6.65 \times 10^{-5}$ 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 $\sim 10^{-9}$); $3a_\oplus/R_\oplus = 1.54 \times 10^{-6} \approx \omega R/c$ because $3k_I \approx 1$. [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 $F[C, \nabla C, N, \dots]$ agrees; but $2\omega R/c = 2J/(k_I M c R)$ 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. $r_{\mathcal{C}}$ 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 $|\vartheta_C| \lesssim 1.5 \times 10^{-6}$ and $\hbar/(m_{sc} c^2) = 1.67 \times 10^7$ 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 $\mu^2 > h^{\mu\nu} \nabla_\mu \vartheta_C \nabla_\nu \vartheta_C$, $\mu = m_{sc}/\hbar \approx 2.0 \times 10^{-16} \text{ m}^{-1}$, while $|\nabla \vartheta_C| \sim 3a\theta/R\oplus^2 \approx 2.4 \times 10^{-13} \text{ m}^{-1}$ — 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,

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

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

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 : $h^\mu{}_\nu(y)\mu\nu = 2\Phi N_\mu N_\nu + 2N(\mu A_\nu) + H_{\mu\nu}$ (A, H spatial). For a ray of spatial direction ℓ^μ , $c \delta t = \int (\Phi - A_\mu \ell^\mu + \frac{1}{2} H_{\mu\nu} \ell^\mu \ell^\nu) d\ell$. Under exact retrace $\ell \rightarrow -\ell$: 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 $\delta p = 0$, and for moving endpoints only the loop holonomy $\oint \Xi = \oint d\Xi$ 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 $\cos \delta_{\text{in}} - \cos \delta_{\text{out}}$, and containing $\ln(r_2/r_1)$ — tracking-distance, station and arc dependence Anderson lacks. [reproduced]

H.2 The magnetic-Weyl candidate. $\tilde{g}^\mu{}_\nu(y)_{\mu\nu} = g_{\mu\nu} + \lambda_B \chi \mathcal{G}(W) B_{\mu\nu} / \sqrt{W}$, $W = E^2 + B^2$, $\mathcal{G}(W)$ the closure gate (0 flat, $\rightarrow 1$ saturated), χ a pseudoscalar for parity. Quadratic in $\ell \Rightarrow$ uplink and downlink add. Weak Kerr: $E_{ij} = (m/r^3)(\delta_{ij} - 3n_{\text{in}i} n_{\text{in}j})$, $B_{ij} = -(3m/r^4)[a_{\text{in}i} n_{\text{in}j} + a_{\text{in}j} n_{\text{in}i} + (\delta_{ij} - 5n_{\text{in}i} n_{\text{in}j})(a \cdot n)]$, $\sqrt{(E_{ij} E^{ij})} = \sqrt{6} m/r^3 \Rightarrow \hat{B}\ell\ell = -\sqrt{(3/2)}(1/r)[2(a \cdot \ell)(n \cdot \ell) + (a \cdot n)(1 - 5(n \cdot \ell)^2)] + O(a^2)$ — *mass cancelled, $O(a/r)$; the closure gate is essential or $M \rightarrow 0$ 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 ($\sim 5.771a$); DSN ray finite; λ_B underived; even in ℓ and in $\nu \Rightarrow$ no $\cos \delta_{\text{in}} - \cos \delta_{\text{out}}$ 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 :

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

For a ray direction ℓ^μ , the scalar and tensor pieces are even under $\ell \rightarrow -\ell$, 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 $U^\mu_E = \Gamma_E(N^\mu + \beta^\mu \mu_E)$, weak rigid rotation $\beta_E = (\omega \times r)/c$. Spatial curl relative to N : $\nabla \times (\omega \times r) = 2\omega$ exactly (verified) $\Rightarrow \mathcal{H}_C = 2\omega/c$; with $r_C = R$ at Earth's clock boundary, $\mathcal{H}_C = r_C |\mathcal{H}_C| = 2\omega R/c$ — Anderson's K. Kerr normalization used $a = J/(Mc)$ and k_I ; clock-flow vorticity uses ω directly, no $GM/(c^2 R)$, 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 $v_I = \mathcal{C} v_U$ cancels exactly through a fixed turnaround ratio q . Direction-odd conversion $v_I(k) = [1 + \varepsilon(x, u, \ell)] v_U(k)$, $\varepsilon(-\ell) = -\varepsilon(\ell)$: $v_{U, I}/(q v_{U, I}) = (1 + \varepsilon)/(1 - \varepsilon) \approx 1 + 2\varepsilon$ survives. $y_{STF} = 2\varepsilon$; conventional $y_{Doppler} \approx -2\delta V_{LOS}/c \Rightarrow \delta V_{arc} = -\mathcal{H}_C V_\infty \cos \delta$ — the transponder's 2 is removed by the $c/2$ conversion; $\Delta V_\infty = \delta V_{out} - \delta V_{in} = \mathcal{H}_C V_\infty (\cos \delta_{in} - \cos \delta_{out}) = (2\omega R/c) V_\infty (\cos \delta_{in} - \cos \delta_{out})$. [reproduced]

I.3 The angular structure. $v_\perp = \sqrt{(v \cdot v - (v \cdot \hat{s})^2)} = V_\infty \cos \delta$ — the *norm* of the equatorial component; a linear contraction $\hat{s} \cdot v$ gives $V \sin \delta$ (wrong function). [reproduced]

I.4 The carrier is a connection, not T_U . Hypersurface-orthogonal $N_\mu = -\nabla_\mu T_U / |\nabla T_U|$: Frobenius $\Rightarrow \omega^\wedge(N) = 0$ — the universal clock has no vorticity, appropriately. Rotation lives in U_E . Synchronization one-form $\mathcal{A}_\mu = h^\wedge(N) \mu \nu \beta^\nu v_E = (\omega \times r)/c$; $\mathcal{F} = 2D[\mu, \mathcal{A}_\nu]$, spatial dual $\mathcal{H}_C = \nabla_\mu N^\mu \mathcal{A} = 2\omega/c$; $R|\mathcal{H}_C| = 2\omega R/c$. Phase-bundle form: $D_\mu \Theta_I = \nabla_\mu \Theta_I - q_C \mathcal{A}_\mu$, transport $W_\gamma = \exp(iq_C \int \gamma \mathcal{A})$, $W\{\gamma^{-1}\} = W_\gamma^{-1}$. Retraced two-way: $W\{\gamma^{-1}\} W_\gamma = 1$ — a universal clock connection produces no residual on a reciprocal path; non-retraced legs close to $\oint \mathcal{A} = \oint \mathcal{F}$ — 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. $v_I = -(1/2\pi) k_{\mu\nu} \mu^\mu$ is standard; its direction dependence is ordinary Doppler. $\varepsilon_{req} = \lambda_C \mathcal{G}_{closure} r_C \mathcal{H}_C (v_\perp/c) \sigma_\gamma$, $\sigma_\gamma = \text{sgn}(k_\mu \mu^\mu)$, $\Omega_C = \sqrt{(\frac{1}{2} \mathcal{F}_{\mu\nu} \mathcal{F}^{\mu\nu})}$: at Earth's boundary $\varepsilon_{req} = \lambda_C (2\omega R/c) (V_\infty/c) \cos \delta \sigma_\gamma$; Anderson iff $\lambda_C = 1$ 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: $\lambda_C \rightarrow \lambda_C + \delta\lambda$ 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,

$$\beta_E = \frac{\omega \times \mathbf{r}}{c}, \quad \nabla \times \beta_E = \frac{2\omega}{c}.$$

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 $\varepsilon(-\ell) = -\varepsilon(\ell)$ 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. $J_A \equiv dT_U/d\tau_A$; $v_A = J_A(1/2\pi)d\Phi/dT_U$. Two-way: Earth emits $v_0 \Rightarrow v^\wedge(U)^\uparrow = v_0/J_E(1)$; spacecraft receives $J_S(2)P^\uparrow v_0/J_E(1)$, emits $q^\times$ that; back to universal $\div J_S(2)$: $v^\wedge(U)^\downarrow = qP^\uparrow v_0/J_E(1)$ — spacecraft clock cancels identically; Earth receives $v_3 = qv_0[J_E(3)/J_E(1)]P^\uparrow P^\downarrow$. Same station, stationary map: $J_E(3) = J_E(1) \Rightarrow$ ordinary rate difference disappears; slowly varying: $J_E(3)/J_E(1) \approx 1 + \Delta_{RT} d \ln J_E/dT_U$ — a round-trip derivative, not $K(\cos \delta_{in} - \cos \delta_{out})$. Three-way ($A \rightarrow B$): $J_B(3)/J_A(1)$ 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 $\ln[J_B/J_A] + \Delta\Pi_{BA}$. [reproduced]

J.2 Clock-Holonomy Requirement. The two-way measurement is a closed contour $\Gamma = \gamma_\uparrow + \gamma_\downarrow - \gamma_E$; $\delta\Phi = \oint_\Gamma \mathcal{A} = \int_\Sigma \mathcal{F}$; an exact scalar rescaling $\mathcal{A} = d\chi$ 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 $S_\gamma = -\frac{1}{8}\int \chi^\wedge \mu\nu\rho\sigma F_{\mu\nu}F_{\rho\sigma}$; real action $\Rightarrow$ 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). $\mathcal{F}^C_{\mu\nu}F_{\mu\rho}F^\wedge_{\nu\rho} = 0$ (antisym $\times$ sym); $\mathcal{F}^C_{\mu\nu}F_{\mu\rho}F^\wedge_{\nu\rho} = 0$ ($F^{\mu\rho}F^\wedge_{\nu\rho} = \frac{1}{4}g^\wedge_{\mu\nu}FF^\wedge$). Dilaton $\mathcal{Z}_C F^2$: reciprocal, direction-even. Axion $\mathcal{G}_C F^\wedge$: polarization, wrong observable. Kinetic mixing $\varepsilon_C \mathcal{F}^\wedge CF$: source/diagonalization, no direction-odd cone. Nonbirefringent principal $K^{\mu\nu}(F_{\mu\rho}F_{\nu\rho} - \frac{1}{4}g_{\mu\nu}F^2) \equiv$ effective metric — the only viable polarization-independent sector; the required $K^\wedge_{\mu\nu} \text{req} \sim N^{(\mu R\nu)}$ is an optical shift one-form $\Rightarrow \delta t_\uparrow + \delta t_\downarrow = 0$ 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 $\delta v \sim v d(L_{dev} \varepsilon/c)/dt$, suppressed by $L_{dev}/c \sim \text{ns} - \mu\text{s}$ 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 $B^{\mu-C}\psi_\nu\psi F_{\mu\nu}$ — 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: $L_{\text{int}} = \gamma \phi u^\mu \nabla_\mu \mathcal{R} = \mathcal{A}_\mu u^\mu$ with $\mathcal{A}_\mu = \gamma \phi \nabla_\mu \mathcal{R}$. $\mathcal{F}_{\mu\nu} = 2 \nabla_{[\mu} \mathcal{A}_{\nu]} = \gamma (\nabla_\mu \phi \nabla_\nu \mathcal{R} - \nabla_\nu \phi \nabla_\mu \mathcal{R}) = \gamma (d\phi \wedge d\mathcal{R})_{\mu\nu}$ (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: $\oint \Gamma_\mu \mathcal{A}^\mu = \int \Sigma \gamma d\phi \wedge d\mathcal{R} \neq 0$ wherever $\nabla \phi \nparallel \nabla \mathcal{R}$. **Antisymmetric STF force $\Leftrightarrow$ zero mechanical work $\Leftrightarrow$ 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: $\delta y_{\text{Anderson}} = -(4\Omega R V \omega / c^2)(\cos \delta_{\text{in}} - \cos \delta_{\text{out}})$; the derivation must show $(1/2\pi v_o)(d/dt_E) \oint \Gamma_\mu \mathcal{A}^\mu$ equals it. Three bridges open: $\mathcal{A}$ 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 $(1/2\pi) \oint p = 0$. Retarded/advanced closure norm $Q = [(1/\pi) \oint p_{\text{Rp}_A}]^{1/2}$ 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 $D_{ij} = (1/\pi) \oint p_{ip_j}$ has diagonals $\Omega^2 R^2 \cos^2 \delta_i$ and off-diagonal $\Omega^2 R^2 \cos \delta_{\text{in}} \cos \delta_{\text{out}} \cos(\alpha_{\text{in}} - \alpha_{\text{out}})$; separated arcs keep the diagonal difference (Anderson), joint closure keeps the cross-coherence. **But** orbit determination is linear to first order: $\Delta V = h^T_{\text{VWP}_\perp} s / (h^T_{\text{VWP}_\perp} h_V)$ is a linear functional of s ; a positive nonlinear Q cannot arise in the estimator from a zero-mean p ($\oint p = 0 \Rightarrow$ 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 $\rightarrow$ amplitude, right ascension $\rightarrow$ 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 $\cos \phi_S / \cos \alpha$). [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 $\delta \hat{v} = \delta V / V \neq 0$. 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, $h_V \approx a h_{\text{RA}} + b h_{\text{Dec}}$, direction and speed are partially degenerate, and the estimator represents a transverse deflection as $\Delta V \neq 0$ with $\Delta V_{\infty, \text{physical}} = 0$. With continuous multi-observable tracking, $\text{rank}(H)$ increases, the degeneracy breaks, and the same signal is reconstructed as a tiny deflection, absorbed, or rejected — $\Delta V \rightarrow 0$ without the field vanishing. Later nulls become evidence of greater observational closure. Two sub-branches: **B1** kinematic projection (original no-work force $\rightarrow$ real transverse deflection $\rightarrow$ Doppler/range residual $\rightarrow$ apparent ΔV ; no new coupling; investigate first); **B2** clock holonomy (connection $\rightarrow$ direct signal/clock phase $\rightarrow$ apparent ΔV ; needs the clock–connection coupling theorem, substantive after photon sequestering). Exact next calculation: $\delta v(T) = \int a_{\text{STF}} dT'$; verify $v \cdot \delta v = 0$; propagate $\delta y_{2w} = -(2/c) \hat{n} \cdot \delta v + \delta y_{\text{lt}}$, $\delta p = \hat{n} \cdot \delta r + \delta p_{\text{prop}}$; pass through the actual estimator. [reproduced]

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

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

Then

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

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 $\hat{\mathbf{n}} \cdot \delta \mathbf{V}$. A Doppler-dominated estimator with weak angular rank may represent a transverse deflection as $\Delta \hat{V}_\infty$. 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: $\kappa_C(s) = \text{sgn}(\Omega) \|\ell_s\| = (\Omega R / c) \cos \delta$. 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, $\Delta V / V_\infty = (2\Omega R / c)(\cos \delta_{\text{in}} - \cos \delta_{\text{out}})$ 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 $\times$ utilization. $\varepsilon_a = \eta_a (2\Omega_{CR} / c) \cos \delta_a$, $\eta_a \in [-1, 1]$; $\Delta V / V_\infty = (2\Omega_{OR} / c)[\eta_{\text{in}} \cos \delta_{\text{in}} - \eta_{\text{out}} \cos \delta_{\text{out}}]$; Anderson is $\eta_{\text{in}} = \eta_{\text{out}} = 1$; nulls at $\eta \approx 0$ or $\eta_{\text{in}} \cos \delta_{\text{in}} \approx \eta_{\text{out}} \cos \delta_{\text{out}}$. η_a must not be fitted: $\eta_a = h^\mu T_{\text{VWP}} \perp s_{\text{STF}, a} / (C_a h^\mu T_{\text{VWP}} \perp h_V)$, $C_a = V_\infty (2\Omega_{CR} / c) \cos \delta_a$ — 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 $s_{\text{STF}}(t)$, derived from the action or clock/link coupling, supplies the utilization. [reproduced]

L.5 The bound. $|\varepsilon_a| \leq (2|\Omega_O| R_O / c) \cos \delta_a$; $|\Delta V / V_\infty| \leq (2|\Omega_O| R_O / c)(\cos \delta_{\text{in}} + \cos \delta_{\text{out}})$. 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: Ω_{PR_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 $2|\Omega|R \cos \delta/c$, 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

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

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 = $\oplus$. $K_{\text{source}} = 2\Omega_{sR_s}/c$ and $K_{\text{observer}} = 2\Omega_{oR_o}/c$ 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 = $\oplus$: the dynamical branch predicts $K_B = 2\Omega_{BR_B}/c$ with projections on the planet's axis; the observer branch predicts $K_{\text{obs}} = 2\Omega_{\oplus R_{\oplus}}/c$ 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 $\Omega \rightarrow -\Omega$; independent of G and M ; no periapsis-curvature dependence; scale $\Omega R/c$. Source-curvature force: obstructed for parity-even

invariants; needs an odd invariant or added structure; needs cancellation/amplification of the compactness $GM/(c^2R) \approx 7 \times 10^{-10}$ (a source-local effect $\sim$ compactness $\times \Omega R/c \sim 10^{-15}$ vs Anderson 3×10^{-6} — nine orders); the natural gravitational scale is not $\Omega R/c$. Observer-clock map: linear, sign-reversing, G- and M-free, and $\Omega R/c$ 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. $N^\mu = \Gamma(u^\mu_{\text{O}} + v^\mu_{\text{O}})$, $\Gamma = -u_{\text{O}} \cdot N$; $v_{\text{O}} = -k \cdot u_{\text{O}}$, $v_{\text{U}} = -k \cdot N$; $v_{\text{O}}/v_{\text{U}} \approx 1 - v_{\text{O}} \cdot \hat{s}/c$; two-way $\delta y_{\text{O}} \approx -(2/c)v_{\text{O}} \cdot \hat{s}$; Earth $v_{\text{O}} = \Omega_{\oplus} \times r_{\text{O}}$. Right symmetry; but a station gives $\Omega R \cos \lambda \cos \delta \sin(\alpha - \theta)$, 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). $r = H_x \delta x + r_{\text{link}} + r_{\text{clock}}$; $\Delta V = h_{\text{T_VWP_}\perp}^T / (h_{\text{T_VWP_}\perp} h_{\text{V}}) \Rightarrow \Delta V \neq 0 \Rightarrow \Delta E_{\infty} \neq 0$. Three branches: energy-changing force ($v \cdot \delta v \neq 0$; Doppler, range, angular all change; ordinary geometry); no-work deflection ($v \cdot \delta v = 0$, $\delta v_{\perp} \neq 0$; direction changes; different stations project one trajectory); clock/link holonomy ($\delta x = \delta v = 0$, $\delta \Phi_{\Gamma} \neq 0$; no optical trajectory change; intrinsic link dependence). Observable decomposition: $\delta y_2 \approx -(2/c)(\hat{n} \cdot \delta v + \hat{n} \cdot \delta r) + \delta y_{\text{link}} + \delta y_{\text{clock}}$; $\delta \rho \approx \hat{n} \cdot \delta r + c \delta t_{\text{link}}$; $\delta \theta \approx P_{\perp} \hat{n} \delta r / \rho$; $\delta E_{\infty} = v_{\infty} \cdot \delta v_{\infty}$. Link test: $\mathcal{Q}_{\text{AA}} = \ln[J_{\text{A}}(T_3)/J_{\text{A}}(T_1)] + \Pi_{\text{A}\uparrow} + \Pi_{\text{A}\downarrow}$; $\mathcal{Q}_{\text{AB}} - \mathcal{Q}_{\text{AA}} = \ln[J_{\text{B}}/J_{\text{A}}] + \Delta \Pi_{\text{BA}}$; $\mathcal{Q}_{\text{S} \rightarrow \text{A}} = \ln[J_{\text{A}}/J_{\text{S}}] + \Pi_{\text{A}}$. **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 $\rightarrow$ work-producing branch; a common deflection with $\delta E_{\infty} = 0 \rightarrow$ original no-work interaction; a station/link-dependent residual with no optical change $\rightarrow$ carrier/holonomy; disappearance under full joint estimation $\rightarrow$ observational projection; disappearance without structure $\rightarrow$ weakens the identification. [reproduced]

M.6 The one-bit channel cannot carry $\omega R/c$. The advanced closure certificate carries one topological bit (closed/open); $\omega R/c$ 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 $\neq$ dynamical amplitude: $(1/4\pi^2) \int \omega_{\text{R}} \omega_{\text{A}} = 1$ normalizes a completed transaction and does not fix $K_{\text{R}}^{-1} J_{\text{rot}}$; $4\pi^2$ 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

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

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

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

Therefore $\Delta\hat{V} \neq 0$ 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 $f(\phi)\mathcal{G}$, $\mathcal{G}$ 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): $c_T^2 - 1 = \alpha_T \approx 8(\ddot{f} - H\dot{f})/M_{\text{Pl}}^2$, cross-checked against the exact ratio $F_T/Q_T = (1 - 8\dot{f}/M^2)/(1 - 8H\dot{f}/M^2)$. $f = \kappa(\mathcal{Z}/\Lambda)(\phi/M_{\text{Pl}})M_{\text{Pl}}^2$, $\kappa = \mathcal{O}(1)$ the C.5b auxiliary factor; $(\mathcal{Z}/\Lambda)/c^2 = 1.5 \times 10^{-6} \text{ s}^2$; $H_0 = 2.43 \times 10^{-18} \text{ s}^{-1}$; $m_s = 3.94 \times 10^{-23} \text{ eV}$. [standard; reproduced]

N.2 Tracking regime. $\phi \sim H_0 \phi$, $\dot{\phi} \sim H_0^2 \phi$, Planck-order stabilized modulus $x_0 = \phi/M_{\text{Pl}} \leq 1$: $|c_T/c - 1| \leq 8\kappa(\mathcal{Z}/\Lambda)H_0^2 x_0/c^2 \approx 7 \times 10^{-41} \sim 25$ 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 $|\mathcal{R}_{2C}|_{\{z=1\}} \sim 2.6 \times 10^{-37} \text{ s}^{-1}$; 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.] $\phi = A \cos m_s t$, $m_s/H_0 = 2.5 \times 10^{10}$ — the potentially dangerous case. Amplitude from the framework's own $\rho_{\text{DE}} = \frac{1}{2}m_s^2 A^2$: with $\rho_{\text{DE}} = 0.7 \times 3H_0^2 M_{\text{Pl}}^2 = 3.2 \times 10^{-47} \text{ GeV}^4$ and $m_s = 3.94 \times 10^{-32} \text{ GeV}$, $A = 2.0 \times 10^8 \text{ GeV}$, $A/M_{\text{Pl}} = 8.3 \times 10^{-11}$. $|c_T/c - 1| \lesssim 8\kappa(\mathcal{Z}/\Lambda)m_s^2 A/(M_{\text{Pl}} c^2) \approx 1.8 \times 10^{-30}$ at $\kappa = 1$ cycle-averaged (the instantaneous envelope $|\dot{\phi}|_{\text{max}} = m_s^2 A$ 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 $\phi/M_{\text{Pl}} \approx 4.7 \times 10^4$ — super-Planckian. [reproduced] *Process note:* a first pass mis-read the dark-matter paper's "A ~ 780 SI units" as $\phi/M_{\text{Pl}} = 780$, 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

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

Using the retained scalar–Gauss–Bonnet normalization, the tracking regime gives $|c_T/c - 1| \lesssim 7 \times 10^{-41}$. For $\phi = A \cos(m_s t)$, taking A from $\rho = \frac{1}{2}m_s^2 A^2$ gives $A/M_{\text{Pl}} \simeq 8.3 \times 10^{-11}$ 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. $ds^2_{10} = e^{\{-6\sigma\}} g_{\mu\nu} dx^\mu dx^\nu + e^{\{2\sigma\}} \hat{g}_{mndy} mdy^\mu n$, block-diagonal ($G_{\mu m} = 0$); 4D massless sector $g_{\mu\nu}$ and σ , no vector; the curvature-squared descendant $A(\sigma)\mathcal{S}$ with $[y] = M^{-1}$; $L^* = 3.64 \times 10^{-30}$ m from the internal-trace projector; the Kähler potential with $\text{Re } T \equiv e^{\{4\sigma\}}$, $-3\ln(T+\bar{T}) = -12\sigma - 3\ln 2$ (σ the log-breathing coordinate; the exponent is fixed by canonical normalization against the reduction's $\varphi_c = \sqrt{24} M_{\text{Pl}} \sigma$ — §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 $\text{Re } T \equiv e^{\{2\sigma\}}$, whose $n = 2$ gives $\varphi_c = \sqrt{6} M_{\text{Pl}} \sigma$ 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. $L_Y = -\frac{1}{4} \text{Re } f_Y(\varphi) F^2$; $f_Y = f_0 + f_1 \delta\varphi$; canonical $F^\wedge(c) = \sqrt{f_0} F \Rightarrow g_\varphi \varphi = \partial\varphi / \text{Re } f_Y|_{\{\varphi_0\}}$ — not ζ/Λ (different dimension and origin). Sequestering: $f_{\text{SM}} \sim T_s$ depends on the local cycle, $\partial\tau_s/\partial\tau_b \approx 0 \Rightarrow g^{\text{tree}}_\varphi = 0$; residual mixing $K_{b5} \sim 1/\mathcal{V}$: $g^{\text{eff}}_\varphi = c_Y/(\mathcal{V} M_{\text{Pl}})$, $|c_Y| \lesssim 0.612$ by analogy with $\alpha_{\text{eff}} \sim 0.612/\mathcal{V}$ (assumption, not theorem); $\mathcal{V} > 175 \Rightarrow g^{\text{eff}} \lesssim 1.4 \times 10^{-21} \text{ GeV}^{-1}$; virtual $\gamma\gamma \rightarrow \varphi^* \rightarrow \gamma\gamma$ at 1.6 eV: $|\mathcal{M}| \lesssim 5 \times 10^{-60}$; $\Gamma = g^2 m_{S^3}/(64\pi) \lesssim 6 \times 10^{-139} \text{ GeV}$, $\tau_\varphi \gtrsim 10^{114} \text{ s}$. Photon-coupling cancellation: $L = -\frac{1}{4} Z(\varphi) F^2$, $Z = 1 + g_\varphi \delta\varphi$, $\nabla_\mu [ZF^\wedge \mu\nu] = j^\wedge \nu$; geometric optics: both polarizations on one null cone, common transport $\nabla_\mu [Z|a|^2 k^\wedge \mu] = 0$; $K_\varphi = c_\varphi \mathbb{1}$ on the polarization space $\Rightarrow (K_A \otimes K_B) \rho(K^\dagger_A \otimes K^\dagger_B) = |c_{Ac_B}|^2 \rho \Rightarrow \rho' = \rho$ after normalization; efficiency cancels under fair sampling; free wave $F^2 = 0$. On-shell $\varphi \rightarrow \gamma\gamma$ gives $2 \times 10^{-23} \text{ eV}$ photons ($\lambda \approx 6.7 \text{ ly}$), $10^{23} \times$ below optical. $S_{\text{STF}} = S_{\text{QM}} + O(E^2/\mathcal{V}^2 M_{\text{Pl}}^2)$; the visible-sector coupling is unnormalized-Z-free: V7.9's $(\alpha/\Lambda)\varphi F^2$ lacked the $\frac{1}{4}$ and overloaded α ; corrected in the boxed action and the LOD-appendix width. [reproduced]

O.3 The carrier audit — no field carries both $O(\omega)$ 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 $T_U \rightarrow T_U + C \Rightarrow$ orientation, foliation, ordering — not absolute winding, not planetary boundary data; completion open. Ordinary Kerr $g_{\text{t}\varphi}$: $O(a)$, carries J not R; GR. Curvature phase ϑ_C : $O(a)$, local r not source R; geometric, not dynamical. Axion ϑ_P : $O(a)$ via $P = 288m^2 a \cos \theta/r^7$ (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 $\vartheta \propto (\alpha_{\text{CS}}/f^2)P$ retains $m^2 a/R^5$ (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 $P/C^2 \approx 6a \cos \theta/r$ — which loops back to Branch B (a regularized $\mathcal{O}_{\text{odd}} = P/\sqrt{(C^2)^2 + P^2 + \mathcal{J}^2}$ with $\mathcal{J}a$ derived closure scale). Matter-vorticity carrier B_μ : could carry R via the boundary ($\chi^\wedge \mu_\Sigma = R_\Sigma \varpi^\wedge \mu$, $|\chi_\Sigma| \approx \omega R/c$) but is not in the reduction; would need $\mathcal{H}^{\mu\nu} B_\nu = J^\wedge \mu_{\text{rot}}$, a source coupling, and a photon coupling — three underived quantities. **The present 10D theory contains no field carrying both $O(\omega)$ and source-boundary information; the cross-disformal metric is not generated by the compactification performed ($\hat{B}_{\text{KK}} = 0$). ** [reproduced]

O.4 Circularity ledger. $L^* = 3.64 \times 10^{-30} \text{ m}$ vs dark-energy-required 3.55×10^{-30} : conditional consistency check. Coupling near the historical flyby value: not validation (flyby derivation withdrawn). $\Omega_{\text{STF}} \sim 0.65$ vs observed: matched downstream benchmark. Flux integer $\sim$ 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. $A(\sigma)\mathcal{S}$ 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 $\text{Re } T = e^{4\sigma}$, the canonical normalization is $\phi_c = \sqrt{24}M_{\text{Pl}}\sigma$. 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 $u_A = \mathcal{C}_A$, $q = \sqrt{u^2}$,

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

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

$$H_{IJ}^{(a)} = -\frac{\kappa A}{q} J^T (I - \hat{u} \hat{u}^T) J, \quad A = D_U \phi + \theta \phi.$$

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

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

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
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 $A(k)$, 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 $\mathcal{Q}_{\text{crit}}(m_s) = m_{\text{sM_PIH}_0}/(4\pi^2)$ — a natural-unit parametric expression. (iii) Its SI value $\mathcal{Q}_{\text{crit}} \equiv \mathcal{Q}_{\text{GR}}(730 \text{ R_S}) \approx 10^{-27} \text{ m}^{-2}\text{s}^{-1}$ — an assignment. [record]

Q.2 The audit. $\hbar H_0 = 1.60 \times 10^{-33} \text{ eV}$; unreduced $M_{\text{PI}} = 1.2209 \times 10^{28} \text{ eV}$; $\mathcal{Q}_{\text{crit}} = 1.95 \times 10^{-29} \text{ eV}^3$; $1 \text{ eV}^3 = 1/((\hbar c)^2 \hbar) \text{ m}^{-2}\text{s}^{-1} = 3.90 \times 10^{28} \text{ m}^{-2}\text{s}^{-1} \Rightarrow \mathcal{Q}_{\text{crit}} \approx 0.76 \text{ m}^{-2}\text{s}^{-1}$; reduced $M_{\text{PI}} \Rightarrow 0.15$. Neither is 10^{-27} ; the discrepancy is 26–27 orders ($10^{-27} \text{ m}^{-2}\text{s}^{-1} = 2.56 \times 10^{-56} \text{ eV}^3$). The 10^{-27} is $\mathcal{Q}_{\text{GR}}$ at 730 R_S (Appendix A.5: $\approx 2 \times 10^{-27}$). The former evaluation was not a unit conversion; it introduced an unreported normalization by matching to $\mathcal{Q}_{\text{GR}}$. 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 $1.07 \times 10^{-27} \text{ m}^{-2} \text{ s}^{-1}$; 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 $\mathcal{Q}_{\text{ext}}(x) = (3\sqrt{3}/20)c^7/(G^3M^3)x^{-7}$ (companion of mass $M/2$ at separation a ; all values below independently re-derived): $\mathcal{Q}_{\text{ext}}(730 R_S) = 1.0137 \times 10^{-27} \text{ m}^{-2} \text{ s}^{-1}$, so the required constitutive suppression against $\mathcal{Q}_{\text{crit}} = 0.7606 \text{ m}^{-2} \text{ s}^{-1}$ is $Z_{\mathcal{Q}} = 1.333 \times 10^{-27}$. The compactification supplies $(\ell_{\text{PI}}/L)^5 = 1.726 \times 10^{-27}$ — **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 $C_s = 0.772$ recovers it. The exponent fitted to the requirement is $p = 5.02$, so the fifth power is singled out among neighbouring integers $((\ell_{\text{PI}}/L)^4 = 3.9 \times 10^{-22}$, $(\ell_{\text{PI}}/L)^6 = 7.7 \times 10^{-33})$. Three cautions prevent promotion to a derivation, and they are the audit's own: (i) six compact dimensions naturally produce six volume powers — $5 = d_{\text{int}} - 1$ 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 — $\sqrt{(m_s/M_{\text{PI}})/(4\pi^2)} = 1.439 \times 10^{-27}$ 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 $Z_{\mathcal{Q}} = C_s(\ell_{\text{PI}}/L)^5$ with C_s 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 $x \approx 0.11$ (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 $\sqrt{K} = \sqrt{48 Gm/(c^2 a^3)}$ 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 $\mathcal{R}_{\text{mid}} = 16 \mathcal{R}_{\text{proxy}}$ exactly at leading order [reproduced analytically]. Imposing the same threshold there moves the anchor by $a \rightarrow 16^{1/3} a = 1.486a$ and $t \rightarrow 16^{1/3} t = 4.876t$ — i.e. $730 R_S / 3.324 \text{ yr} \rightarrow 1085 R_S / 16.2 \text{ yr}$. 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 $\Omega_{\text{GW}}/\omega_c \sim 10^6$ — deeply saturated — and time-remaining-to-merger is not a local oscillation frequency (the Countdown–Response point: $\tau_{\text{merge}} = T_s$ at the central anchor is a numerical comparison, not a dynamical resonance). The well-posed replacement observable is $\mathcal{Q}_{\text{bin}}[N, u, y] = N^\alpha \nabla_\alpha \sqrt{(8\mathcal{E}^{\text{ext}}_{\mu\nu}[u, y]\mathcal{E}^{\text{ext}}_{\mu\nu}[u, y])}$ 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 $x = r/R_S$,

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

A fixed threshold gives

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

If $x_*(60M_\odot) = 730$, then $x_*(10^6M_\odot) = 11.3$, $x_*(10^8M_\odot) = 1.57$, and $x_*(10^9M_\odot) = 0.586$. 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 $m_s M_{\text{Pl}} H_0 / (4\pi^2)$ converts to order $10^{-1} \text{--} 1 \text{ m}^{-2} \text{s}^{-1}$, 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 $0.22/0.08 = 2.75\sigma$; Rosetta I $0.27/0.05 = 5.4\sigma$; Cassini $0.93/0.10 = 9.3\sigma$. 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 $+0.523 \text{ mm/s}$, reconstruction null. Rosetta III: $+1.099 \text{ mm/s}$, null. Juno: $+6.34 \text{ mm/s}$ 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”, $\delta_{\text{in}} = -18.4^\circ$, $\delta_{\text{out}} = +39.2^\circ$, $G = 0.476$, $+4.8 \text{ mm/s}$ — is wrong on three counts: Juno is published; $G = \cos 18.4^\circ - \cos 39.2^\circ = 0.174$, not 0.476; its own formula then gives $(3.099 \times 10^{-6})(10389)(0.174) = 5.60 \text{ mm/s}$, 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 $\Delta V/V_\infty = (2\Omega_{\text{OR}_O/c})[\eta_{\text{in}} \cos \delta_{\text{in}} - \eta_{\text{out}} \cos \delta_{\text{out}}]$ 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 $P_\perp$; compute η_a from the STF template $s_{\text{STF},a}$ (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 $|\Delta V|$ 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
$A = 0$ 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

$$R_{\text{structural}}^{(1)} = 58, \quad R_{\text{structural}}^{(\pm)} = 116.$$

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 $\det(I + \epsilon A) = 0$.

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 $|\epsilon||\mathbf{A}|_2 < 1$;
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 $A^a_b(k)$, 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

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.

Grade unchanged: coherent gravitational candidate, not acompleted 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:

physical covariance	$\Rightarrow$ diagonal Ward identity,
advanced/deformed invariance	$\Rightarrow$ off-shell equation identity,
noise compatibility	$\Rightarrow$ constraint on stochastic sources.

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

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

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

$$P_{\mu\nu} = g_{\mu\nu} + n_\mu n_\nu, \quad \tilde{K}_{\mu\nu} = K_{\mu\nu} - K P_{\mu\nu}.$$

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

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

Therefore the open tensor

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

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,

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

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

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

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

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

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

A local first-order representative is

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

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

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

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,

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

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

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

The chain-rule term is not optional.

III.E Varied material world tube

A representative carrier is a scalar material field B with

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

and smooth activation window

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

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 uncanceled force proportional to $E_B \nabla_\nu B$.

III.F Retained finite environment

The regulated common bath is

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

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

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

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

$$K_{\text{sel}}^R(\omega) = \frac{-i\omega}{\omega_c - i\omega}.$$

The self-energy and noise matrices factorize,

$$\Sigma_{ij}^R = g_i g_j K_{\text{sel}}^R, \quad \mathcal{N}_{ij} = g_i g_j \mathcal{N}_D.$$

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 ELIMINATION
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 eliminated
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 description
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 kernel
linear $g_i O_i X_\alpha$ interaction	closed covariant system–environment vertex when fully varied	generator of the influence kernels

V8.2 MODULE OR OPERATOR	OPEN-EFT CLASS BEFORE ELIMINATION	CLASS AFTER THE RELEVANT ELIMINATION
rank-one scalar ϕ/Q self and cross kernels	not present before trace	nontrivial scalar open operators
$i\Psi_a^\dagger \mathcal{N} \Psi_a$ 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 renormalization 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 $\chi_{QQ}^{\text{aux}} = 0$ 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,

$$Z(\omega) = K_{\text{sel}}^R(\omega) \tilde{Q}_\Delta(\omega),$$

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_{CMC}^μ 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

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

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

For the boundary-CMC pullback,

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

the identity takes the form

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

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

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

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

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

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

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

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

$$E_A^{\text{red}} = K_{AB}^R \Phi_r^B + \dots$$

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

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

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

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

the same operator gives

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

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

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

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

$$\nabla_{\mu}^{(s)} T^{\mu}_{\nu,s,\text{tot}} = \sum_A E_{A,s} \nabla_{\nu}^{(s)} \Phi_s^A + E_{\partial,s} \Xi_{\nu,s}, \quad s = 1, 2,$$

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.

VIA 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:

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

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

CLAIM	RESULT UNDER THE NEW FRAMEWORK	VERIFICATION STATUS
capacity Hessian supplies environmental QQ response	rejected as before	disproved at fixed base geometry
local memory has rank two per leg	unchanged	proved structurally
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.

STF v8.2 remains a coherent gravitational candidate, not acompleted 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

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

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

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

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

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

$$\Sigma_{QQ}^R(z) = \int_0^{\infty} d\Omega \, 2\Omega \rho_{QQ}(\Omega) \left[\frac{1}{z^2 - \Omega^2} + \frac{1}{\Omega^2} \right], \quad \text{Im } z > 0.$$

Requiring the exact v8.2 selected response

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

fixes its positive ideal continuum uniquely through the retarded discontinuity:

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

It obeys

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

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

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

then conditionally

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

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

$$\rho_{QQ}^H(\omega) = \frac{\beta_{\text{loc}} \lambda_H^2}{4\pi} P_A S_H^{AB}(0) P_B \omega + O(\omega^3).$$

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.

Grade unchanged: coherent gravitational candidate, not acompleted 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

$$\Gamma_{\text{DSW}}^{\text{EM}} = \frac{q^2 a^3 \epsilon^2}{12\pi^2}$$

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

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

the leading classical dissipative force is

$$F_{\text{diss}} = -\gamma_1 \dot{q} + \dots$$

and the long-hold decoherence rate is

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

For the uniformly accelerated electromagnetic dipole they find

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

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 $\Omega \rightarrow 0$ 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

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

and

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

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

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

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,

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

or equivalently,

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

The unrecovered positive-affine-frequency norm contains

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

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 $\Delta > 0$,

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

The gradient in curvature-state space is

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

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

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

The windowed system operator is

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

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 $\tilde{Q}_\Delta$. Let that force be $\mathcal{F}_Q$. With the retarded convention used in this paper,

$$G_{FF}^R(z) = \sum_\alpha \frac{c_\alpha^2}{z^2 - \Omega_\alpha^2}, \quad \text{Im } z > 0,$$

and

$$\rho_{QQ}(\Omega) = -\frac{1}{\pi} \text{Im } G_{FF}^R(\Omega + i0) = \sum_\alpha \frac{c_\alpha^2}{2\Omega_\alpha} \delta(\Omega - \Omega_\alpha).$$

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

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

The doubled bath action is

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

The leading interaction is

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

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

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

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

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

The v8.2 selected high-pass response has zero DC. A local counterterm is therefore fixed by the matching condition

$$\Sigma_{QQ}^R(0) = 0.$$

In the present sign convention this means

$$\boxed{\Sigma_{QQ}^R(z) = G_{FF}^R(z) - G_{FF}^R(0).}$$

At finite regulator the corresponding doubled local contact may be written

$$S_{\text{ct},Q}^{\text{CTP}} = -\frac{1}{2} \sum_{s=\pm} s \int_{\mathcal{M}_s} d^4x \sqrt{-g_s} G_{FF}^R(0) \tilde{Q}_{\Delta,s}^2,$$

where the sign is defined so that its quadratic kernel shifts the bare response by $-G_{FF}^R(0)$. Because $\tilde{Q}_{\Delta} = WQ_{\Delta}$, this contact contributes its own metric, readout, and B -equation terms.

Equivalently,

$$\Sigma_{QQ}^R(z) = \int_0^{\infty} d\Omega \, 2\Omega \rho_{QQ}(\Omega) \left[\frac{1}{z^2 - \Omega^2} + \frac{1}{\Omega^2} \right].$$

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

$$S_{\text{IF}}^{(2)} = \int d^4x d^4x' \tilde{Q}_{\Delta,a}(x) \Sigma_{QQ}^R(x, x') \tilde{Q}_{\Delta,r}(x') + \frac{i}{2} \int d^4x d^4x' \tilde{Q}_{\Delta,a}(x) \mathcal{N}_{QQ}(x, x') \tilde{Q}_{\Delta,a}(x'),$$

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

$$\Sigma_{QQ}^R(0) = 0$$

and its imaginary part on the positive real axis is

$$-\text{Im } \Sigma_{QQ}^R(\omega + i0) = \pi \rho_{QQ}(\omega) \geq 0.$$

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

$$K_{\text{sel}}^R(z) = \frac{-iz}{\omega_c - iz}.$$

If the Q channel has coefficient g_Q^2 , then

$$\Sigma_{QQ}^R(z) = g_Q^2 K_{\text{sel}}^R(z).$$

Taking the retarded discontinuity gives

$$-\frac{1}{\pi} \text{Im } \Sigma_{QQ}^R(\Omega + i0) = \frac{g_Q^2}{\pi} \frac{\Omega \omega_c}{\Omega^2 + \omega_c^2}.$$

Therefore

$$\rho_{QQ}^D(\Omega) = \frac{g_Q^2}{\pi} \frac{\Omega \omega_c}{\Omega^2 + \omega_c^2}.$$

Substitution into the once-subtracted dispersion relation gives exactly

$$\int_0^\infty d\Omega \, 2\Omega \rho_{QQ}^D(\Omega) \left[\frac{1}{z^2 - \Omega^2} + \frac{1}{\Omega^2} \right] = g_Q^2 \frac{-iz}{\omega_c - iz}.$$

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

$$g_Q^2 = 2 \int_0^\infty \frac{\rho_{QQ}^D(\Omega)}{\Omega} d\Omega.$$

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

$$\mathcal{N}_{QQ}^D(\omega) = 2g_Q^2 \frac{|\omega| \omega_c}{\omega^2 + \omega_c^2} \coth\left(\frac{\beta|\omega|}{2}\right).$$

It is nonnegative and has the finite low-frequency limit

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

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

$$O_i = (\phi, \tilde{Q}_\Delta)$$

and a common bath direction

$$O_g = g_\phi\phi + g_Q\tilde{Q}_\Delta,$$

the response matrix factorizes:

$$\Sigma_{ij}^R = g_i g_j K_{\text{sel}}^R.$$

Hence

$$\left(\Sigma_{\phi Q}^R\right)^2 = \Sigma_{\phi\phi}^R \Sigma_{QQ}^R.$$

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

$$g_\phi^2 = |\gamma_\times| r, \quad g_Q^2 = \frac{|\gamma_\times|}{r}, \quad r > 0.$$

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

$$T_{\mu\nu}^{QX} = -\frac{2}{\sqrt{-g}} \frac{\delta S_{QX}}{\delta g^{\mu\nu}}.$$

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

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

diagonal covariance gives the ordinary enlarged-parent identity

$$\nabla_\mu T^\mu{}_{\nu, \text{tot}} = \sum_A E_A \nabla_\nu \Psi^A + \mathcal{B}_\nu[\partial\mathcal{M}, V_4],$$

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 $WQ_\Delta c_\alpha X_\alpha$ 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

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

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

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

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.AA 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

$$S_H^{\text{proj}}(\omega) = S_0 + O(\omega^2),$$

then

$$\rho_{QQ}^H(\omega) = \frac{\beta_{\text{loc}} S_0}{4\pi} \omega + O(\omega^3).$$

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

$$\rho_{QQ}^D(\omega) = \frac{g_Q^2}{\pi\omega_c} \omega + O(\omega^3)$$

gives

$$\frac{g_{Q,H}^2}{\omega_c} = \frac{\beta_{\text{loc}}}{4} \lambda_H^2 P_A S_H^{AB}(0) P_B,$$

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

$$\rho_{QQ}^H(\omega) \sim \frac{\beta_{\text{loc}} \lambda_H^2}{4\pi} P_{\mathcal{E}}^{ab} P_{\mathcal{E}}^{cd} \Pi_{ab,cd} \frac{M^5}{D^{10}} \omega.$$

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

$$\rho_H(\omega) \propto \omega \quad (\omega \ll \kappa)$$

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 P_{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_{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:

Supplies:	yes, conditionally, as a projected additive Ohmic infrared sector;
Bounds:	no model-independent bound on g_Q^2 or the full ρ_{QQ} ;
Irrelevant:	only when the channel is absent, unprojected, protocol-only, or already included in the retained gravitational susceptibility.

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:

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_{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_{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 $P_A G_{\text{grav}}^{AB} P_B$;
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 $\text{Im } z > 0$, 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

$$-\frac{1}{\pi} \text{Im} \Sigma^R(\omega) = \frac{g^2}{\pi} \frac{\omega\omega_c}{\omega^2 + \omega_c^2} = \rho(\omega).$$

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:

$$\rho_{QQ}(\omega) = -\frac{1}{\pi} \text{Im} \Sigma_{QQ}^R(\omega + i0), \quad \omega > 0,$$

and, in a KMS state,

$$\mathcal{N}_{QQ}(\omega) = -2 \coth\left(\frac{\beta\omega}{2}\right) \text{Im} \Sigma_{QQ}^R(\omega) = 2\pi\rho_{QQ}(|\omega|) \coth\left(\frac{\beta|\omega|}{2}\right).$$

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

1. STF First Principles v8.1, frozen publication baseline, 26 August 2026.
2. STF First Principles v8.2, gravitational-candidate architecture, 28 August 2026.
3. STF v8.2 Open-Operator and Deformed-Identity Classification Gate, version 1.0, 28 August 2026.
4. STF v8.1 Covariant Clock, World-Tube, Gaussian Bath, and Ward Completion, project calculation archive.
5. STF v8.1 Compact-Alignment QQ Susceptibility and Environment Normalization Gate, project calculation archive.
6. STF v8.1 Boundary-CMC Rank-One Drude Bath Reconciliation and Local Dirac Gate, project calculation archive.

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.
9. D. L. Danielson, J. Kudler-Flam, G. Satishchandran, and R. M. Wald, [How to Minimize the Decoherence Caused by Black Holes](#), arXiv:2501.04773.

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

$$K_{\text{sel}}^R(\omega) = \frac{-i\omega}{\omega_c - i\omega}, \quad K_{\text{sel}}^R(0) = 0,$$

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,

$$\delta\tilde{Q}_{\Delta,+} = \delta\tilde{Q}_{\Delta,-} = \epsilon, \quad \delta X_{\alpha,+} = \delta X_{\alpha,-} = \lambda_\alpha \epsilon, \quad D_U \epsilon = 0,$$

then the 1PI Ward identity forbids an undifferentiated static $Q_a Q_r$ contact. The resulting retarded kernel obeys $K^R(0) = 0$ to every loop order. A finite Gaussian environment written only through the relative coordinates $X_\alpha - \lambda_\alpha \tilde{Q}_\Delta$ 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

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

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

$$\Sigma_{QQ}^R(z) = G_{FF}^R(z) - G_{FF}^R(0), \quad \Sigma_{QQ}^R(0) = 0.$$

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	STF_First_Principles_Paper_V8_1_fixed_FINAL_2026-08-26.md
publication	
baseline	

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

$$W = C - DX, \quad \mathcal{J} = C - XC_X + X^2D_X,$$

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 $K(\phi, \tilde{X})$, 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 $K(\tilde{X})$ retains only the global shift. Explicit ϕ dependence generally removes

even that. A cuspiton-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 $(\tilde{\square}\phi)^2$. At first loop order it is equation-of-motion redundant, and the essential on-shell representative is $\tilde{X}^2$. 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 $\tilde{Q}_{\Delta,+}$ and $\tilde{Q}_{\Delta,-}$ be the two closed-time-path histories and define

$$\tilde{Q}_{\Delta,r} = \frac{1}{2}(\tilde{Q}_{\Delta,+} + \tilde{Q}_{\Delta,-}), \quad \tilde{Q}_{\Delta,a} = \tilde{Q}_{\Delta,+} - \tilde{Q}_{\Delta,-}.$$

At quadratic order the 1PI influence functional contains

$$\Gamma_{\text{IF}}^{(2)} = \int d^4x d^4x' \tilde{Q}_{\Delta,a}(x) K_{QQ}^R(x, x') \tilde{Q}_{\Delta,r}(x') + \frac{i}{2} \int d^4x d^4x' \tilde{Q}_{\Delta,a}(x) N_{QQ}(x, x') \tilde{Q}_{\Delta,a}(x').$$

The desired condition is

$$K_{QQ}^R(\omega = 0, \mathbf{k}) = 0$$

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

$$\delta\tilde{Q}_{\Delta,+} = \epsilon, \quad \delta\tilde{Q}_{\Delta,-} = \epsilon,$$

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

$$\delta\tilde{Q}_{\Delta,r} = \epsilon, \quad \delta\tilde{Q}_{\Delta,a} = 0.$$

The exact Ward identity is therefore

$$\int_{\mathcal{L}} d\tau \frac{\delta\Gamma}{\delta\tilde{Q}_{\Delta,r}(\tau, \sigma)} = 0,$$

with a separate identity for each line label σ when the transformation is a subsystem symmetry.

Differentiating once with respect to $\tilde{Q}_{\Delta,a}$ and then setting the advanced fields to zero gives

$$\int_{\mathcal{L}} d\tau' K_{QQ}^R(\tau, \sigma; \tau', \sigma') = 0.$$

Fourier transformation along the stationary clock line sets the integral to $K_{QQ}^R(0, \mathbf{k})$. 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,

$$\nabla_\mu T^\mu{}_{\nu, \text{tot}} = \sum_I E_I \nabla_\nu \Psi^I \text{tensor-index terms},$$

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 $\sqrt{-g} \tilde{Q}_{\Delta,a} \tilde{Q}_{\Delta,r}$ 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

$$S_{\text{rel}} = \frac{1}{2} \sum_{\alpha} \int d^4x \sqrt{-g} \left[(D_U X_{\alpha})^2 - \Omega_{\alpha}^2 (X_{\alpha} - \lambda_{\alpha} \tilde{Q}_{\Delta})^2 \right].$$

It is invariant under

$$\delta \tilde{Q}_{\Delta} = \epsilon, \quad \delta X_{\alpha} = \lambda_{\alpha} \epsilon, \quad D_U \epsilon = 0,$$

provided any transverse bath derivatives, state, and boundary data share the same symmetry. Expanding the square gives

$$-\frac{1}{2} \Omega_{\alpha}^2 X_{\alpha}^2 + c_{\alpha} X_{\alpha} \tilde{Q}_{\Delta} - \frac{1}{2} \frac{c_{\alpha}^2}{\Omega_{\alpha}^2} \tilde{Q}_{\Delta}^2, \quad c_{\alpha} = \Omega_{\alpha}^2 \lambda_{\alpha}.$$

Thus the bilinear vertex and its local static counterterm are not independent coefficients. The common-translation null vector of the potential Hessian is

$$v_0 = (1, \lambda_1, \dots, \lambda_n).$$

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

$$\Sigma_{QQ}^R(z) = \sum_{\alpha} c_{\alpha}^2 \left[\frac{1}{z^2 - \Omega_{\alpha}^2} + \frac{1}{\Omega_{\alpha}^2} \right],$$

so

$$\Sigma_{QQ}^R(0) = 0.$$

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

$$c_{\text{ct}} = 2 \int_0^{\infty} \frac{\rho_{QQ}(\Omega)}{\Omega} d\Omega = \sum_{\alpha} \frac{c_{\alpha}^2}{\Omega_{\alpha}^2}.$$

The sign with which this coefficient appears in the action is fixed by the convention for G_{FF}^R ; the invariant statement is

$$\Sigma_{QQ}^R(z) = G_{FF}^R(z) - G_{FF}^R(0).$$

At each loop order a genuine symmetry requires the renormalized contact and spectral moment to move together:

$$\delta c_{\text{ct}}^{(L)} = 2 \int_0^\infty \frac{\delta \rho_{QQ}^{(L)}(\Omega)}{\Omega} d\Omega.$$

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 $Q_a Q_a$ noise.

V. Functional-form alternatives

V.A History-difference form

A sufficient exact 1PI functional form on each clock line is

$$\Gamma_{\text{IF}}^{\text{diff}} = \int d\tau d\tau' Q_a(\tau) L^R(\tau - \tau') [Q_r(\tau') - Q_r(\tau)] + \Gamma_{aa}[Q_a] + \dots$$

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 $Q_a Q_r$ 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,

$$K_{\text{bath}}^R(\omega) \sim -i\gamma\omega \implies K_{\text{deriv}}^R(\omega) \sim -i\gamma\omega^3.$$

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

$$K_{QQ}^R(0) = 0$$

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

VIA 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

$$\|\delta \mathcal{C}\| = \frac{s}{M_*^2 q_N} |\epsilon| \longrightarrow \infty \quad (q_N \rightarrow 0, \Delta > 0).$$

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

$$\tilde{Q}_\Delta = W(B) Q_\Delta, \quad W(B) = B^2(3 - 2B).$$

Trying to realize $\delta \tilde{Q}_\Delta = \epsilon$ 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

$$\delta Q_\Delta = \epsilon, \quad \delta X_\alpha = \lambda_\alpha W(B) \epsilon.$$

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

$$K_{\text{sel}}^R(\omega) = \frac{-i\omega}{\omega_c - i\omega}.$$

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 $X_\alpha - \lambda_\alpha \tilde{Q}_\Delta$	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 $\tilde{Q}_\Delta$ 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

$$c_0(\mu) = c_{\text{ct}}(\mu) + \Sigma_{\text{loops}}^R(0; \mu).$$

Without a Ward identity, zero DC is the condition

$$c_0(\mu_*) = 0$$

at a chosen matching scale μ_* . Perturbatively this requires

$$c_{\text{ct}}^{(L)} = -\Sigma_{QQ}^{R,(L)}(0)$$

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

$$\delta c_0^{(L)} \sim \frac{1}{(16\pi^2)^L \Lambda_{\text{EFT}}^4} F_L(\text{dimensionless couplings and ratios}).$$

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 $|c_0| < \varepsilon_{\text{stat}}$, the required relative tuning at loop order L is

$$\mathcal{T}_L \lesssim \frac{\varepsilon_{\text{stat}}}{|\delta c_0^{(L)}|}.$$

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 $\tilde{Q}_\Delta$ 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 $\bar{W} = 0$ 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

$$\text{diagonal diffeomorphism invariance} \implies K_{QQ}^R(0) = 0.$$

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

$$\text{Im } K_{\text{sel}}^R(\omega) \propto -\omega \quad (\omega \rightarrow 0),$$

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 $Q_a Q_r$ 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 $Q_a Q_r$ 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 $D_U W \neq 0$;
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 $\mathcal{Y} = \tilde{Q}_\Delta - R$, with a diagonal translation $\delta\tilde{Q}_\Delta = \delta R = \epsilon$. The compact constraint tying an independent $\tilde{Q}_\Delta$ 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 $Q_a Q_r$ 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 $D_U W \neq 0$;

10. singularity of the curvature realization at $q_N = 0$;
11. the $\omega \rightarrow \omega^3$ 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.

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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,

$$S_{\text{direct}} = S_{\text{EH}} + S_{\phi} + \kappa \int d^4x \sqrt{-g} \phi D_U q_N[g, N], \quad q_N = \sqrt{R^2 + 8\mathcal{W}_N}.$$

Sector (b) is the surviving clock-adapted, action-level order-reduced parent on the branch analytic in ϵ_{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

$$\hbar\Omega = (1.482, 1.349) \times 10^{-19} \text{ eV}, \quad \frac{\hbar c}{a} = (1.012, 1.140) \times 10^{-16} \text{ eV}.$$

The paper's standard ghostful fourth-order model is forced into a heavy-mode regime and gives the stronger GW170817 scale $m \gtrsim 10^{-11} \text{ eV}$. 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

$$S_{\text{rate}}^{(2)} \supset -\frac{\kappa A_0}{4|R_0|} \int d^4x a^3 \ddot{\gamma}_{ij} \ddot{\gamma}^{ij}, \quad A_0 = \dot{\phi}_0 + 3H\phi_0,$$

and the factorized tensor propagator has equal and opposite residues. A locally frozen canonical pole diagnostic is

$$m_{\text{gh}}^2(x) = \frac{M_{\text{Pl}}^2 q_N(x)}{2\kappa |A(x)|},$$

up to the explicitly acknowledged order-unity polarization normalization. With the v8.2 $\kappa = 1.0189 \times 10^{70}$, the v8.1 tracking or oscillating scalar benchmarks, and declared FLRW/Schwarzschild curvature proxies, the diagnostic lies from 10^{-38} eV on FLRW through about 10^{-24} eV at pulsar separations and 10^{-19} – 10^{-16} 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

IA 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	f7eca3fb88e

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.

IB 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

$$V_{4\text{th}}(r) = -\frac{Gm_1m_2}{r} \left(1 - \frac{4}{3}e^{-m_2r} + \frac{1}{3}e^{-m_0r} \right),$$

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

$$\frac{m_2^2\alpha_2}{M_{\text{Pl}}^2}, \quad \frac{m_0^2(3\alpha_1 + \alpha_2)}{M_{\text{Pl}}^2},$$

so the Newtonian potential and GR quadrupole flux are recovered when $\alpha_1, \alpha_2 \rightarrow 0$, 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 d	1.9491×10^9 m	1.48195×10^{-19} eV	1.01243×10^{-16} eV
PSR J1738+0333	0.3547907398724 d	1.7307×10^9 m	1.34915×10^{-19} eV	1.14017×10^{-16} 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

$$\dot{P}_{\text{HT}}^{\text{obs}} = -(2.398 \pm 0.004) \times 10^{-12}, \quad \dot{P}_{\text{HT}}^{\text{GR}} = -(2.40263 \pm 0.00005) \times 10^{-12},$$

and

$$\dot{P}_{1738}^{\text{obs}} = -(25.9 \pm 3.2) \times 10^{-15}, \quad \dot{P}_{1738}^{\text{GR}} = -27.7_{-1.9}^{+1.5} \times 10^{-15}.$$

Taking the largest displacement between the observed one-sigma endpoints and the central GR value gives diagnostic fractional envelopes

$$\varepsilon_{\text{HT}}^{1\sigma} = 3.5919 \times 10^{-3}, \quad \varepsilon_{1738}^{1\sigma} = 1.8051 \times 10^{-1}.$$

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 $m \gtrsim 10^{-11}$ 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 $m \sim 10^{-11}$ 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

$$m \gtrsim 9.861 \times 10^{-16} \text{ eV} \quad (\text{Hulse-Taylor}),$$

and

$$m \gtrsim 6.175 \times 10^{-16} \text{ eV} \quad (\text{J1738}).$$

It then reports 6.175×10^{-16} eV as the combined tightest lower bound. If one universal equal mass must satisfy both quoted inequalities, their intersection is instead

$$m \gtrsim \max(9.861, 6.175) \times 10^{-16} \text{ eV} = 9.861 \times 10^{-16} \text{ eV}.$$

This arithmetic point does not alter the stronger 10^{-11} 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,

$$S_{\text{rate}} = -\kappa \int d^4x \sqrt{-g} A q_N + S_{\partial}, \quad A = D_U \phi + \theta \phi.$$

For a curvature state u_A with $q = \sqrt{u_A u_A}$,

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

If normal metric accelerations enter through $J_{AI} = \partial u_A / \partial a_I$, the physical acceleration Hessian contains

$$H_{IJ}^{(a)} = -\frac{\kappa A}{q} J^T (I - \hat{u} \hat{u}^T) J.$$

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

$$L_T^{(2)} = \frac{A_T}{2} \dot{\gamma}^2 + \frac{C_T}{2} \ddot{\gamma}^2 + \dots$$

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

$$\mathcal{F}_T(\omega) = \mathcal{F}_{\text{GR}}(\omega) \left[1 - \Theta(\omega - m_{\text{gh}}) \mathcal{V} \left(\frac{m_{\text{gh}}^2}{\omega^2} \right) \right], \quad \mathcal{V}(0) = 1.$$

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 $A_T = M_{\text{Pl}}^2/4$ and the coefficient shown in Appendix P.2 gives the canonical diagnostic

$$m_{\text{gh}}^2(x) = \left| \frac{A_T}{C_T} \right| = \frac{M_{\text{Pl}}^2 q_N(x)}{2\kappa |A(x)|}.$$

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 $x = \phi/M_{\text{Pl}}$, gives $A \simeq 4H_0xM_{\text{Pl}}$, hence

$$m_{\text{gh,track}}^2 = \frac{3M_{\text{Pl}}H_0}{2\kappa x}.$$

At the declared upper benchmark $x = 1$,

$$m_{\text{gh,track}} \simeq 2.39 \times 10^{-38} \text{ eV}.$$

For the oscillating benchmark $\phi = A_\phi \cos m_s t$, use the envelope $|A| \simeq m_s A_\phi$ and $A_\phi/M_{\text{Pl}} = 8.3 \times 10^{-11}$. Then

$$m_{\text{gh,osc}}^2 = \frac{6M_{\text{Pl}}H_0^2}{\kappa m_s (A_\phi/M_{\text{Pl}})}, \quad m_{\text{gh,osc}} \simeq 3.35 \times 10^{-38} \text{ eV}.$$

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_{Gb} TRACKING	M_{Gb} OSCILLATING
Hulse-Taylor total mass at reproduced separation	$1.69 \times 10^{-24} \text{ eV}$	$2.36 \times 10^{-24} \text{ eV}$
J1738 total mass at reproduced separation	$1.53 \times 10^{-24} \text{ eV}$	$2.15 \times 10^{-24} \text{ eV}$
$2.5M_\odot$ at 750 km	$2.10 \times 10^{-19} \text{ eV}$	$2.94 \times 10^{-19} \text{ eV}$
$2.5M_\odot$ at 20 km	$4.82 \times 10^{-17} \text{ eV}$	$6.74 \times 10^{-17} \text{ eV}$
$1.25M_\odot$ at 10 km	$9.64 \times 10^{-17} \text{ eV}$	$1.35 \times 10^{-16} \text{ eV}$

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} 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

$$K_{\text{sel}}^R(\omega) = \frac{-i\omega}{\omega_c - i\omega}, \quad |K_{\text{sel}}^R| = \frac{|\omega|}{\sqrt{\omega_c^2 + \omega^2}}.$$

The direct rate term corresponds to

$$K_{\text{local}}^R \simeq -\frac{i\omega}{\omega_c} \quad (|\omega| \ll \omega_c).$$

Taking $\hbar\omega_c \simeq m_s = 3.94 \times 10^{-23}$ eV, the ratios are

$$\frac{\Omega_{\text{HT}}}{\omega_c} \simeq 3.76 \times 10^3, \quad \frac{\Omega_{1738}}{\omega_c} \simeq 3.42 \times 10^3,$$

and for a 10 Hz angular frequency,

$$\frac{2\pi\hbar(10 \text{ Hz})}{m_s} \simeq 1.05 \times 10^9.$$

The ratio of the local approximation's magnitude to the exact response is

$$\frac{|K_{\text{local}}|}{|K_{\text{sel}}|} = \sqrt{1 + \frac{\omega^2}{\omega_c^2}}.$$

It therefore over-extrapolates by the same factors. The exact memory is already saturated:

$$|K_{\text{sel}}| > 0.99999995$$

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

direct local $q_N[g, N]$ metric action: CLOSEDGENERALLY.

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 $(\mathcal{F}_{ij}, \Pi_{\mathcal{F}}^{ij})$, varies every field, and then selects the solution analytic in ϵ_{STF} and connected to Einstein gravity. The jet Jacobian is

$$\mathbf{J}_{\text{jet}}(k) = I_6 + \epsilon_{\text{STF}} \mathbf{A}(k),$$

with sufficient invertibility condition

$$|\epsilon_{\text{STF}}| \|\mathbf{A}(k)\|_2 < 1$$

for every physical momentum below the EFT cutoff. The augmented CMC-volume operator must likewise obey

$$\|\epsilon_{\text{STF}} \mathbb{J}_0^{-1} \delta \mathbb{J}\|_2 < 1.$$

At the quadratic retarded level, write schematically

$$K_T^R = K_{T,\text{GR}}^R + \epsilon_{\text{STF}} \Pi_T^R + O(\epsilon_{\text{STF}}^2).$$

The analytic solution is

$$\gamma = D_{\text{GR}}^R J_T - \epsilon_{\text{STF}} D_{\text{GR}}^R \Pi_T^R D_{\text{GR}}^R J_T + O(\epsilon_{\text{STF}}^2),$$

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 $\mathbf{A}(k)$, $\delta \mathbb{J}$, 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

$$\delta_{\dot{P}}^{(s)} = \frac{\dot{P}_{\text{STF}}^{(s)} - \dot{P}_{\text{GR}}^{(s)}}{\dot{P}_{\text{GR}}^{(s)}}, \quad \delta_{\dot{\Omega}} = \frac{\dot{\Omega}_{\text{STF}} - \dot{\Omega}_{\text{GR}}}{\dot{\Omega}_{\text{GR}}}.$$

The linked inputs impose the diagnostic conditions

$$|\delta_{\dot{P}}^{\text{HT}}| \lesssim 3.59 \times 10^{-3},$$

$$|\delta_{\dot{P}}^{1738}| \lesssim 1.81 \times 10^{-1},$$

and

$$|\delta_{\Omega}^{170817}| \lesssim 6.67 \times 10^{-3}$$

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 $|K_{\text{sel}}| \simeq 1$. 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 $A(k)$, 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 $A(k)$ 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:

$$\dot{E}_{\text{orb}} = - \left(\mathcal{F}_T + \mathcal{F}_{\text{STF}} + \mathcal{F}_{\text{clock}} + \mathcal{F}_{\text{mem/env}} + \mathcal{F}_{\text{matter}} \right).$$

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

extra direct ghost emission: CONDITIONAL PASS,
binary-pulsar total flux: OPEN,
GW170817 chirp and tensor cone: OPEN.

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 9.861×10^{-16} 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 $m_{\text{gh}}^2 = M_{\text{pl}}^2 q / (2\kappa A)$	local frozen P.2 normalization	derived diagnostic	background dependent
displayed FLRW pole estimates are $O(10^{-38}$ eV)	v8.1 benchmarks	reproduced diagnostic	direct route remains closed
displayed compact Weyl scan lies below 10^{-11} 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 $A(k)$ 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} 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 $r \sim 10^{14}$ 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 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 $t_{\text{acc}} = \xi_{\text{acc}} \ell_B / c$, and the synchrotron time $t_{\text{syn}}^{A,Z}(\mathcal{R}_H, \mathcal{B})$. The maximum-rigidity production surface is

$$\Sigma_U^{A,Z} : \quad \mathfrak{F}_{A,Z} \equiv \ln \left(\frac{t_{\text{syn}}^{A,Z}(\mathcal{R}_H, \mathcal{B})}{t_{\text{acc}}(\ell_B)} \right) = 0,$$

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 $t_{\text{syn}}(\mathcal{R}_H)/t_{\text{acc}} \propto r^{5/2}$. 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 $\tau_\gamma \simeq c/v_{\text{sh}}$ 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

$$S_{\text{vis}}^{\text{CTP}} = -\frac{1}{2} \sum_{s=\pm} s \int d^4x \sqrt{-g_s} \frac{Q_{\Delta,s}}{\Lambda_i^4} \mathcal{G}_i(\Upsilon_{Z,s}) W_i \mathcal{M}_{i,s}^{\mu\nu} F_{\mu\nu,s},$$

where $\mathcal{M}_i^{\mu\nu}$ is an antisymmetric, varied material polarization or magnetization operator of the plasma. It induces

$$J_{\text{prod},i}^\mu = \nabla_\nu \left[\frac{Q_\Delta}{\Lambda_i^4} \mathcal{G}_i(\Upsilon_Z) W_i \mathcal{M}_i^{\nu\mu} \right], \quad \nabla_\mu J_{\text{prod},i}^\mu = 0.$$

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

$$\mathfrak{R}_{\text{ch}} \equiv \frac{g_{\text{U}}^2/P_{\text{U}}^{\text{crit}}}{g_{\gamma}^2/P_{\gamma}^{\text{crit}}} = \left(\frac{T_{\text{U}}}{T_{\gamma}}\right)^{11/4} = \left(\frac{3.3 \text{ yr}}{71 \text{ d}}\right)^{11/4} \simeq 2.41 \times 10^3.$$

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	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	f7eca3fb88f

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:

- the displayed architecture has no derived UHECR or GRB production operator;
- a Maxwell term homogeneous in $F_{\mu\nu}$ cannot generate classical photons from $F_{\mu\nu} = 0$;
- a sequestered ultralight scalar does not produce high-energy photons merely through its on-shell decay;
- the production world tube and self-field prescription are load-bearing;
- 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

$$t_m(a) = \frac{5}{256} \frac{c^5 a^4}{G^3 \mu M^2},$$

and

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

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 $\tau_- = 0.1 \text{ yr}$. 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

$$\mathcal{R}_{\text{max,EV}} \lesssim 3 \times 10^{-16} \Gamma R_{\text{cm}} B_G,$$

$$L_{\text{bol}} \gtrsim 10^{41} \Gamma_{\text{jet}}^2 \mathcal{R}_{\text{max,EV}}^2 \text{ erg s}^{-1},$$

and an observed UHECR energy-injection density of order

$$\dot{Q}_{\text{UHECR}} \sim 6 \times 10^{44} \text{ erg Mpc}^{-3} \text{ yr}^{-1}.$$

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 $r_0 = 500$ km, approximately 150 ms after merger, are

$$\mathcal{B}_0 \simeq 3.3 \times 10^{12} \text{ G}, \quad \ell_B \simeq r/3, \quad \mathcal{B}(r) \propto r^{-3/2}.$$

Particle-in-cell results motivate

$$\frac{dN}{d\mathcal{R}} \propto \mathcal{R}^{-p} \operatorname{sech} \left[\left(\frac{\mathcal{R}}{\mathcal{R}_{\text{cut}}} \right)^2 \right],$$

and

$$\mathcal{R}_{\text{cut,EV}} \simeq (3 \times 10^{-16})(0.65)\mathcal{B}_G \ell_{B,\text{cm}}.$$

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 , He, O, Si, Fe, Te,

$$\mathcal{R}_{\text{cut}} \simeq (6.2, 9.4, 7.1, 6.4, 6.0, 5.9) \text{ EV}$$

at

$$r_{\text{crit}} \simeq (1.8, 0.8, 1.4, 1.7, 1.9, 2.0) \times 10^{14} \text{ cm}.$$

Using the paper's $v_{\text{ej}} = 0.1c$ - $0.2c$ gives source-frame expansion times of 0.154-0.772 d. The jet calculation moves to $r \sim 10^{15}$ cm and gives approximate proton and helium cutoffs of 11.5 and 35 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,

$$z = 0.73, \quad \tilde{H} \simeq 5.69 \times 10^{12} \text{ cm}, \quad \tilde{\rho} \simeq 4.20 \times 10^{-9} \text{ g cm}^{-3},$$

and

$$t_{\text{delay}} \simeq (1+z) \frac{\tilde{H}}{4\gamma_{\text{sf}}^2 c} = 11.264 \text{ s.}$$

The final shocked-fluid Lorentz factor $\gamma_{\text{sf},f} = 15$ yields

$$\Delta t \simeq (1+z) \frac{\tilde{H}}{2\gamma_{\text{sf},f}^2 c} \simeq 0.729 \text{ s.}$$

The inferred shock-breakout luminosity is approximately $10^{51} \text{ erg s}^{-1}$. 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

$$\begin{aligned} Q_\Delta &= M_*^2 \left(\sqrt{q_N^2 + \Delta^2} - \Delta \right), \\ (D_U + \omega_c)Z &= D_U Q_\Delta, \\ \Upsilon_Z &= \frac{\omega_c |Z|}{M_*^2 (q_N^2 + \delta_B^2)^{3/4}}, \end{aligned}$$

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

$$|K_{\text{sel}}^R| = \frac{|\omega|}{\sqrt{\omega_c^2 + \omega^2}} \simeq 1.$$

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:

$\text{supp}(f\mathcal{O}) \subseteq \text{supp}(\mathcal{O})$ 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

$$h_{\mu\nu}^{(u)} = g_{\mu\nu} + u_\mu u_\nu.$$

Define the comoving magnetic four-vector and its magnitude by

$$\mathcal{B}^\mu = {}^*F^{\mu\nu}u_\nu, \quad \mathcal{B} = \sqrt{h_{\mu\nu}^{(u)}\mathcal{B}^\mu\mathcal{B}^\nu}.$$

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

$$\mathcal{R}_H = \xi_H \mathcal{B} \ell_B, \quad t_{\text{acc}} = \xi_{\text{acc}} \frac{\ell_B}{c},$$

where the numerical values corresponding to the linked PIC fit are $\xi_H \rightarrow (3 \times 10^{-16})(0.65)$ in $\text{EV}/(\text{G cm})$ and $\xi_{\text{acc}} \simeq 1.6$.

For a nucleus (A, Z) , define the synchrotron time covariantly in the ejecta frame,

$$t_{\text{syn}}^{A,Z} = \frac{E}{-(u^\mu \nabla_\mu E)_{\text{syn}}},$$

using the local magnetic magnitude and the standard radiative power. The maximum-rigidity surface is

$$\Sigma_U^{A,Z} \equiv \{x \in \mathcal{W}_{\text{ej}} : \mathfrak{F}_{A,Z}(x) = 0\}, \quad \mathfrak{F}_{A,Z} \equiv \ln \frac{t_{\text{syn}}^{A,Z}(\mathcal{R}_H, \mathcal{B})}{t_{\text{acc}}(\ell_B)}.$$

This equality must be supplemented by

$$n_{A,Z} > 0, \quad \mathcal{R}_H \geq \mathcal{R}_{\text{req}}, \quad t_{\text{esc}} < t_{\text{life}}, \quad u^\mu \nabla_\mu \mathfrak{F}_{A,Z} \neq 0.$$

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,

$$\mathcal{B} \propto r^{-3/2}, \quad \ell_B \propto r, \quad \mathcal{R}_H \propto r^{-1/2}.$$

At $\mathcal{R}_H$, synchrotron power scales as $E^2 \mathcal{B}^2 \propto r^{-4}$, so $t_{\text{syn}} \propto r^{7/2}$, whereas $t_{\text{acc}} \propto r$. Thus

$$\frac{t_{\text{syn}}}{t_{\text{acc}}} \propto r^{5/2}.$$

The crossing is monotone and unique for each species in the declared regime. This reproduces the physical meaning of the linked r_{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

$$\tau_\gamma(x, k) = \int_x^{\partial \mathcal{W}_{\text{disk}}} \kappa_\gamma \rho (-u \cdot k) d\lambda.$$

Let v_{sh} be the locally measured shock speed. The breakout surface can be defined by

$$\Sigma_\gamma \equiv \left\{ x \in \mathcal{W}_{\text{disk}} : \mathfrak{F}_\gamma(x) \equiv \tau_\gamma(x, k) - \frac{c}{v_{\text{sh}}} = 0 \right\}.$$

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 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 yr, 71 d, or 0.1 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

$$\nabla_\mu [Z_F(Q_\Delta) F^{\mu\nu}] = 0.$$

The solution $F_{\mu\nu} = 0$ remains exact. The same classical non-entailment applies to a scalar $Q_\Delta F_{\mu\nu} \tilde{F}^{\mu\nu}$ 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

$$S_{\text{vis}}^{\text{CTP}} = -\frac{1}{2} \sum_{s=\pm} s \int_{\mathcal{M}_s} d^4x \sqrt{-g_s} \frac{Q_{\Delta,s}}{\Lambda_i^4} \mathcal{G}_i(\Upsilon_{Z,s}) W_i \mathcal{M}_{i,s}^{\mu\nu} F_{\mu\nu,s}.$$

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

$$J_{\text{prod},i}^\mu = \nabla_\nu \left[\frac{Q_\Delta}{\Lambda_i^4} \mathcal{G}_i(\Upsilon_Z) W_i \mathcal{M}_i^{\nu\mu} \right].$$

Because the bracket is antisymmetric,

$$\nabla_\mu J_{\text{prod},i}^\mu = 0$$

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. $\mathcal{M}_U^{\mu\nu}$ 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 $\mathcal{R}_{\text{cut}}$ 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,

$$\nabla_\mu \left(T_{\text{grav}\nu}^\mu + T_{Q\nu}^\mu + T_{Z\nu}^\mu + T_{\text{mat}\nu}^\mu + T_{\text{EM}\nu}^\mu + T_{\text{env}\nu}^\mu \right) = 0$$

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 uncanceled 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 yr	conditional outer activation boundary	none	pre-merger
3.32 yr	UHECR observational/phase anchor	BNS maximum-rigidity surface at 0.15-0.77 d	STF pre; linked post
71 d	GRB observational anchor	AGN-disk breakout at 11.264 s	STF pre; linked post
0.1 yr = 36.5 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,

$$g_i^2 \mathcal{A}_0^2 \tau_i^{-11/4} = P_i^{\text{crit}}.$$

Then

$$\frac{g_i^2}{P_i^{\text{crit}}} = \frac{\tau_i^{11/4}}{\mathcal{A}_0^2}.$$

For the UHECR and GRB anchors,

$$\mathfrak{R}_{\text{ch}} \equiv \frac{g_{\text{U}}^2 / P_{\text{U}}^{\text{crit}}}{g_{\gamma}^2 / P_{\gamma}^{\text{crit}}} = \left(\frac{T_{\text{U}}}{T_{\gamma}} \right)^{11/4}.$$

Using the legacy rounded values gives

$$\left(\frac{3.3 \text{ yr}}{71 \text{ d}} \right)^{11/8} = 49.10, \quad \mathfrak{R}_{\text{ch}} = 49.10^2 = 2.410 \times 10^3.$$

Using the reproduced 3.324 yr and 71.82 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^{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 0.37-0.77 d and the 11.264 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 s for nuclei to form in the cooling BNS outflow;
- 0.15-0.77 d for the listed bulk-outflow critical radii;
- hours to roughly a day for source-produced neutrinos;
- 11.264 s for the fitted AGN-disk shock breakout;
- 0.729 s for the fitted burst duration.

None is 0.1 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

$$\tau_+ = 53.8804 \text{ yr}$$

from $n = 11/8$, $\bar{\tau}_I = 3.31 \text{ yr}$, and $\tau_- = 0.1 \text{ yr}$. 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 $\Re_{\text{ch}} \simeq 2.4 \times 10^3$;

5. an independently derived lower support boundary $\tau_- = 0.1 \text{ yr}$;
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 $\mathfrak{R}_{\text{ch}}$ 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
$\Sigma_U^{A,Z}$ 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
$\mathfrak{R}_{\text{ch}} \simeq 2.4 \times 10^3$ is required under the common quadratic law	timing algebra	derived target	item 25 remains open
the linked physical thresholds derive $\mathfrak{R}_{\text{ch}}$	different operators/populations	false transfer	no upgrade
the linked times derive $\tau_- = 0.1 \text{ yr}$	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	$t_{\text{syn}} = t_{\text{acc}}$	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	$\tau_{\gamma} \simeq c/v_{\text{sh}}$	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	$\tau_{-} = 0.1$ 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_U^2/P_U^{crit} and $g_\gamma^2/P_\gamma^{\text{crit}}$ 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 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.

References

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7. Z. Paz, *STF v8.2 Open-Operator Deformed-Identity Classification Gate*, version 1.0.

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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
$H^{\text{cap}} = M_*^2 J^{-1}$	compact geometry	QQ propagator	theorem
$\chi_{QQ}^{\text{aux}} = 0$	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

References

Project papers and external literature carried forward from v8.1 (retained in full; the gravitational-revision citations follow).

Project papers (existshappens.com): *First Principles* V7.9 — *derivation record*, papers/first-principles-v7-9/ (SM unification K; CICY Q; flavour R; Weil–Petersson S; full 10D reduction L; cosmology M; MOND I; inflation J; dipole H); *Clock-Separation Theorem* V1.1; *Universal Embedding Principle* V1.1; *Topological Closure on the Complexified Null Cone* V6.3; *The Complexified Null Cone as the Geometric Seat of Retrocausal Activation* V1.0; *The Structure of What Happens* (General Theory) V3.1; *Theory of Time* V4.3; *Consciousness, Time & Identity* V4.0; *Retrocausality & Life* V0.7; *Temporal Workspace* V0.5; *Closure–Capacity Correspondence* V1.0; *Theorem Class* V1.0; *One Bit of Destiny* V1.0; *Bandwidth Argument* V2.0; *Framework Guide* V3.3; observational manuscript, uhecrtoday.com/papers/manuscript/.

External: Acedo, L. (2017), arXiv:1701.05735 (Rosetta/Juno nulls). Anderson, J.D. et al. (2008), PRL 100, 091102. Bellini, E. & Sawicki, I. (2014), JCAP 07, 050 (α -basis). Bonilla & Sopuerta (1999), gr-qc/9904031 (Bel tensor). Boyle, Caldwell & Kamionkowski (2002), PLB 545, 17 (spintessence). Costa & Herdeiro (2008), gr-qc/0612140; Costa & Natário (2014), arXiv:1207.0465 (GEM congruences). Crossley, Glorioso & Liu (2017), JHEP 09, 095 (SK EFT). Durante et al. (2022), Nature Commun. (Jovian normal modes). Galley, C. (2013), PRL 110, 174301 (nonconservative action). Hehl & Obukhov (2003), *Foundations of Classical Electrodynamics*; Hehl (2016) arXiv:1601.00320 (premetric). Hervik, Ortaggio & Wylleman (2013), arXiv:1203.3563 (superenergy norms). Henry (2000), astro-ph/9912320; Cherubini et al. (2003), gr-qc/0302095 (Kerr invariants). JPL DESCANSO Monograph 2 §13 (DSN observables); Monograph 14 ch.5 (transponders); Descanso 16 (Juno). Kase & Tsujikawa (2019), IJMPD 28, 1942005. Kobayashi, Yamaguchi & Yokoyama (2011), PTP 126, 511. Margot et al. (2018), NTRS 20190002330 (Earth k_J); Jupiter interior arXiv:1109.1627; Venus arXiv:2103.01504. Mbelek (2008), arXiv:0809.1888. Minguzzi (2002), gr-qc/0204063 (sync connection). Nichols et al. (2011), PRD 84, 124014 (frame-drag). Owen et al. (2021), PRD 103, 124057. Semerák (2016), arXiv:1608.05948 (Kerr Kretschmann). Senovilla (2000), gr-qc/9906087 (superenergy). Turyshchev & Toth (2010), arXiv:0907.4184. TU Delft flyby reanalysis, repository uuid:a537388f... VSI spacetimes, gr-qc/0503040. Wald (1984), *General Relativity*. Yagi et al. (2014), arXiv:1311.7144 (preferred-frame PPN). Yunes & Pretorius (2009), PRD 79, 084043 (dynamical CS).

Added or re-stated for the gravitational revision.

STF project record. Z. Paz, *The Selective Transient Field from First Principles*, v8.1 (frozen baseline, 26 August 2026); the sixteen v8.1-only gravitational-completion checkpoint papers and NumPy reproduction scripts (27 August 2026); *Clock-Separation Theorem*; *Universal Clock Carrier*; *Universal Embedding Principle*; *Topological Closure on the Complexified Null Cone*; *Closure–Capacity Correspondence*; *One Bit of Destiny*; *Bandwidth Argument*; observational manuscript at uhecrtoday.com.

External literature. J. D. Anderson et al., *Anomalous Orbital-Energy Changes Observed during Spacecraft Flybys of Earth*, Phys. Rev. Lett. **100**, 091102 (2008). E. Bellini and I. Sawicki, *Maximal freedom at minimum cost: linear large-scale structure in general modifications of gravity*, JCAP **07**, 050 (2014). C. R. Galley, *Classical mechanics of nonconservative systems*, Phys. Rev. Lett. **110**, 174301 (2013). M. Crossley, P. Glorioso, and H. Liu, *Effective field theory of dissipative fluids*, JHEP **09**, 095 (2017). T. Kobayashi, M. Yamaguchi, and J. Yokoyama, *Generalized G-inflation*, Prog. Theor. Phys. **126**, 511 (2011). R. M. Wald, *General Relativity* (University of Chicago Press, 1984). J. M. M. Senovilla, *Super-energy tensors*, Class. Quantum Grav. **17**, 2799 (2000). M. Hehl and Y. Obukhov, *Foundations of Classical Electrodynamics* (Birkhäuser, 2003). L. Acedo, arXiv:1701.05735 (2017). K. Yagi et al., arXiv:1311.7144 (preferred-frame constraints).

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For the constrained Hamiltonian, CMC, and covariant Noether frameworks: P. A. M. Dirac, *Lectures on Quantum Mechanics* (Yeshiva University, 1964); J. W. York, Jr., *Role of conformal three-geometry in the dynamics of gravitation*, Phys. Rev. Lett. **28**, 1082–1085 (1972); M. Henneaux and C. Teitelboim, *Quantization of Gauge Systems* (Princeton University Press, 1992); V. Iyer and R. M. Wald, *Some properties of Noether charge and a proposal for dynamical black hole entropy*, Phys. Rev. D **50**, 846–864 (1994).

End of STF First Principles v9.0.

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