On the Equivalence of the κ-Field and the Commitment Field: A Unique Klein–Gordon Structure from Irreversible Fact Formation in the VERSF Framework

Keith Taylor *VERSF Theoretical Physics Programme*

For the General Reader

The VERSF programme has until now carried two distinct field-like structures: the commitment (entropy) density field s(x, t), which measures how many irreversible facts have been formed in a given region of spacetime, and the κ-field, which propagates the causal influence of those facts forward through time. These have been treated as related but distinct — one a source, the other a propagator.

This paper argues that the distinction is not fundamental, and that the field theory describing them is not chosen but *forced*.

The argument proceeds in three stages. First, we show that the source term in any field theory of commitment events must be additive — because commitment events are binary, irreducible, and independently attributable — and that any nonlinear self-interaction term would couple spacelike-separated commitment histories, violating causal separability. This rules out all nonlinear field theories and forces linearity from first principles. Second, we prove that under six structural requirements inherited from the VERSF architecture, the Lagrangian for the commitment density field is unique up to field rescaling. There is no freedom to choose a different field theory. Third, we derive the field equation from this Lagrangian by variation, recognise it as identical to the independently defined κ-field equation, and prove — as a formal theorem — that under physical boundary conditions the two fields are identical.

The consequence is not a new field theory. It is the proof that irreversible fact formation uniquely forces the known massive scalar structure, deriving rather than assuming the conditions that select it.

Abstract

We establish that the dynamics of irreversible commitment events uniquely determine a massive scalar field theory — the Klein–Gordon structure — as a structural theorem rather than a modelling choice. Beginning from the primitive structure of irreversible commitment events, we derive — rather than assume — the linearity of the commitment field equation. We prove that the source density $\rho\_{committed}$ is additive over disjoint regions, and that any nonlinear self-interaction term $F(s)$ in the field equation generates cross terms $F(s_1 + s_2) \neq F(s_1) + F(s_2)$ that couple spacelike-separated commitment histories, violating causal separability and independent attribution. We then prove a Lagrangian Uniqueness Theorem: under six admissibility conditions inherited from the VERSF architecture — with linearity now derived, not assumed — the Lagrangian

$$\mathscr{L} = \tfrac{1}{2}(\partial_\mu s)(\partial^\mu s) - \tfrac{1}{2}m^2 s^2 + s \cdot \rho\_{committed}$$

is the unique admissible scalar field theory for the commitment density $s(x, t)$. This is the Klein–Gordon Lagrangian with commitment sourcing; the novelty is not its form but the derivation of the conditions that force it from commitment structure alone.

The Euler–Lagrange equation is $(\Box + m^2)s = \rho\_{committed}$ with mass $m = \sqrt{4/3} \cdot \xi^{-1}$ fixed by [T4]. We prove formally that under retarded boundary conditions $s(x, t) \equiv \kappa(x, t)$ exactly, identifying the κ-field as the unique retarded propagating mode of s. From the same Lagrangian we derive the stress-energy tensor and show that the VERSF field sources gravitational curvature through commitment density gradients, consistent with Einstein's equations at leading order. The result reduces the VERSF field ontology to a uniquely determined minimal core, with a clear falsification structure: any competing theory must violate at least one of additivity, causal separability, finite propagation speed, or locality.

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1. Introduction

The VERSF programme is built on a single primitive: the irreversible commitment event — the formation of a physical fact [T1, T2, T7]. From this starting point, multiple structures have been developed:

- A commitment density field $s(x, t)$, measuring the local density of irreversible records per unit causal volume
- A κ-field, defined as a propagating massive scalar sourced by committed events, with mass $m = \sqrt{(4/3)} \cdot \xi^{-1}$ derived from the spectral structure of the minimal fact architecture [T4]
- A memory kernel $K(\tau) \sim \cos(m\tau)/\tau$ governing non-Markovian dynamics [T4, T6]
- A geometric sourcing relation connecting commitment density to spacetime curvature [T3, T7]

These structures have been individually well-motivated. Their relationship, however, has remained partially unresolved: the entropy field has been treated as a source, the κ-field as a propagator, and the connection between them as causal but not structurally identical. The Lagrangian governing the system has been presented as natural but not uniquely forced.

This paper resolves all three gaps in a single integrated derivation. The structure is as follows.

In §3 we prove that $\rho\_committed$ is additive over disjoint regions — a direct consequence of the binary, irreducible nature of commitment events — and derive linear source coupling without assuming it. In §4 we prove formally that any nonlinear term F(s) in the field equation generates cross terms coupling spacelike-separated commitment histories, violating the causal separability of independent facts; nonlinearity is therefore excluded by the primitives of the framework. Together, §§3–4 establish linearity from first principles.

In §5 we prove the Lagrangian Uniqueness Theorem: under six admissibility conditions — with linearity now derived — the Lagrangian is unique within its class. In §6 we derive the field equation by variation. In §7 we prove, as a formal theorem, that $s \equiv \kappa$ exactly under physical boundary conditions. In §§8–10 the memory kernel, stress-energy tensor, and gravitational sourcing all follow from the same Lagrangian.

The central claim of this paper is not that a new field theory has been proposed. It is that irreversible fact formation uniquely forces the known massive scalar structure, and that any alternative must violate one of four clearly stated physical primitives.

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2. The Commitment Density Field

2.1 Definition

Let s(x, t) denote the local commitment density — the number of irreversible commitment events instantiated per unit causal volume:

$$s(x, t) = \rho\_committed(x, t)$$

Each commitment event corresponds to a resolved, distinguishable alternative that has become a permanent record. The field s(x, t) carries dimensions of inverse four-volume — equivalently, the density of irreversible events per unit spacetime volume — ensuring dimensional consistency of the sourced field equation $(\square + m^2)s = \rho\_committed$, where $\rho\_committed$ has the same dimensions. The field s(x, t) is positive-definite, locally defined, and satisfies three structural conditions:

- **Distinguishability**: each contribution corresponds to a genuinely resolved binary distinction
- **Persistence**: committed records are stable against local reversal within the causal future
- **Locality**: each event is instantiated within a region of minimum size $\xi = (\hbar c/\rho)^{(1/4)}$, the coherence scale from the CCC condition [T1]

2.2 Conservation Law

Committed distinguishability satisfies a continuity equation. Let **J**(x, t) denote the commitment flux and Σ(x, t) the local commitment production rate:

$$\partial_t s + \nabla \cdot J = \Sigma$$

In the absence of active sourcing this reduces to $\partial_t s + \nabla \cdot J = 0$, expressing transport of existing committed structure without new record creation.

2.3 Roles in Prior VERSF Results

The commitment density field appears in two previously established roles:

Time production. The local rate of time advance is proportional to $s(x, t)$ [T7].

Geometric sourcing. Spacetime geometry is sourced by commitment density, with the bound density $\rho\_bound \propto s$ entering the geometric sector [T3, T7].

In both cases s has been treated as an instantaneous, local quantity. The field theory developed in the following sections extends this to a full dynamical framework with a unique, derivable equation of motion.

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3. Additivity of Commitment Sources and Linear Source Coupling

Before writing down a Lagrangian, we establish a foundational property of the source structure. This allows linearity — which appears as condition (A5) in the uniqueness theorem — to be derived rather than assumed.

3.1 Theorem (Additivity of Commitment Sources)

Statement. *Let ρ_committed(x, t) denote the local density of irreversible commitment events. Then for any two disjoint spacetime regions R_1, R_2 with $R_1 \cap R_2 = \emptyset$:*

$$\rho\_committed(R_1 \cup R_2) = \rho\_committed(R_1) + \rho\_committed(R_2)$$

Proof. Each commitment event contributes exactly one irreducible unit of distinguishability — one resolved binary distinction. This follows from the definition of a commitment event in VERSF: it is the minimal, indivisible transition from pre-factual possibility to committed record [T1, T2]. From this minimality:

- Commitment events are countable: $N\_committed(R) \in \mathbb{N}$ for any bounded region R
- No sub-bit contributions exist: partial commitments are pre-factual and do not contribute to ρ_committed
- No cancellation is possible: irreversibility prevents subtraction of committed records

Therefore, for disjoint regions:

$N\_committed(R_1 \cup R_2) = N\_committed(R_1) + N\_committed(R_2)$

Dividing by the respective volumes and taking the local limit yields additivity of the density field. ■

3.2 Corollary (Linear Source Coupling)

Additivity of ρ_committed implies that the source term in the Lagrangian must couple linearly to ρ_committed. Any coupling of the form f(ρ_committed) with f nonlinear would assign different total source strength to two identical but spatially translated commitment distributions — violating additivity. The unique additive coupling at leading order is:

$\mathscr{L}\_source = s \cdot \rho\_committed$

The implication from additivity to linearity does not follow from additivity alone, but from the conjunction of additivity, locality, and independent attribution. Together these require that any functional coupling F(ρ) must satisfy $F(\rho_1 + \rho_2) = F(\rho_1) + F(\rho_2)$ for all disjoint commitment densities ρ_1, ρ_2 — since the total source over $R_1 \cup R_2$ must equal the sum of the individual sources by the additivity theorem. By Cauchy's functional equation, the continuous solutions to this additive constraint are precisely the linear maps F(ρ) = cρ. Continuity here is not an additional assumption: it is forced by the smoothness of the field s, which is required for the Euler–Lagrange procedure to be well-defined. This continuity follows from the requirement that small variations in local commitment density produce small variations in the field response — a condition necessary for the existence of well-defined local dynamics and the applicability of the Euler–Lagrange formalism. The unique admissible coupling is therefore established from first principles, without appeal to convenience or smoothness assumptions beyond those already implicit in the field-theoretic framework.

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4. No-Go Theorem for Nonlinear Extensions

We now show that nonlinear self-interaction terms in the field equation are excluded by the causal separability of independent commitment histories. The argument is given in functional form to make it mathematically unavoidable.

4.1 Theorem (Nonlinear Exclusion)

Statement. *No Lagrangian of the form*

$\mathscr{L} = \tfrac{1}{2}(\partial s)^2 - V(s) + s \cdot \rho\_committed$

with V(s) containing terms beyond quadratic order is admissible within the VERSF commitment framework.

Proof. The proof proceeds in two independent steps. Step A derives the combination rule from physical primitives, with no reference to F. Step B then uses the derived combination rule to constrain F.

Step A — Deriving the combination rule (independent of F).

Consider two commitment configurations with disjoint spatial support: $\rho_1(x,t)$ in region R_1 and $\rho_2(x,t)$ in region R_2, with R_1 and R_2 spacelike-separated. Let s_1 and s_2 denote the respective field solutions for each source in isolation. Write the total field response to the combined source as:

$$\mathbf{s\_total = f(s_1, s_2)}$$

where f is an *unknown* combination function to be determined — it is not assumed to be addition. The physical primitives of the framework impose three constraints on f, none of which reference F or assume linearity:

- **Causal separability**: $f(s_1, 0) = s_1$ and $f(0, s_2) = s_2$ — when one source is absent, the total field equals the remaining solution alone
- **Associativity**: $f(f(s_1, s_2), s_3) = f(s_1, f(s_2, s_3))$ — combining three independent configurations in any order gives the same result
- **Continuity**: f is continuous, inherited from the smoothness of s required by the field-theoretic structure

These conditions characterise a continuous, commutative, associative binary operation on $\mathbb{R}$ with identity — equivalently, a continuous group operation on $\mathbb{R}$. By the classification of such operations [F5], the unique continuous solution satisfying all three is:

$$\mathbf{f(s_1, s_2) = s_1 + s_2}$$

The combination rule is therefore additive. This is a theorem about f derived solely from independent attribution, causal separability, and continuity — not an assumption, and not a consequence of anything about F.

Step B — Constraining F using the derived combination rule.

Having established $s\_total = s_1 + s_2$ from Step A, we now apply the field equation. The d'Alembertian $\square + m^2$ is a linear differential operator, so:

$$(\square + m^2)(s_1 + s_2) = (\square + m^2)s_1 + (\square + m^2)s_2$$

Each individual solution satisfies its own field equation:

$(\square + m^2)s_1 = \rho_1 + F(s_1)$ $(\square + m^2)s_2 = \rho_2 + F(s_2)$

The combined field $s\_total = s_1 + s_2$ must satisfy the field equation with combined source $\rho_1 + \rho_2$:

$(\Box + m^2)(s_1 + s_2) = \rho_1 + \rho_2 + F(s_1 + s_2)$

Substituting the individual equations into the left side:

$\rho_1 + F(s_1) + \rho_2 + F(s_2) = \rho_1 + \rho_2 + F(s_1 + s_2)$

Cancelling $\rho_1 + \rho_2$:

$\mathbf{F(s_1 + s_2) = F(s_1) + F(s_2)}$

This is the Cauchy additivity condition on F, derived as a consequence — not an assumption. By Cauchy's functional equation, the unique continuous solution is $F(s) = cs$, i.e. F is linear. Any nonlinear F violates this condition and is therefore excluded. ■

The two-step structure is essential. Step A derives additivity of the combination rule from physical primitives with no reference to F. Step B then applies that derived result to constrain F. There is no circularity: $F(s_1 + s_2) = F(s_1) + F(s_2)$ appears as a *conclusion* of Step B, not as a premise of Step A.

4.2 Corollary

The admissible potential is at most quadratic:

$\mathbf{V(s) = \tfrac{1}{2}m^2s^2}$

with $m \neq 0$ required by the finite coherence scale. A massless field ($m = 0$) would produce an infinite-range propagator inconsistent with the minimum localisation scale ξ established by the CCC condition [T1].

4.3 Physical Interpretation

Linearity of the field equation is not a mathematical convenience or a smoothness assumption. It is forced by the discreteness of facts. Each commitment event is an independently attributable binary distinction; the field equation must respect this by treating spatially separated commitment histories as dynamically independent. Only a linear field equation guarantees this. The no-go theorem makes this connection mathematically explicit.

Stated in the language of standard field theory: nonlinearity violates superposition, which is the condition required for independent causal evolution of disjoint spacetime regions. In a framework where physical facts are locally instantiated and independently attributable, superposition is not an optional feature — it is a structural necessity.

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5. Lagrangian Uniqueness Theorem

With linear source coupling established (§3) and nonlinear self-interactions excluded (§4), we prove that the full Lagrangian is unique within its admissibility class.

5.1 Admissibility Conditions

We impose six conditions, each independently motivated by the VERSF architecture:

(A1) Locality. The dynamics are expressible as a local functional:

$\mathscr{L} = \mathscr{L}(s, \partial_\mu s)$ No non-local integral terms are permitted.

(A2) Lorentz Covariance. $\mathscr{L}$ is a scalar under SO(1,3), the Lorentz group acting on the emergent spacetime of committed records [T3]. The commitment density s counts irreversible events — positive-definite, unsigned records of distinguishability with no preferred spatial orientation. It therefore transforms as a true scalar under parity P, not a pseudo-scalar. This excludes the pseudo-scalar branch of the Lorentz-covariant classification without additional assumptions.

(A3) Second-Order Field Equations. The equation of motion contains at most second derivatives of s. Higher derivatives introduce Ostrogradsky instabilities [F4] and spurious degrees of freedom inconsistent with minimal field content.

(A4) Finite Propagation Speed. Disturbances propagate at speed c, requiring the field equation to be hyperbolic. This is forced by the causal order of commitment events and the CCC condition [T1].

(A5) Linear Sourcing. The source term is linear in $\rho_{committed}$ and the field equation is linear in s. *Derived in §§3–4 from commitment additivity and nonlinear exclusion; not assumed.*

(A6) Minimal Field Content. No additional independent fields or degrees of freedom beyond s(x, t) are introduced.

5.2 Theorem (Lagrangian Uniqueness)

Statement. *Under conditions (A1)–(A6), the most general admissible Lagrangian for the scalar commitment field s(x, t) is:*

$$\mathscr{L} = \tfrac{1}{2}(\partial_\mu s)(\partial^\mu s) - \tfrac{1}{2}m^2 s^2 + s \cdot \rho_{committed}$$

up to overall normalisation, field rescaling $s \to \alpha s$, and addition of total derivatives.

Proof. We proceed by exhaustion over all admissible scalar Lagrangians.

Step 1 — General local scalar form. From (A1) and (A2), $\mathscr{L}$ must be a Lorentz scalar constructed from s and its first derivatives. The only independent Lorentz scalars available at this order are s and $(\partial_\mu s)(\partial^\mu s)$. Therefore:

$$\mathscr{L} = f(s, (\partial_\mu s)(\partial^\mu s))$$

Step 2 — Restriction to second-order dynamics. From (A3), the field equation must contain at most second derivatives of s. A term $[(\partial_\mu s)(\partial^\mu s)]^n$ with $n \geq 2$ produces, through the Euler–Lagrange procedure, fourth-derivative terms of the form $\partial^2(s \cdot \partial^2 s)$, violating (A3). Therefore the kinetic sector must be linear in $(\partial_\mu s)(\partial^\mu s)$:

$$\mathscr{L} = a(s) + b(s) \cdot (\partial_\mu s)(\partial^\mu s)$$

Step 3 — Linearity of the field equation. From (A5), the field equation must be linear in s. The Euler–Lagrange equation for the above form is:

$$a'(s) + b'(s)(\partial_\mu s)(\partial^\mu s) - 2b(s)\Box s = \rho_{committed}$$

Linearity requires $b'(s) = 0$ (otherwise the second term is nonlinear in s via the field-dependent coefficient) and $a'(s)$ at most linear in s. Therefore $b(s)$ = constant and $a(s) = \alpha s + \beta s^2$. Absorbing the normalisation fixes $b = ½$.

Step 4 — Kinetic term. With $b = ½$, the kinetic term is the unique Lorentz-covariant form:

$$½(\partial_\mu s)(\partial^\mu s) = ½[(\partial_t s)^2 - c^2(\nabla s)^2]$$

which enforces finite propagation speed c, satisfying (A4).

Step 5 — Potential term. From Step 3, $a(s) = \alpha s + \beta s^2$. The linear term can be absorbed into $\rho_{committed}$ by field redefinition. The quadratic term gives the unique admissible potential $V(s) = ½m^2s^2$ with $m^2 = -2\beta > 0$.

Step 6 — Source term. From (A5) and §3, the source coupling is $\mathscr{L}_{source} = s \cdot \rho_{committed}$, the unique admissible linear coupling.

Step 7 — No further terms survive. All admissible Lorentz scalars have been enumerated. No additional terms are consistent with (A1)–(A6). ■

5.3 Relation to Standard Field Theory

The Lagrangian established here is the massive Klein–Gordon Lagrangian with commitment sourcing. This is a well-known structure in relativistic field theory; indeed, the only Lorentz-invariant, local, second-order scalar field theory with linear sourcing is the Klein–Gordon field [F1]. The novelty is that the admissibility conditions required for a fact-producing universe uniquely select the Klein–Gordon structure, thereby elevating it from a modelling choice to a structural necessity.

The novelty lies not in the Lagrangian itself but in the derivation of the conditions that select it:

- **Linearity** is not assumed — it is derived from the additivity of binary facts and the causal separability argument of §4
- **Scalar nature** is not assumed — it follows from minimal field content (A6) and the absence of additional degrees of freedom
- **The mass term** is not free — its scaling $m \sim \xi^{-1}$ is fixed by the CCC sector and its precise value $m = \sqrt{4/3} \cdot \xi^{-1}$ by the spectral derivation of [T4]

This positions the result clearly for referees familiar with standard field theory: the framework derives the Klein–Gordon structure from ontological primitives rather than postulating it.

5.4 What the Theorem Rules Out

The uniqueness theorem excludes the following by construction:

- Nonlinear scalar field theories — excluded by (A5) and §4
- Nonlocal kernels as fundamental inputs — excluded by (A1)
- Arbitrary potential functions V(s) beyond quadratic — excluded by (A3) and §4
- Additional hidden scalar fields — excluded by (A6)
- Higher-derivative kinetic terms — excluded by (A3) and Step 2

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6. The Field Equation and the Mass Scale

6.1 Euler–Lagrange Derivation

Applying the Euler–Lagrange equation to the unique Lagrangian:

$$\partial\mathscr{L}/\partial s - \partial_\mu(\partial\mathscr{L}/\partial(\partial_\mu s)) = 0$$

Computing each term:

$$\partial\mathscr{L}/\partial s = -m^2 s + \rho_{committed}$$

$$\partial_\mu(\partial\mathscr{L}/\partial(\partial_\mu s)) = \partial_\mu(\partial^\mu s) = \Box s$$

Substituting and rearranging yields the fundamental field equation of VERSF:

$$(\Box + m^2)\, s = \rho_{committed}$$

This is a massive Klein–Gordon equation sourced by the commitment density. It is derived, not assumed.

6.2 The Mass Scale

The mass parameter m is not a free parameter within the VERSF framework: its scaling is fixed by the CCC condition, and its numerical value is independently derived from the minimal fact architecture [T4]. Dimensional closure over the CCC sector — containing only ρ (void energy density), ℏ, and c — forces $m \sim \xi^{-1} = (\rho/\hbar c)^{1/4}$. This fixes the scaling but not the numerical prefactor. The precise value

$$\mathbf{m = \sqrt{4/3} \cdot \xi^{-1} \approx 1.155\ \xi^{-1}}$$

is derived independently in [T4] from the minimum positive eigenvalue of the physical closure operator constructed from the K = 7 Fano-plane constraint structure. That derivation is logically independent of the present Lagrangian argument and fully consistent with it.

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7. The κ-Field as the Retarded Mode of s

7.1 The κ-Field Equation

Prior to this paper, the κ-field was defined independently in [T4] as the propagating massive scalar satisfying:

$$(\Box + m^2)\, \kappa(x, t) = \rho_{committed}(x, t)$$

with retarded solution:

$$\kappa(x, t) = \int G_{ret}(x - x', t - t')\, \rho_{committed}(x', t')\, d^3x'\, dt'$$

7.2 Structural Identity

The Euler–Lagrange equation of §6 and the κ-field equation are identical — same operator, same source, same mass. Both equations admit the general solution:

$$s(x, t) = \kappa(x, t) + s_{hom}(x, t)$$

where κ is the retarded particular solution and s_{hom} satisfies the homogeneous equation $(\Box + m^2)s_{hom} = 0$.

7.3 Theorem (Field Identification)

Statement. *Let s(x, t) satisfy*

$$(\Box + m^2)\, s = \rho_{committed}$$

with retarded boundary condition $s(x, t) \to 0$ as $t \to -\infty$. Then $s(x, t) = \kappa(x, t)$, where κ is the retarded solution.

Proof. Define the difference field:

$$\delta(x, t) = s(x, t) - \kappa(x, t)$$

Since both s and κ satisfy the same field equation with the same source, δ satisfies the homogeneous equation:

$$(\Box + m^2)\,\delta = 0$$

The retarded boundary condition on s gives $s(x, t) \to 0$ as $t \to -\infty$. The retarded solution κ satisfies $\kappa(x, t) = 0$ for t before the support of $\rho\_committed$, so $\kappa \to 0$ as $t \to -\infty$ also. Therefore:

$$\delta(x, t) \to 0 \text{ as } t \to -\infty$$

It remains to show $\delta = 0$ identically. Any nonzero solution to $(\Box + m^2)\delta = 0$ in 3+1 dimensions carries a positive conserved energy:

$$E = \int \left[\tfrac{1}{2}(\partial_t\delta)^2 + \tfrac{1}{2}(\nabla\delta)^2 + \tfrac{1}{2}m^2\delta^2\right] d^3x \geq 0$$

This quantity is time-independent on shell. A solution satisfying $\delta \to 0$ as $t \to -\infty$ has $E = 0$ at $t \to -\infty$, and therefore $E = 0$ for all time. Since each integrand is non-negative and their sum vanishes, each term vanishes pointwise, giving $\delta = 0$ identically [F3].

Therefore:

$$s(x, t) \equiv \kappa(x, t) \;\blacksquare$$

7.4 Interpretation

The κ-field is not an independent degree of freedom but the unique retarded realisation of the commitment field under physical boundary conditions. Introducing κ separately in prior work was a productive intermediate step — it allowed the mass and memory kernel to be derived before the full Lagrangian unification was available. That step is now superseded. One field, one equation, one mass scale.

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8. Memory Kernel as Green's Function

8.1 Kernel Structure

The memory kernel $K(\tau)$, previously derived from the retarded massive propagator in [T4], now follows directly as the Green's function of the unified field equation. For a committed worldline with proper time τ, the retarded Green's function of $(\square + m^2)$ evaluated on the forward light cone gives $J_0(m\tau)$ — the zeroth Bessel function. In the long-proper-time limit $m\tau \gg 1$, the standard asymptotic expansion gives:

$$J_0(m\tau) \sim \sqrt{2/\pi m\tau} \cdot \cos(m\tau - \pi/4)$$

yielding, up to overall phase and normalisation:

$$K(\tau) = G_{ret}|_{worldline} \sim \cos(m\tau) / \tau$$

This is not an additional structure. It is the intrinsic Green's function of the commitment field equation, with the oscillation frequency set by the derived mass $m = \sqrt{4/3} \cdot \xi^{-1}$ and the algebraic $1/\tau$ decay reflecting the spreading of the causal cone in 3+1 dimensions.

8.2 Memory as Field Self-Propagation

Under the identification $s \equiv \kappa$, memory is the time-delayed self-propagation of the commitment density field. The non-Markovian correction to the evolution of an observable $O(t)$:

$$dO/dt = F[O(t)] + \int_0^t K(t - \tau)\, G[O(\tau)]\, d\tau$$

is not an external effect. It is the consequence of the commitment field propagating its own past values forward through the retarded Green's function. Memory is a structural feature of the unique field dynamics, not a supplementary mechanism. This structure provides a direct physical mechanism for long-time correlations in quantum systems — distinct from phenomenological non-Markovian models, which introduce memory kernels by hand — and is in principle experimentally testable through the oscillatory late-time signature derived in §8.3.

8.3 Observable Signature

For a decay process with standard rate λ, the κ-field memory correction gives:

$$N(t) \sim e^{(-\lambda t)} + \varepsilon \cdot \cos(mt + \varphi) / [(\lambda^2 + m^2)t]$$

The frequency, amplitude suppression, and phase are all fixed by the single derived mass $m = \sqrt{4/3} \cdot \xi^{-1}$. This remains the primary falsifiable prediction of the framework [T5].

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9. Stress-Energy Tensor

9.1 Derivation

The stress-energy tensor of the commitment field follows from the standard Belinfante–Rosenfeld procedure applied to the unique Lagrangian:

$$T_{\mu\nu} = \partial_\mu s \cdot \partial_\nu s - g_{\mu\nu} \mathscr{L}$$

Substituting $\mathscr{L}$ explicitly:

$$T_{\mu\nu} = \partial_\mu s \cdot \partial_\nu s - g_{\mu\nu} \left[\tfrac{1}{2}(\partial_\lambda s)(\partial^\lambda s) - \tfrac{1}{2}m^2 s^2 + s \cdot \rho_{committed}\right]$$

9.2 Component Interpretation

Component	Physical content
T_{00}	Energy density of propagating commitment density
T_{0i}	Commitment flux — flow of irreversible fact through a spatial surface
T_{ij}	Spatial stress from gradients in commitment density

9.3 On-Shell Conservation

When s satisfies the field equation, $T_{\mu\nu}$ satisfies:

$$\partial^\mu T_{\mu\nu} = -(\partial_\nu s)\, \rho_{committed}$$

The non-zero right-hand side reflects energy-momentum injection by active commitment sourcing. This does not represent a violation of total energy-momentum conservation: the sourcing term $\rho_{committed}$ carries its own energy-momentum content, and when the full stress-energy budget — including the commitment source contribution — is taken into account, the total is conserved. In source-free regions ($\rho_{committed} = 0$), $T_{\mu\nu}$ is conserved independently in the standard sense.

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10. Gravitational Sourcing

10.1 Status of This Section

The results here should be interpreted as a **consistency bridge, not a full derivation of gravity**. Specifically:

- The stress-energy tensor derived from the commitment Lagrangian is inserted into Einstein's field equations
- The weak-field limit reproduces the expected sourcing structure — gravitational potential proportional to commitment density
- The full emergence of general relativity from VERSF requires the geometric sector developed separately in [T3]

The role of this section is not to derive gravitational dynamics from the commitment field alone, but to demonstrate that the derived stress-energy tensor is consistent with known gravitational sourcing, thereby validating the commitment field as a physically admissible matter sector. This framing is deliberate. The section establishes a necessary condition for the framework's viability; it does not claim to replace [T3].

10.2 Insertion into Einstein's Equations

$$G_{\mu\nu} = 8\pi G\, T_{\mu\nu}$$

Inserting the derived stress-energy tensor:

$$G_{\mu\nu} = 8\pi G\, [\partial_\mu s \cdot \partial_\nu s - g_{\mu\nu} (\tfrac{1}{2}(\partial_\lambda s)(\partial^\lambda s) - \tfrac{1}{2}m^2 s^2 + s \cdot \rho_{committed})]$$

10.3 Weak-Field Limit

Setting $s(x, t) = s_0 + \delta s(x, t)$ with $|\delta s| \ll s_0$ and working in the quasi-static limit where time derivatives are suppressed relative to spatial gradients, the Newtonian gravitational potential Φ satisfies at leading order:

$$\nabla^2\Phi \propto \nabla^2 s$$

Therefore:

$$\Phi \propto s$$

This result holds in the regime where $|\nabla^2 s| \gg m^2|s|$ and $|\partial^2_t s| \ll |\nabla^2 s|$ — that is, on spatial scales $L \gg \xi$ and timescales long compared to m^{-1}, where the mass term and time derivatives are subleading relative to the spatial gradient structure. This regime corresponds physically to scales large compared to the coherence scale $\xi \sim m^{-1}$, where the mass term $m^2 s$ is negligible relative to $\nabla^2 s$ in the sourcing equation and the gravitational sourcing reduces to the Newtonian form. Outside this regime the full Klein–Gordon sourcing must be retained. Within it, gravity is sourced by the local commitment density, consistent with the geometric sourcing relation $\rho_{bound} \propto s$ established in [T3, T7], and providing field-theoretic grounding for that earlier phenomenological identification.

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11. Unified Field Structure

The integrated derivation establishes the following chain, in which every step follows from the previous without additional assumptions:

```
Binary, irreducible commitment events
        ↓ §3
Additivity of ρ_committed → linear source coupling
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        ↓ §4
Causal separability → nonlinear self-interactions excluded
        ↓ §5
Six admissibility conditions → unique Lagrangian ℒ
        ↓ §6
Euler–Lagrange variation → (□ + m²)s = ρ_committed
        ↓ §7 (Theorem)
Retarded boundary conditions → s(x,t) ≡ κ(x,t) exactly
        ↓ §§8–10
Memory kernel, stress-energy tensor, gravitational sourcing
```

The following table summarises how previously separate programme components now emerge from a single structure:

Component	Previous status	Present status
Entropy field s	Instantaneous density, defined separately	The unique fundamental dynamical field
κ-field	Independent propagating scalar [T4] — defined before the Lagrangian unification was available	Retarded mode of s; s ≡ κ exactly (Theorem §7.3). This paper supersedes the separate κ-field framing of [T4]; the two are not in contradiction — [T4] correctly derived the mass and memory kernel, and those results carry over intact
Linearity of field equation	Assumed as condition (A5)	Derived from commitment additivity (§3) and nonlinear exclusion (§4)
Lagrangian	Motivated but not uniquely forced	Proven unique under six admissibility conditions (§5)
Memory kernel	Derived separately from massive propagator	Green's function of the unique field equation (§8)
Gravitational sourcing	Phenomenological relation $\rho_{bound} \propto s$	$T_{\mu\nu}$ from $\mathscr{L}$ inserted into Einstein's equations (§10)

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12. Physical Consequences and Predictions

12.1 Coupled Constraints Across Sectors

Because all phenomena derive from a single field equation with a single mass parameter, the framework predicts coupled constraints across previously independent observational sectors:

- The κ-field oscillation frequency $f = \sqrt{(4/3)} \cdot c/(2\pi\xi)$ and the gravitational coupling through $T_{\mu\nu}$ are governed by the same m and ξ. A measurement of either constrains both.
- Memory amplitude suppression (through $(\lambda^2 + m^2)^{-1}$) and gravitational source strength (through T_{00}) share the same mass scale. Cross-domain consistency is a prediction, not a modelling choice.

12.2 Reduction of Free Parameters

The integrated derivation eliminates parameters at every stage. The Lagrangian form is uniquely fixed; the mass is derived in [T4]; the source coupling is forced by additivity. The commitment sector of the framework contains no tunable field-theoretic parameters.

12.3 Falsifiability

The primary experimental prediction remains the oscillatory late-time correction:

$$N(t) \sim e^{(-\lambda t)} + \varepsilon \cdot \cos(mt + \varphi) / [(\lambda^2 + m^2)t]$$

with characteristic frequency $f = \sqrt{(4/3)} \cdot c/(2\pi\xi)$. Detection of this signature would simultaneously confirm the field structure, the mass scale, and the non-Markovian dynamics [T5].

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13. Scope and Open Questions

What has been derived in this paper:

- Additivity of $\rho_{committed}$ from binary, irreducible commitment structure (§3)
- Exclusion of nonlinear self-interactions from causal separability (§4)
- Lagrangian uniqueness under six admissibility conditions (§5)
- Field equation $(\Box + m^2)s = \rho_{committed}$ by Euler–Lagrange variation (§6)
- Exact identification $s \equiv \kappa$ under retarded boundary conditions, as a formal theorem (§7)
- Stress-energy tensor $T_{\mu\nu}$ from $\mathscr{L}$ (§9)
- Weak-field gravitational sourcing at leading order (§10)

What is taken from prior work:

- The mass value $m = \sqrt{(4/3)} \cdot \xi^{-1}$ from [T4]
- Lorentz covariance of the κ-sector from [T3]
- The geometric sourcing relation $\rho_{bound} \propto s$ from [T3, T7]

What remains open:

- The full gravitational sector — deriving the complete metric coupling beyond leading-order — requires the gravitational part of the BCB Lagrangian [T3]
- The precise correspondence between $T_{\mu\nu}$ sourcing and the geometric relation $|g|^{1/2} \propto s$ from [T7] requires a formal derivation
- The connection between the commitment field and specific Standard Model sectors is developed as a structural interpretive framework in §15; a formal derivation of the Standard Model from s(x, t) remains an open problem

- Higher-order corrections to the minimal Lagrangian are not considered here

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14. Conclusion

We have established the following integrated result:

Master Theorem (Unique Commitment Field Theory). *Under the binary, irreducible structure of commitment events, additivity of $\rho_{committed}$, and six admissibility conditions — with linearity derived, not assumed — there exists a unique scalar field theory for the commitment density s(x, t):*

$$\mathscr{L} = \tfrac{1}{2}(\partial_\mu s)(\partial^\mu s) - \tfrac{1}{2}m^2 s^2 + s \cdot \rho_{committed}$$

with equation of motion $(\Box + m^2)s = \rho_{committed}$ and exact identification $s(x, t) \equiv \kappa(x, t)$ under retarded boundary conditions. The mass $m = \sqrt{(4/3)} \cdot \xi^{-1}$ is fixed by [T4].

The consequences are:

- **Ontological economy**: one propagating field, not two; no separate κ-field ontology required
- **Uniqueness**: the Lagrangian is not chosen — it is the only field theory consistent with the commitment structure of VERSF
- **Linearity derived**: the linear field equation follows from the binary nature of facts and causal separability, not from a smoothness assumption
- **Memory intrinsic**: the kernel $K(\tau) \sim \cos(m\tau)/\tau$ is the Green's function of the field equation, not a supplementary mechanism
- **Gravitational consistency**: $T_{\mu\nu}$ derived from $\mathscr{L}$ sources curvature through commitment density gradients, consistent with [T3, T7] at leading order
- **Coupled predictions**: a single mass scale governs oscillation frequency, memory amplitude, and gravitational source strength simultaneously

14.1 On the Status of the Result

The central claim of this paper is not that a new field theory has been proposed. It is that the known massive scalar structure is **uniquely forced by irreversible fact formation**. The Klein–Gordon form is not borrowed from standard field theory — it is the only form that survives the constraints of commitment ontology.

Any competing theory must therefore violate at least one of:

- **Additivity** of commitment events — implying sub-bit or cancellable facts
- **Causal separability** of independent commitment histories — implying spacelike-separated facts interact

- **Finite propagation speed** — implying commitment influence is instantaneous or superluminal
- **Locality** — implying fact formation is governed by non-local integral operators

This provides a clear falsification pathway. The burden falls on any alternative to identify which of these four physical primitives it is prepared to abandon, and to defend that abandonment.

In this sense, the present work should be viewed as a structural reduction of scalar field theory to its minimal admissible form under fact-based ontology, rather than a replacement of existing physical frameworks. The Klein–Gordon structure is not overturned — it is derived. The Standard Model is not discarded — its field content is reinterpreted as emergent. General relativity is not superseded — its sourcing is grounded. The ambition of the framework is unity through derivation, not displacement through assertion.

In practical terms, the framework proposes that what we interpret as particles, forces, and fields are different observational manifestations of how irreversible distinguishability propagates and stabilises in spacetime.

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15. Relation to Standard Model Field Content

15.1 Statement of the Problem

The Standard Model of particle physics is formulated in terms of multiple independent quantum fields: fermionic matter fields, gauge fields associated with the symmetry group $SU(3)\times SU(2)\times U(1)$, and the Higgs scalar field. These fields are typically treated as fundamental degrees of freedom, each carrying independent dynamical content.

The VERSF framework developed in this work yields a single scalar field $s(x, t)$, representing the local commitment density. The existence of a unique Lagrangian and equation of motion for this field raises an immediate structural question: how does a single-field ontology relate to the multi-field structure of the Standard Model?

This section addresses that question at the level of interpretation and structural mapping. It does not claim a derivation of Standard Model dynamics from the commitment field. The gap between the two is substantial and acknowledged; the purpose here is to establish an interpretive framework in which such a derivation would be well-posed.

15.2 Ontological Distinction: Fundamental vs Effective Fields

The key distinction is between:

- **Fundamental fields**: irreducible degrees of freedom required by the ontology of the theory

- **Effective fields**: emergent variables describing collective or constrained behaviour of underlying structure

Within the present framework, the commitment density s(x, t) is the only fundamental field, as established by the Lagrangian Uniqueness Theorem (§5). All other field-like structures must be interpreted, if they are to appear, as effective descriptions arising from constrained dynamics of s.

This position is consistent with standard practice in physics, where effective field theories describe low-energy or coarse-grained behaviour without identifying the underlying microscopic variables — as in the emergence of quasiparticles in condensed matter systems from a single underlying Hamiltonian.

15.3 Constraint-Structured Mode Decomposition

The field s(x, t) is not an unconstrained scalar. It is subject to the structural conditions established throughout this paper and the prior VERSF programme: finite distinguishability, irreversibility, finite localisation capacity, and the $K = 7$ minimal constraint dimensionality [T2]. These constraints restrict the admissible configurations of s, defining a structured space within which the field evolves.

The BCB Lagrangian unification [T3] establishes that the Standard Model gauge group $SU(3) \times SU(2) \times U(1)$ is derivable from the BCB constraint structure. The present paper provides the interpretive context for understanding why that derivation yields multiple effective field sectors from a single underlying field: the $K = 7$ constraint architecture supports distinct propagation, stabilisation, and interaction modes, each corresponding to a different effective degree of freedom at the level of the emergent Standard Model description.

The structural proposal is:

Standard Model fields are hypothesised to correspond to distinct dynamical sectors of s(x, t), arising from different modes of propagation, stabilisation, and constraint-respecting interaction within the $K = 7$ architecture.

The statement that s(x, t) is the only fundamental field does not imply that all effective degrees of freedom remain scalar. Spin and gauge structure are expected to emerge from the constraint algebra and sector decomposition of the underlying field, not from its bare tensorial character — in the same way that quasiparticles with non-trivial statistics emerge from bosonic or fermionic lattice models whose fundamental degrees of freedom have different character.

This is a structural conjecture, not a completed derivation. Its detailed realisation is an open problem, as stated in §15.6.

15.4 Sector Interpretations

Within this framework, different classes of Standard Model fields admit the following structural interpretations. These are offered as precise analogies grounded in the commitment architecture — not as derivations.

Gauge fields are associated with local symmetry transformations that leave physical content invariant while redistributing its representation. As a structural parallel within VERSF, they correspond to constraint propagation modes of s(x, t): local reconfigurations of commitment structure that preserve admissibility while redistributing distinguishability across regions. The precise gauge-theoretic development of this correspondence is carried out in [T3] and is not reproduced here. This analogy operates at the level of constraint-consistency structure — the requirement that local reconfigurations respect the admissibility conditions of the $K = 7$ architecture — and not at the level of gauge redundancy versus physical propagating mode, which is a distinction that would require the full gauge-theoretic treatment of [T3] to address precisely.

Fermionic fields represent stable, localised excitations with conserved quantum numbers. As a structural parallel, they correspond to persistent, bound configurations of the commitment density that satisfy both local stability under propagation and global consistency under constraint closure. The stability condition mirrors the persistence requirement on committed records; the quantum number structure reflects the discrete constraint labels of the $K = 7$ architecture.

The Higgs scalar plays the role of selecting a ground state from among degenerate vacuum configurations — spontaneous symmetry breaking. As a structural parallel, this corresponds to a background commitment configuration selecting a preferred constraint realisation from the admissible set. This is an analogy with spontaneous symmetry breaking, not a derivation of it; the mechanism by which the Higgs potential arises from commitment dynamics has not been established.

On particle masses: In the gravitational sector, mass is identified with bound commitment density. Particle masses in the Standard Model involve a distinct mechanism — Yukawa coupling to the Higgs background — and the two should not be conflated. Whether the VERSF mass identification and the Yukawa mechanism are related within a common framework is an open question.

15.5 Effective Field Theory Interpretation

Under this mapping, the Standard Model can be understood as an effective field theory expansion of the commitment field around specific constrained backgrounds:

$$\mathscr{L}_{SM} \approx \mathscr{L}_{eff}[s]$$

where $\mathscr{L}_{eff}$ is obtained by expanding the dynamics of s(x, t) around particular commitment-sector backgrounds, with different fields corresponding to different irreducible sectors of the resulting perturbative structure.

This interpretation is consistent with the general framework of effective field theory [F1]: the Standard Model describes the low-energy, coarse-grained behaviour of an underlying commitment-density dynamics, just as phonons describe the low-energy behaviour of an underlying crystal lattice without requiring reference to its atomic structure.

15.6 Scope and Limitations

The present work does not derive the Standard Model gauge group, particle spectrum, coupling constants, or interaction structure from the commitment field. The specific open problems are:

- The emergence of SU(3)×SU(2)×U(1) from commitment dynamics beyond the BCB group derivation of [T3] has not been completed at the level of the full Lagrangian
- The mapping between K = 7 constraint labels and gauge generator quantum numbers remains to be formalised
- The reconstruction of the full Standard Model Lagrangian from s(x, t) via mode decomposition is an open problem
- The precise sense in which fermionic fields arise from commitment configurations — including the origin of spin-statistics — requires development of the fermionic sector of the BCB framework

These are not afterthoughts. They define the frontier of the programme.

15.7 Conditional Structural Implication

If the programme outlined in §15.6 can be completed — if the Standard Model field content can be shown to arise as effective sectors of the commitment field dynamics — then the following structural conclusion would follow:

The multiplicity of Standard Model fields is not fundamental but emergent from the constraint-structured dynamics of a single commitment density field.

This conclusion is not asserted as current. It is the target of the research programme that §15.3–15.5 motivate and frame.

15.8 Falsification Path

The interpretive framework of this section generates a structural claim that is falsifiable in principle. If Standard Model fields are emergent sectors of a single underlying commitment field, their parameters must exhibit cross-sector constraints reflecting their common origin — constraints that would be accidental coincidences in a genuinely independent multi-field theory.

The specific energy regime, observable ratios, and accessible cross-sector relationships that would constitute such a test remain to be derived from the completed mode decomposition of §15.3. Until that derivation is in hand, the falsification criterion cannot be stated with the precision required to make it a practical experimental test. The honest formulation is therefore: the existence of systematic cross-sector parameter constraints is a structural consequence of the single-field ontology and is falsifiable in principle; the specific form of those constraints is an open problem whose resolution is a prerequisite for any definitive experimental engagement with this section's claims.

15.9 Summary

Element	Status
s(x, t) as unique fundamental field	Established by Lagrangian Uniqueness Theorem (§5)
Standard Model fields as effective sectors	Structural proposal; grounded in [T2, T3]; not yet derived
Gauge group SU(3)×SU(2)×U(1)	Derived at BCB level in [T3]; full field-theoretic realisation open
Fermionic sector	Structural analogy identified; derivation open
Higgs mechanism	Analogy with constraint-background selection; not derived
Cross-sector parameter constraints	Conjectured class; specific form requires completed mode decomposition

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16. Anticipated Objections and Clarifications

The present work makes a structural claim: that the massive scalar field equation arises uniquely from the minimal requirements of irreversible fact formation. Given the scope of this claim, several natural objections arise. We address them explicitly.

16.1 "This is just the Klein–Gordon equation — what is new?"

Objection. The Lagrangian derived in §5 is the standard Klein–Gordon Lagrangian. This structure is already well known; the result therefore appears trivial.

Response. The novelty lies not in the form of the equation but in its derivation from physical primitives. In conventional field theory, the Klein–Gordon equation is introduced by postulating Lorentz invariance, locality, and a quadratic action. The present paper shows that these properties are not independent assumptions but are forced by the structure of irreversible commitment events — specifically by additivity of committed distinguishability, causal separability of independent facts, finite propagation speed, and locality of physical processes. Klein–Gordon is therefore not a choice within fact-based ontology: it is structurally unavoidable. Any alternative field theory must violate at least one of these conditions.

16.2 "Additivity does not imply linear dynamics"

Objection. In general, additive sources do not require linear field equations.

Response. This is correct in isolation, and the present derivation does not rely on additivity alone. Linearity follows from the conjunction of additivity of commitment sources, locality of field response, and causal separability of disjoint regions. These jointly imply — via the functional equation argument of §4.1 Step A, independently of the field equation — that the combination rule for independent field solutions must be additive: $f(s_1, s_2) = s_1 + s_2$. Linearity of the equation then follows as a consistency condition, not an assumption.

16.3 "The exclusion of nonlinear terms is too strong"

Objection. Many physically relevant field theories are nonlinear. Excluding all nonlinearities appears unjustified.

Response. The exclusion applies only to fundamental dynamics at the level of commitment formation. Nonlinearities may still arise at the level of effective field theory expansions, through coupling to additional sectors, or via coarse-graining of underlying dynamics. What is excluded is nonlinear self-interaction among independently attributable commitment events, because such terms couple spacelike-separated commitment histories in violation of causal separability. Linearity is a statement about the fundamental layer, not a constraint on all emergent physics.

16.4 "A scalar field cannot reproduce Standard Model structure"

Objection. A single scalar field cannot account for fermions, gauge bosons, and spin structure.

Response. The claim of the present paper is not that all effective degrees of freedom remain scalar. The field $s(x, t)$ is the fundamental field; Standard Model fields are hypothesised to be emergent sector modes. Spin, gauge structure, and fermionic behaviour are expected to arise from the constraint algebra, sector factorisation, and mode decomposition of the underlying field — not from its bare tensorial character. This is analogous to the emergence of fermions and effective gauge fields in condensed matter systems from bosonic or lattice models whose fundamental degrees of freedom have different character. The present work establishes the dynamical substrate; the emergence of effective sectors is the subject of ongoing and future work [T3].

16.5 "The Standard Model mapping is not a derivation"

Objection. Section 15 provides interpretation but not a derivation of the Standard Model.

Response. This is correct and explicitly acknowledged in §15.6. The role of §15 is to establish the consistency of the interpretive mapping, define a well-posed research programme, and identify the structural bridges required. The derivation of gauge generators, fermionic representations, and the full Lagrangian structure remains an open problem. This is not a weakness of the argument presented here but a separation of layers: the present paper establishes the field dynamics; the reconstruction of effective sectors is the task of subsequent work.

16.6 "The gravitational connection is incomplete"

Objection. The gravitational sector is not derived from first principles.

Response. The gravitational section (§10) is explicitly framed as a consistency check, not a derivation. The result establishes that the derived stress-energy tensor is physically admissible and that the weak-field limit reproduces expected sourcing behaviour. A full derivation of gravity from the commitment field requires the geometric sector developed in [T3] and its integration with the present field dynamics. This separation is deliberate and stated.

16.7 "Continuity assumptions are implicit in the derivation"

Objection. The use of the functional equation argument in §4.1 introduces continuity assumptions.

Response. Continuity is not an independent postulate. It follows from the requirement that small variations in local commitment density produce small variations in the field response — a necessary condition for the existence of well-defined local dynamics and the applicability of the Euler–Lagrange formalism. Any local field theory requires this condition. Continuity is therefore implicit in the framework's structure, not an additional input.

16.8 "The mass scale is not fully derived within this paper"

Objection. The scaling $m \sim \xi^{-1}$ is given, but the numerical prefactor is taken from an external result.

Response. The mass scale enters in two logically independent steps. The scaling $m \sim \xi^{-1}$ is derived from coherence constraints via the CCC condition [T1], which establishes that no mass scale other than ξ^{-1} exists within the CCC sector. The precise numerical value $m = \sqrt{(4/3)} \cdot \xi^{-1}$ is derived independently in [T4] from the minimum positive eigenvalue of the physical closure operator constructed from the $K = 7$ Fano-plane constraint structure. The present paper uses the second result without re-deriving it; this separation maintains logical clarity and avoids duplication across the programme.

16.9 "Where are the experimental predictions?"

Objection. The framework lacks direct experimental engagement.

Response. The primary falsifiable prediction is the non-Markovian oscillatory correction to late-time decay dynamics, derived in §8.3:

$$\mathbf{N(t) \sim e^{(-\lambda t)} + \varepsilon \cdot \cos(mt + \varphi) / [(\lambda^2 + m^2)t]}$$

with oscillation frequency $f = \sqrt{(4/3)} \cdot c/(2\pi\xi)$ fixed entirely by the derived mass scale. This prediction is specific, parameter-free within the framework, and structurally distinct from standard exponential decay. It is not present in any phenomenological decay model that does not incorporate commitment-field memory. In particular, systems with exceptionally long coherence times — such as trapped ions, superconducting qubits, or ultra-cold atomic ensembles — provide natural platforms for probing the predicted oscillatory deviation. Further experimental protocol development is ongoing in [T5].

16.10 Summary of Position

The claims of this paper are deliberately bounded. What is established: the unique admissible scalar field structure for the dynamics of irreversible commitment events, derived from four physical primitives — additivity, causal separability, locality, and finite propagation speed. What is not claimed: a full derivation of the Standard Model, a complete theory of gravity, or a finished unified theory.

Any critique of the present work must therefore identify which of these physical primitives it rejects, and demonstrate that a consistent alternative field-theoretic framework can be constructed without it.

What would falsify this framework. The present framework would be falsified by any of the following: (i) experimental observation of persistent nonlinear self-interaction in isolated commitment-like systems — systems where independent facts exhibit mutual field coupling in spacelike-separated regions; (ii) absence of the predicted oscillatory decay signature in regimes where decoherence is maximally suppressed and the commitment-scale dynamics should be resolvable; (iii) detection of independent propagating field degrees of freedom that cannot be reduced to constraint-structured modes of a single underlying scalar field, and which require independent ontological status rather than effective sector decomposition. Each of these constitutes a precise, in-principle test of the framework's foundational assumptions.

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[T5] Taylor, K. — *Coupled Temporal Bench-Top Experimental Test Protocol for VERSF.* VERSF Theoretical Physics Programme.

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