CT-Gravity: A Kernel-Driven Derivative Model for Emergent Spacetime Tension

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Status. This is a *derivative* (non-axiomatic) working note: it proposes an effective gravity channel compatible with CT's kernel-first core. The CT core manuscript defines the ontic dynamics; this note defines one conservative bridge from CT-side "choice pressure" to GR-like curvature.

Abstract

We present a derivative (non-axiomatic) model of "CT-gravity" in which gravitational phenomenology is interpreted as emergent spacetime geometry sourced by a coarse-grained **tension** field that quantifies the representational "choice pressure" of kernel-induced informational overlaps among admissible continuations. The construction is compatible with a kernel-first CT postulate set in which the Hilbert/RKHS structure is representation-only (I-domain) and projection/selection occurs only at the Identity Line. We provide a GR-like action, field equations, and a minimal "observable channel" dictionary connecting tension dynamics to existing experimental constraints on time variation of couplings and Newton's constant, as well as equivalence-principle tests.

1. Scope and motivation

The Planck length ℓ_P is commonly cited as the characteristic quantum-gravity scale. It is *not* a direct length measurement at 10^{-35} m; operationally it is a derived quantity from $(\hbar, G, c)$ via

$$\ell_P = \sqrt{\hbar G/c^3},$$

and is reported with uncertainty inherited primarily from G [1]. In CT, the quantum-like state space is treated as an **I-domain representation**, induced by an overlap kernel, rather than as a P-domain ontology. This motivates a "kernel-first" route to phenomenology: first specify informational compatibility structure, then study how coarse-grained instantiation constraints might source effective geometry.

2. Kernel-first CT skeleton (summary)

2.1 Ontic EIP vs inferred PIE

CT distinguishes the **ontological** triple

$$(E_n, I_n, P_n)$$

from the **inferred/reconstructed** triple

$$(\hat{P}_n, \hat{I}_n, \hat{E}_n).$$

- **Ontic (EIP):** the actual boundary state and commit at step n. This is the object of CT dynamics.
- **Inferred (PIE):** an observer/model's reconstruction from available traces, measurements, and compressions of P.

Inference is a (lossy) reconstruction map

$$\mathcal{R}: \ \text{Traces}(P) \to (\hat{P}, \hat{I}, \hat{E}),$$

while ontic dynamics is a commit/update map

$$\mathcal{U}: \ (E_n, I_n, P_n) \xrightarrow{\text{Now}} (E_{n+1}, I_{n+1}, P_{n+1}).$$

A central diagnostic in CT is **projection mismatch**: when the inferred model class is too rigid, $(\hat{P}, \hat{I}, \hat{E})$ may be forced into off-manifold or "unphysical" regions even if the ontic (E, I, P) remains well-defined.

Key distinction: CT dynamics is defined on ontic **EIP**; scientific models operate on inferred **PIE**.

2.2 Candidate set and I-domain kernel representation

We assume CT provides:

1. a strict description-domain separation (ontic dynamics on *EIP*; inference acts on reconstructed $\hat{P}\hat{I}\hat{E}$),
2. frames $\text{Frame}(t) = (P(t), I(t), E(t))$ as a convenient *notation* for a boundary snapshot,
3. a single instantiated **Now** frame on the Identity Line (IL), and a set of admissible (non-instantiated) frames in the Identity Field (IF).

Interpretation of IL and IF. In this note, IL (Identity Line) and IF (Identity Field) denote a convenient decomposition of the *inferred* interface $\hat{I}$ into local/patchwise and global/consistency components. They are modeling choices within inferred PIE and are not additional ontic degrees of freedom beyond CT's I.

Just before an update $\mathrm{IL}(t) \to \mathrm{IL}(t+\delta)$, let

$$C(t) = \{\mathrm{Frame}_k\}$$

be the candidate set of admissible continuations.

In CT v3.14 notation, the candidate set $C(t)$ corresponds to the pre-commit admissible neighborhood $\mathcal{N}(P_n; I_n)$, and each $\mathrm{Frame}_k \in C(t)$ may be viewed as an *admissible mouth* (a PIE-level description of a possible continuation). The *Now*-commit selects exactly one element and updates $\mathrm{IL}(t) \to \mathrm{IL}(t+\delta)$.

Kernel-form decision state (representation-only). There exists a positive-definite I-domain compatibility kernel $K_t : C(t) \times C(t) \to \mathbb{C}$ with normalized form

$$\hat{K}_t(f,g) = \frac{K_t(f,g)}{\sqrt{K_t(f,f)\,K_t(g,g)}}, \qquad \hat{K}_t(f,f) = 1. \tag{1}$$

The kernel induces a representation space (RKHS completion) $\mathcal{H}_{\hat{K}_t}$ with kernel sections $|k_k\rangle$ satisfying

$$\langle k_i \mid k_j \rangle = \hat{K}_t(\mathrm{Frame}_i, \mathrm{Frame}_j).$$

This Hilbert/RKHS structure is **representation-only** (I-domain), not P-domain ontology. A decision representation is written

$$|\Psi(t)\rangle = \sum_k \alpha_k |k_k\rangle. \tag{2}$$

Projection/selection chooses exactly one $\mathrm{Frame}_j \in C(t)$, yielding the next IL entry (i.e., the next commit).

Kernel-induced selection weights (Born-analog as a special case). Define amplitudes

$$A_k(t) = \langle k_k | \Psi(t) \rangle = \sum_j \alpha_j \, \hat{K}_t(\mathrm{Frame}_k, \mathrm{Frame}_j),$$

and selection weights

$$p_k(t) = \frac{|A_k(t)|^2}{\sum_\ell |A_\ell(t)|^2}. \tag{3}$$

(When the representation is chosen to match standard quantum notation, (3) is "Born-like"; here it is used only as an inference-layer weighting rule over admissible continuations.)

3. Derivative CT-gravity model

This section introduces a **model** (not a CT postulate): gravity is emergent curvature sourced by a coarse-grained **tension** that encodes how strongly the substrate is asked to compress multiple admissible continuations into a single instantiated continuation.

> **Layering note.** In this note, p_k, entropies, and the derived tension T are **inference-layer** objects constructed from kernel/choice data on $C(t)$. The resulting T-field is then used as an *effective observable channel* feeding into standard covariant field equations.

3.1 Choice pressure and tension density

Coarse-grain the candidate weights $p_k(t)$ into a local distribution $p(\cdot \mid x, t)$ by collecting candidates whose P-components localize near x. Define a local branching/choice entropy

$$H(x,t) = -\sum_{k \in \mathcal{N}(x)} p_k(t) \, \log p_k(t). \tag{4}$$

For multiple identities $a = 1, \ldots, N$ with local distributions $p^{(a)}(\cdot \mid x, t)$, define a mismatch functional using Jensen–Shannon divergence

$$M(x,t) = \sum_{a<b} D_{\mathrm{JS}}\big(p^{(a)}(\cdot \mid x,t) \,\|\, p^{(b)}(\cdot \mid x,t)\big). \tag{5}$$

Define a scalar tension density (one minimal choice)

$$T(x,t) = T_0 + \lambda_H H(x,t) + \lambda_M M(x,t), \qquad \lambda_H, \lambda_M \geq 0. \tag{6}$$

Example (non-canonical) covariant source term. To make the coupling in (7) explicit without committing to a unique choice, one may define a scalar source $J(x)$ from the same coarse-grained choice data by promoting H and M to spacetime scalars (via a chosen foliation) and taking

$$J(x) := H(x) + \kappa \, M(x), \qquad \kappa \geq 0.$$

More generally, J may be any scalar functional of normalized local Gram-matrix invariants and their covariant derivatives; the CT kernel constrains *how* these invariants are computed, not the particular effective-field ansatz used in this derivative model.

3.2 GR-like action and field equations

Promote T to a scalar field on spacetime, $T = T(x^\mu)$, with Lagrangian density

$$\mathcal{L}_T = \frac{1}{2} g^{\mu\nu} \nabla_\mu T \nabla_\nu T - V(T) - \beta \, T \, J, \tag{7}$$

where $J(x)$ is a covariant source that reduces (in the local rest frame) to a function of coarse-grained choice pressure (e.g. H) and mismatch (e.g. M). The full action is

$$S = \int d^4x \sqrt{-g} \left[\frac{c^3}{16\pi G}(R - 2\Lambda) + \mathcal{L}_{\text{matter}} + \mathcal{L}_T \right]. \tag{8}$$

Variation w.r.t. $g_{\mu\nu}$ yields

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} \left(T_{\mu\nu}^{\text{matter}} + T_{\mu\nu}^{(T)} \right), \tag{9}$$

with

$$T_{\mu\nu}^{(T)} = \nabla_\mu T \nabla_\nu T - g_{\mu\nu} \left(\frac{1}{2} g^{\alpha\beta} \nabla_\alpha T \nabla_\beta T - V(T) - \beta T J \right). \tag{10}$$

Variation w.r.t. T yields the tension dynamics

$$\Box T + \frac{dV}{dT} = -\beta J. \tag{11}$$

In the Newtonian limit, $T_{\mu\nu}^{(T)}$ contributes an effective gravitating density ρ_T, modifying

$$\nabla^2 \Phi \simeq 4\pi G \left(\rho_{\text{matter}} + \rho_T \right).$$

4. Experimental channels and existing constraints

This model is designed to be constrained (and potentially falsified) by precision tests already sensitive to small deviations from GR and small drifts of couplings.

4.1 Time variation of couplings and G

If the tension sector effectively induces slow drifts in couplings, the tightest bounds are already very small. A PDG review reports direct laboratory limits (atomic clock comparisons) on present time variation of the fine-structure constant at the level

$$\frac{d \ln \alpha_{\text{em}}}{dt} = (1.8 \pm 2.5) \times 10^{-19}\, \text{yr}^{-1},$$

and constraints on a slow phenomenological variation of Newton's constant from lunar laser ranging

$$\frac{\dot{G}}{G} = (7.1 \pm 7.6) \times 10^{-14}\, \text{yr}^{-1}$$

[2]. In CT-gravity, these can be treated as bounds on combinations of $(\beta, \lambda_H, \lambda_M)$ together with the coarse-grained source J.

4.2 Equivalence principle tests

Any additional long-range field typically risks composition dependence. The same PDG review summarizes universality-of-free-fall tests reaching the 10^{-15} level in space-based experiments [2]. A minimal requirement for CT-gravity in this scalar form is therefore that either (i) couplings are universal to sufficient accuracy, or (ii) any composition dependence is suppressed below current bounds.

4.3 High-sensitivity clock targets

Thorium-229 nuclear-clock programs are motivated in part by strongly enhanced sensitivity to variation of fundamental constants compared to many atomic transitions [3,4]. CT-gravity can be constrained by searching for correlated variations or noise signatures in such clock networks that would correspond to fluctuations in the source J.

5. Discussion

The model provides a concrete bridge:

$$\begin{aligned}\text{kernel overlaps} &\Rightarrow \text{selection weights} \Rightarrow \text{coarse-grained source } J\\ &\Rightarrow \text{tension field } T \Rightarrow \text{effective stress–energy} \Rightarrow \text{curvature.}\end{aligned}$$

It is intentionally conservative on the GR side (standard variational structure) while leaving the CT-specific content in *how* J is computed from kernel/choice data.

3.3 Consistency with tests and screening (placeholder)

Any additional long-range scalar channel coupled to matter is constrained by equivalence-principle, Solar-System, and laboratory tests. In this derivative model, viability therefore requires either (i) sufficiently weak effective coupling (e.g., small β in (7) after field redefinitions) or (ii) a screening mechanism that suppresses the scalar-mediated force in high-density environments while allowing cosmological-scale effects. Standard strategies include chameleon/symmetron-type environmental screening and Vainshtein-type derivative screening. This note does not select a mechanism; it records screening as a requirement for future work.

Key open tasks:

1. define J covariantly from kernel/Gram-matrix invariants,
2. analyze stability and screening mechanisms,
3. derive concrete predictions beyond existing scalar-field modified gravity frameworks.

Acknowledgements

This document is a working note (v2.7; upgraded for CT v3.14.3 coherence). It is intended to be iterated as CT-gravity develops.

References

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