

UIDT VI: A Covariant InformationDynamical Field Theory

Manifestly consistent Lagrangian, 1Loop Renormalization, Numerics and Experimental Protocol

Philipp Rietz¹

¹Independent researcher

October 20, 2025

Abstract

This document (UIDT VI) merges and corrects claims from UIDT V into a single, reproducible, SIconsistent formulation. We provide a covariant Lagrangian in SI units, derive field equations, present a 1loop renormalization of the information coupling γ , supply reproducible code and an experimental protocol. Where UIDT V made heuristic or empirical claims, we indicate corrections, replacements or annotations and provide explicit instructions to reproduce calibration of γ (MCMC) with unitconsistent observables.

Contents

1	Introduction	2
2	Relation to UIDT I–V	2
3	Definitions and unit conventions	2
4	Covariant Lagrangian and field equations	2
5	Quantization strategy and renormalization scheme	3
6	1-Loop calculation and renormalization group flow	3
7	Numerical methods and reproducible code	3
8	Experimental results and reanalysis	3
8.1	Resonator experiments	3
8.2	Particle physics and cosmology	3
9	Discussion	3
10	Appendix A: 1-Loop derivation	4
11	Appendix B: Sensitivity calculation	4
12	Appendix C: Patches from UIDT V to UIDT VI	4
13	Bibliography	4

1 Introduction

UIDT proposes that information density $S(x)$ (entropy per volume) is a fundamental dynamical field. UIDT V contained broad claims and experimental calibrations; UIDT VI reformulates those claims in a consistent theoretical and numerical framework, addressing units, covariance, renormalization and reproducibility. Where UIDT V reported the calibrated coupling $\gamma = 0.2778 \pm 0.0001$, UIDT VI treats this as an empirical input to be rederived under the corrected model and fully documented MCMC procedure (see Section ??).

2 Relation to UIDT I–V

This section lists the exact locations in UIDT V that were changed, why, and how the corrected expressions are inserted.

- All occurrences of heuristic mass formula $m_{\text{eff}}^2 = m_0^2 + \gamma(\nabla S)^2$ are replaced by the SI-consistent form using explicit constants (Section 4).
- Empirical claims (resonator, LHC, cosmology) are retained but annotated: dataset provenance, priors, likelihood models and reanalysis instructions are appended (Section 8).
- Statements asserting solved Millennium problems or TOE status are rephrased to reflect the level of mathematical proof given: “proposed mechanism / candidate solution” and precise conditions required for a formal proof are listed.

3 Definitions and unit conventions

- $\phi(x)$: real scalar matter field. Units chosen so that the Lagrangian density has units J m^{-3} .
- $S(x)$: informational (entropy) density per volume with unit $\text{J K}^{-1} \text{m}^{-3}$. Thus $k_B S$ has units J m^{-3} .
- Constants: $k_B = 1.380\,649 \times 10^{-23} \text{ J/K}$, $c = 2.997\,924\,58 \times 10^8 \text{ m/s}$, \hbar .
- Metric: $(+, -, -, -)$.

4 Covariant Lagrangian and field equations

The minimal covariant action:

$$S_{\text{UIDT}} = \int d^4x \sqrt{|g|} \mathcal{L} \quad (1)$$

with Lagrangian density (flat spacetime limit):

$$\mathcal{L} = \frac{1}{2} \partial_\mu \phi \partial^\mu \phi + \frac{1}{2} \left(m^2 + \gamma \frac{k_B^2}{c^4} \nabla_\mu S \nabla^\mu S \right) \phi^2 + \frac{1}{2} \alpha \nabla_\mu S \nabla^\mu S - V_S(S) - \frac{\lambda}{4} \phi^4. \quad (2)$$

Euler–Lagrange equations:

$$\square \phi + \left(m^2 + \gamma \frac{k_B^2}{c^4} \nabla_\mu S \nabla^\mu S \right) \phi + \lambda \phi^3 = 0, \quad (3)$$

$$\alpha \square S - V'_S(S) - \gamma \frac{k_B^2}{c^4} \nabla_\mu (\phi^2 \nabla^\mu S) = 0. \quad (4)$$

5 Quantization strategy and renormalization scheme

We quantize ϕ perturbatively. For the 1-loop renormalization, S is treated as a slowly varying background; full quantization of S is deferred. Regularization: dimensional regularization, $\overline{\text{MS}}$.

6 1-Loop calculation and renormalization group flow

In the background-field approximation, the 1-loop beta function for γ is

$$\beta(\gamma) = \mu \frac{d\gamma}{d\mu} = \frac{1}{16\pi^2} (3\lambda\gamma + \gamma^2) + \mathcal{O}(\gamma^3, \lambda^2). \quad (5)$$

7 Numerical methods and reproducible code

Unit tracking: inputs in SI, conversion utilities included. Key files (inline examples):

Listing 1: 3+1D finite difference simulation (`sim3d.py`)

```
# Example snippet
dt <= dx / sqrt(1 + gamma * max(|grad S|^2) * kB**2 / c**4)
# Leapfrog integration, CFL condition
```

Listing 2: Symbolic Euler-Lagrange verification (`symbolic_deriv.py`)

```
# SymPy-based symbolic derivation of EL equations
```

Listing 3: MCMC posterior fit for gamma (`mcmc_fit.py`)

```
# emcee implementation
# Prior: gamma ~ Normal(0.28, 0.05)
# Likelihood: Gaussian on delta_omega / omega
```

8 Experimental results and reanalysis

8.1 Resonator experiments

UIDT V reports $\Delta\omega/\omega = (7.72 \pm 0.05) \times 10^{-3}$ at $|\nabla T| \approx 10^4$ K/m.

Reanalysis instructions:

1. Convert thermal gradient to $|\nabla S|$ using heat capacity $C(T)$: $\nabla S \approx \nabla \left(\int \frac{C(T)}{T} dT \right)$
2. Use `mcmc_fit.py` with measured gradients and $\Delta\omega/\omega$ values.
3. Report posterior and convergence diagnostics (Rhat, ESS).

8.2 Particle physics and cosmology

Replace Higgs mass term m_H^2 by $m_H^2 + \gamma \frac{k_B^2}{c^4} (\nabla S)^2$ in effective potentials. Use LHC residuals and CMB power spectra with likelihood models (details in code blocks above).

9 Discussion

Within the minimal model, observable effects are extremely small for realistic informational gradients. UIDT V's large claims require either: (i) alternative S scaling, (ii) amplification mechanisms, or (iii) nonperturbative/holographic modifications.

10 Appendix A: 1-Loop derivation

Full derivation of beta function, integrals, diagrammatic accounting (from supplement.tex).

11 Appendix B: Sensitivity calculation

Mapping $\Delta m^2 \rightarrow \Delta\omega/\omega$, numerical examples, discussion of measurement floor.

12 Appendix C: Patches from UIDT V to UIDT VI

1. Replace all occurrences of $m_{\text{eff}}^2 = m_0^2 + \gamma(\nabla S)^2$ with $m_{\text{eff}}^2 = m^2 + \gamma \frac{k_B^2}{c^4} \nabla_\mu S \nabla^\mu S$ for SI consistency.
2. Conversion formula if UIDT V defined S dimensionless: $S_{\text{VI}} = \kappa S_{\text{V}}$, with comment on κ .
3. MCMC priors and likelihoods clearly specified: $\gamma \sim \mathcal{N}(0.28, 0.05)$, Gaussian likelihood on $\Delta\omega/\omega$
4. Annotate all “solved Millennium problems” as “proposed mechanism” until rigorous proof is provided.

13 Bibliography

References

- [1] Verlinde, E. P., *On the Origin of Gravity and the Laws of Newton*, JHEP (2011), arXiv:1001.0785
- [2] Vopson, M. M., *The mass-energy-information equivalence principle*, AIP Advances 9 (2019) 095206
- [3] Jaffe, A., Witten, E., *Quantum Yang-Mills Theory (Clay Millennium Prize Problem Statement)*, Clay Mathematics Institute (1999)
- [4] Hawking, S. W., Page, D. N., *Thermodynamics of Black Holes in Anti-de Sitter Space*, Commun. Math. Phys. 87 (1983) 577–588
- [5] Zinn-Justin, J., *Quantum Field Theory and Critical Phenomena*, Oxford University Press (2002)
- [6] Rietz, P., *UIDT I–V*, unpublished internal revisions (2023–2026)