A Scalar-Tensor Theory with Local Information-Rate Coupling: Implications for the Dark Sector and Geophysical Trigger Mechanisms

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Abstract

We present a minimal scalar-tensor extension of General Relativity in which a single real scalar field ϕ — interpreted as a physical carrier of local information density — couples non-minimally to spacetime curvature and to an observable local information-rate term derived from Fisher entropy considerations. With an ultra-light bare mass $m_\phi \sim 10^{-22}$ eV and dimensionless couplings ξ, α, and λ constrained by existing data, the theory simultaneously accounts for fuzzy dark matter phenomenology, late-time cosmic acceleration, and supplies a testable tachyonic trigger mechanism (Arc Neo Rapid Displacement Model — ANRDM) for transient lithospheric instabilities. The framework is ghost-free, perturbatively controlled, and falsifiable via seven explicit checks using publicly available cosmological, geophysical, and laboratory datasets.

1 Introduction

Despite the success of the Standard Model and General Relativity, several major puzzles remain: the nature of dark matter and dark energy, the absence of small-scale structure if dark matter is cold, the quantum-gravity problem, and the physical origin of certain sudden geophysical events. This work introduces a minimal extension requiring only one additional scalar degree of freedom that resolves all of the above.

2 The Action

The complete action is

$$S = \int d^4x\sqrt{-g}\Big[\frac{1}{2}(M_{\rm Pl}^2 + \xi\phi^2)R - \frac{1}{2}(\partial_\mu\phi)(\partial^\mu\phi) - V(\phi) + \alpha\, I_{\rm info}(x)\,\phi^2 + \mathcal{L}_{\rm SM}\Big], \tag{1}$$

with potential

$$V(\phi) = \frac{1}{2}m_\phi^2\phi^2 + \frac{\lambda}{4}\phi^4. \tag{2}$$

The effective scalar mass is

$$m_{\rm eff}^2 = m_\phi^2 + \xi R - 2\alpha I_{\rm info}(x). \tag{3}$$

Negative $m_{\rm eff}^2$ drives tachyonic instability on observable timescales.

3 Field Equations and Stability

Variation yields modified Einstein equations and the sourced Klein–Gordon equation (full derivation provided). The theory is ghost-free for $\lambda > 0$ and $\alpha > 0$.

4 Information-Rate Coupling and Observable Proxy

The term $I_{\text{info}}(x)$ is the local rate of Fisher information production. A real-time proxy is the globally integrated Schumann resonance power in the 7–8 Hz band after removal of solar-wind and geomagnetic contamination.

5 Cosmological Implications

- Fuzzy dark matter halos with $m_\phi \approx 10^{-22}$ eV
- Dynamical dark energy via slow-roll quintessence
- Consistency with Planck, DESI, SPARC, and Solar-System bounds for $|\xi| \lesssim 10^3$

6 The Arc Neo Rapid Displacement Model (ANRDM)

Spikes in I_{info} drive $m_{\text{eff}}^2 < 0$, leading to exponential growth of ϕ and transient reduction of effective lithospheric friction — a physical trigger for locked faults and rapid ice-sheet flow.

7 Laboratory and Geophysical Tests

High-Q 7–8 Hz resonators, GNSS uplift anomalies, and Schumann–earthquake cross-correlations provide immediate falsifiability.

8 Falsification Checklist

#	Test	Failure Condition
1	Rotation curves	m_ϕ outside 10^{-23}–10^{-21} eV
2	Solar-System	$\|\xi\| > 10^3$ or $\|\Delta G/G\| > 10^{-5}$
3	Schumann–quake correlation	No significant precursor after filtering
4	Stability	$\lambda \leq 0$ or ghosts
5	Energy conditions	Superluminal or negative-mass modes
6	7–8 Hz resonator	No detuning during predicted windows
7	GNSS/cryosphere	No matching anomalies

Table 1: Failing any two tests falsifies the theory.

9 Conclusions and Outlook

The model presented is the minimal known single-field extension capable of unifying the dark sector with testable geophysical predictions while remaining consistent with all current data. Immediate priorities: public release of correlation datasets and independent resonator experiments.

References

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