

# Coherence-Driven Curvature: A Six-Dimensional Model of Emergent Spacetime via a Curved Memory Field

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## Abstract

We present a six-dimensional spacetime framework wherein a compactified two-sphere encodes a dynamic scalar field  $\tau_2$  representing curvature memory or coherence. The energy stored in this hidden geometry feeds back into the observable 4D universe, subtly modifying spacetime curvature. Emergence events, denoted  $\tau_3$ , are defined functionally in terms of  $\tau_2$ 's energy density. The model yields physically testable consequences, such as oscillating time dilation and curvature-induced phase shifts, and provides a structured theoretical foundation for resonance-driven emergence in gravitational settings.

## 1 Introduction

Emergent phenomena in physics often elude classical explanations. We propose a geometric approach to emergence, where coherence and resonance are modeled as curvature patterns within a higher-dimensional spacetime. This model is motivated by questions of field memory, precursor structures, and the dynamics of seemingly spontaneous events within flat spacetime. The mathematical foundation of our approach draws from general relativity [1], Kaluza-Klein theory [2], and scalar field dynamics in curved space [3].

## 2 Geometric Framework

We define a six-dimensional spacetime  $\mathcal{M}^6$  with coordinates  $x^A = (x^0, x^1, x^2, x^3, \theta, \phi)$ , where  $x^\mu$  represent the 4D spacetime coordinates and  $(\theta, \phi)$  are spherical coordinates on a compact 2-sphere  $S^2$ . The metric takes a block-diagonal form:

$$ds^2 = \eta_{\mu\nu} dx^\mu dx^\nu + R^2 (d\theta^2 + \sin^2 \theta d\phi^2) \quad (1)$$

with  $\eta_{\mu\nu} = \text{diag}(-1, +1, +1, +1)$  and  $R$  the curvature radius of  $S^2$ .

### 3 Scalar Field Dynamics on $S^2$

We define a real scalar field  $\tau_2(\theta, \phi, t)$  living on  $S^2$ . Its Lagrangian density is:

$$\mathcal{L} = -\frac{1}{2R^2} \left[ (\partial_\theta \tau_2)^2 + \frac{1}{\sin^2 \theta} (\partial_\phi \tau_2)^2 \right] - \frac{1}{2} m^2 \tau_2^2 \quad (2)$$

The field equation becomes:

$$-\partial_t^2 \tau_2 + \frac{1}{R^2} \left[ \frac{1}{\sin \theta} \partial_\theta (\sin \theta \partial_\theta \tau_2) + \frac{1}{\sin^2 \theta} \partial_\phi^2 \tau_2 \right] = m^2 \tau_2 \quad (3)$$

Solutions are expanded in spherical harmonics:

$$\tau_2(\theta, \phi, t) = \sum_{\ell=0}^{\infty} \sum_{m=-\ell}^{\ell} a_{\ell m}(t) Y_{\ell m}(\theta, \phi) \quad (4)$$

with time evolution:

$$\ddot{a}_{\ell m}(t) + \omega_\ell^2 a_{\ell m}(t) = 0, \quad \omega_\ell^2 = m^2 + \frac{\ell(\ell+1)}{R^2} \quad (5)$$

### 4 Emergence and $\tau_3$ Definition

We define  $\tau_3$  events as functional emergences of  $\tau_2$ :

$$\tau_3(t) = \begin{cases} 1 & \text{if } \max_{\theta, \phi} T_{00}(\tau_2) > E_{\text{crit}} \\ 0 & \text{otherwise} \end{cases} \quad (6)$$

where  $T_{00}(\tau_2)$  is the energy density of  $\tau_2$  and  $E_{\text{crit}}$  is a coherence threshold.

### 5 Projection into 4D Spacetime

We integrate over the  $S^2$  to define an effective 4D energy:

$$\mathcal{E}_{\tau_2}(t) = \int_{S^2} d\Omega \left[ \frac{1}{2} \dot{\tau}_2^2 + \frac{1}{2R^2} |\nabla_{S^2} \tau_2|^2 + \frac{1}{2} m^2 \tau_2^2 \right] \quad (7)$$

This modifies the 4D Einstein tensor:

$$G_{\mu\nu}^{\text{eff}} = -\eta_{\mu\nu} \kappa_{\text{eff}} \mathcal{E}_{\tau_2}(t) \quad (8)$$

### 6 Test Particle Dynamics

We model a test particle in a perturbed metric:

$$g_{00}(t) = -(1 + \epsilon \cos^2(\omega t)), \quad g_{ij} = \delta_{ij} \quad (9)$$

and find the proper time relation:

$$\frac{d\tau}{dt} = \frac{1 + \epsilon \cos^2(\omega t)}{C} \quad (10)$$

This describes oscillating time dilation tied directly to  $\tau_2$  dynamics.

## 7 Conclusion and Future Work

This model proposes a geometric mechanism for coherence and emergence through compactified curvature memory. Next steps include coupling  $\tau_2$  to matter fields, modeling nonlinear interactions, simulating  $\tau_3$  transitions, and exploring potential empirical signatures in time-based measurements or gravitational wave data.

## References

- [1] C. W. Misner, K. S. Thorne, and J. A. Wheeler, *Gravitation*, W. H. Freeman, 1973.
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- [3] N. D. Birrell and P. C. W. Davies, *Quantum Fields in Curved Space*, Cambridge Monographs on Mathematical Physics, 1982.