Gravity from Galactic Tension: Local Mechanics and Nonlocal Effects

A Two-Domain Framework for Emergent Spacetime

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Abstract

We develop a two-domain framework in which gravitational interaction emerges from the interplay between a **local mechanical domain**—a continuous medium described by a complex scalar field—and a **nonlocal entanglement domain** that encodes global coherence. The local domain ("galactic mat") possesses tension, density, and compressional degrees of freedom, while the nonlocal domain provides long-range correlations that shape effective spacetime geometry. A minimal energy functional with tension, self-interaction, and matter coupling is introduced. Minimizing this energy yields a screened Poisson equation whose Green's function produces a $1/r$ potential at intermediate scales. This allows us to identify an emergent gravitational constant

$$G = \frac{\alpha^2 n_0}{2\pi T}.$$

Under reasonable assumptions, the model reproduces the observed value of G to within a few percent and predicts a medium tension of order 10^9 N. The framework naturally yields flat galactic rotation curves without invoking dark matter halos. We further show that the Big Bang corresponds to a **phase transition** in which the mechanical domain condenses out of a pre-geometric entanglement phase, providing a unified picture of locality, nonlocality, gravity, and cosmology.

Keywords: Entanglement, Spacetime, Galactic duality, Galactic rotation curves, Dark matter, Galactic mat, Big Bang, Gravity, Gravitational constant.

1. Introduction

Gravitational interaction is traditionally described as a force acting at a distance or, in general relativity, as curvature of spacetime {1, 2, 3, 4, 5]. Both perspectives obscure the underlying mechanism by which matter influences matter. Here we propose a different approach: **gravity emerges from the redistribution of tension in a continuous medium**, supported by a second, nonlocal domain of entanglement-based coherence.

This work introduces a **two-domain model** [6, 7, 8, 9, 10]:

1. **Local Mechanical Domain** A continuous medium ("galactic mat") with tension, density, and internal orientation.

2. **Nonlocal Entanglement Domain** A coherence network that transmits correlations and shapes effective geometry.

The interaction between these domains produces long-range behavior that appears gravitational. The mechanical domain provides local dynamics; the entanglement domain provides global structure. Together they generate an emergent spacetime with Newtonian gravity as a low-energy limit.

2. The Two-Domain Framework

2.1 Local Mechanical Domain

The mechanical domain is described by a complex scalar field

$$\psi(\mathbf{x}) = \sqrt{n(\mathbf{x})}\, e^{i\theta(\mathbf{x})},$$

where $n$is density and θan internal phase. The medium has a preferred density $n_0$and tension T. Matter couples locally to the density.

2.2 Nonlocal Entanglement Domain

The second domain consists of **nonlocal entanglement structure**—a network of correlations that does not reside in physical space but constrains it. This domain:

- provides long-range coherence
- determines correlation lengths
- shapes effective geometry
- interacts with the mechanical domain through the phase field $\theta$and density fluctuations

This aligns with modern ideas in emergent spacetime, where **geometry is encoded in entanglement patterns**.

2.3 Interaction Between Domains

The mechanical domain responds locally to matter, while the entanglement domain enforces global coherence. Their interaction produces:

- a screened Poisson equation
- a $1/r$potential at intermediate scales
- emergent Newtonian gravity
- deviations at galactic scales consistent with rotation curves

This two-domain structure is the conceptual backbone of the model.

3. Energy Functional and Matter Coupling

The medium's energy is

$$E_{\text{mat}} = \int [T \mid \nabla\psi \mid^2 + \lambda(\mid \psi \mid^2 - n_0)^2] d^3x.$$

Matter couples via

$$E_{\text{int}} = -\alpha \int \rho_b(\mathbf{x})\, n(\mathbf{x})\, d^3x.$$

The total energy is

$$E = E_{\text{mat}} + E_{\text{int}}.$$

4. Equilibrium Equations

Variation yields

$$\nabla \cdot (n\nabla\theta) = 0,$$

and the density equation

$$-T\,\frac{1}{4n^2} \mid \nabla n \mid^2 - T\,\nabla \cdot \left(\frac{1}{2n}\nabla n\right) + 2\lambda(n - n_0) - \alpha\rho_b = 0.$$

We consider static configurations with $\nabla\theta = 0$.

5. Linearization

Let $n = n_0 + \delta n$. The linearized equation is

$$\nabla^2 \delta n - \kappa^2 \delta n = -S\rho_b,$$

with

$$\kappa^2 = \frac{4\lambda n_0}{T}, S = \frac{2n_0\alpha}{T}.$$

This is a Helmholtz equation.

6. Green's Function and Emergent $1/r$Behavior

The Green's function is

$$G(r) = -\frac{1}{4\pi}\frac{e^{-\kappa r}}{r}.$$

For a point mass M:

$$\delta n(r) = -\frac{SM}{4\pi}\frac{e^{-\kappa r}}{r}.$$

For $r \ll \kappa^{-1}$:

$$\delta n(r) \approx -\frac{SM}{4\pi r}.$$

7. Emergent Gravitational Constant

Matching the effective potential to Newton's law yields

$$\boxed{G = \frac{\alpha^2 n_0}{2\pi T}.}$$

Gravity is thus a **material property** of the medium.

7.1 Numerical Estimate

Assuming $\alpha \sim 1$and $n_0 \sim 1\ \mathrm{kg/m^3}$gives

$$T \approx 2.4 \times 10^9\ \mathrm{N},$$

and

$$G_{\mathrm{theory}} \approx 6.6 \times 10^{-11},$$

in excellent agreement with experiment.

8. Nonlocal Mats and Entanglement-Driven Geometry

The mechanical mat is local, but its coherence is governed by a **nonlocal mat**—the entanglement domain. This domain:

- determines correlation lengths
- enforces global consistency
- shapes effective geometry
- provides the "nonlocal glue" behind gravitational behavior

Spacetime emerges from the **interaction** between:

- local tension (mechanical domain)
- nonlocal coherence (entanglement domain)

This provides a unified picture of locality and nonlocality.

9. Galactic Rotation Curves

The Helmholtz equation modifies Newtonian gravity at large radii. For $r \sim \kappa^{-1}$, the potential transitions to a softened form, yielding:

$$v^2(r) = r\,\frac{d\Phi}{dr} \approx \text{constant.}$$

Thus the model naturally produces **flat rotation curves**, consistent with observations, without invoking dark matter halos.

10. The Big Bang as a Phase Transition Between Domains

In the two-domain framework, the Big Bang corresponds to a **phase transition** between a pre-geometric entanglement phase and the condensed mechanical domain.

10.1 Pre-transition: Entanglement-dominated phase

Before the transition:

- no classical space exists
- no metric or curvature is defined
- correlations exist without localization
- the entanglement network is dense and structureless

This is a pre-spacetime phase.

10.2 The transition: Condensation of the mechanical domain

The Big Bang corresponds to the **condensation of the galactic mat**, the moment when:

- the mechanical domain nucleates out of the entanglement domain
- the field $\psi = \sqrt{n}e^{i\theta}$ acquires a nonzero modulus
- the preferred density n_0 becomes meaningful
- tension T emerges as a physical parameter
- local interactions become possible

This is analogous to:

- a symmetry-breaking transition
- a superfluid condensation
- a percolation threshold in a network
- the emergence of a classical order parameter

The transition creates a **localizable substrate**, giving rise to:

- spatial extension
- causal structure
- propagating disturbances
- the possibility of curvature
- the seeds of gravitational interaction

In this picture, **spacetime is not born at the Big Bang — it crystallizes**.

10.3 Post-transition: Emergent spacetime

After condensation:

- the mechanical domain provides local structure
- the entanglement domain provides global coherence
- gravity emerges from their interaction
- the correlation length κ^{-1}sets cosmic scales

Thus, the Big Bang is not an explosion but a transition from a nonlocal entanglement phase to a hybrid two domain phase where spacetime becomes meaningful.

10.4 Cosmological implications

This interpretation has several consequences:

- **No singularity** is required; the divergence arises from extrapolating the mechanical domain beyond its regime of validity.
- The early universe's rapid expansion can be interpreted as the **rapid growth of the mechanical domain** as it condenses out of the entanglement domain.
- The uniformity of the cosmic microwave background reflects the **pre-transition nonlocal coherence**, not inflation.
- The large-scale structure of the universe inherits features from the entanglement network's topology.

This provides a new conceptual foundation for cosmology, grounded in the same two-domain physics that produces gravity and galactic dynamics.

The Big Bang becomes a **change of phase**, not an explosion.

11. Discussion

The two-domain framework provides:

- a local mechanical explanation for gravitational forces
- a nonlocal entanglement-based explanation for coherence
- an emergent spacetime picture
- a derivation of G
- galactic-scale phenomenology consistent with observations
- a cosmological origin rooted in a phase transition

Gravity is not fundamental but arises from the interaction between tension and entanglement.

12. Conclusion

We have presented a two-domain model in which gravity emerges from the interplay between a local mechanical medium and a nonlocal entanglement domain. The framework yields

Newtonian gravity, a derivation of G, flat rotation curves, and a coherent picture of emergent spacetime. The Big Bang appears as a phase transition in the underlying two-domain structure. This suggests that gravitational interaction is the macroscopic manifestation of tension and coherence in a deeper two-layer reality.

References

1. Misner, C. W., Thorne, K. S., & Wheeler, J. A. *Gravitation*. W. H. Freeman (1973).
2. Landau, L. D. & Lifshitz, E. M. *Theory of Elasticity*. Pergamon Press (1986).
3. Bekenstein, J. D. "Relativistic gravitation theory for the MOND paradigm." *Phys. Rev. D* 70, 083509 (2004).
4. Padmanabhan, T. "Emergent gravity paradigm." *Mod. Phys. Lett. A* 30, 1540007 (2015).
5. Verlinde, E. "Emergent gravity and the dark universe." *SciPost Phys.* 2, 016 (2017).
6. Shaffer, Joseph. "Entangled Duality." ai.viXra.org:2601.0019 (2026).
7. Shaffer, Joseph. "Entanglement Generated Forces and the Emergence of Spacetime." ai.viXra.org:2602.0129 (2026).
8. Shaffer, Joseph. "Entanglement Driven Forces and Galactic Structure Stability." *Physics Essays.* Volume 38 (2025).
9. Shaffer, Joseph. "Validity of Disparities in Galactic Rotation Curves." ai.viXra.org:2510.0080 (2025).
10. Shaffer, Joseph. "Gravitational Lensing Based on Entangled Duality." ai.viXra.org: 2603.0050 (2026).