Gravity from Galactic Tension: Local Mechanics and Nonlocal Effects
A Two-Domain Framework for Emergent Spacetime

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Abstract

This paper proposes a conceptual framework in which both the gravitational constant G and the phenomenon commonly referred to as dark energy arise from a single physical mechanism: a frozen-in tension within a medium formed during an early-universe phase transition. The model assumes the existence of a continuous, elastic-like substrate created during the Big Bang. As the universe expanded, this medium experienced strain, producing a uniform tension that remained fixed once the expansion rate slowed. The gravitational constant emerges from the stiffness and strain of this medium. The conceptual framework relies on a two-domain model, consisting of a local mechanical domain and a nonlocal entanglement domain. The framework naturally yields flat galactic rotation curves without invoking dark matter halos.

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

Note to Readers of a Future Era: In every era, people try to understand what holds the universe together. Some look for complexity; others look for simplicity. This work belongs to the second tradition. It proposes that gravity and cosmic acceleration may arise from one underlying physical property: tension frozen into the fabric of the universe during its earliest moments.

If you are reading this long after it was written, the mathematics may look old-fashioned, and the assumptions may have been replaced by better theories. But the spirit behind it — the belief that nature prefers simple, unified explanations — will still be familiar. Every generation adds a piece to the story of the universe. This was one attempt to add ours.

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

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

Matter couples via

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

The total energy is

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

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. See the Appendix for many more details.

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. Although speculative, this framework offers a unified and mathematically simple interpretation of two otherwise independent constants of nature.

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Appendix

Cosmic Tension: A Single Mechanism Behind Gravity and Dark Energy

A1. Introduction

Gravity and dark energy represent two of the most persistent mysteries in modern cosmology. Gravity is described by general relativity, yet the value of the gravitational constant Gremains an empirical input rather than a derived quantity. Dark energy, inferred from cosmic acceleration, is typically modeled as a cosmological constant with no known physical origin.

This Appendix explores a conceptual model in which both phenomena arise from a single physical cause: a tension frozen into a continuous medium formed during an early-universe phase transition. The goal is not to replace established physics but to offer a simplified, unified interpretation that may inspire future theoretical development.

A2. The Phase-Change Medium

We assume that during the Big Bang, the universe underwent a phase transition that produced a continuous, elastic-like medium. Let:

- E= effective stiffness (analogous to a Young's modulus)
- ε= dimensionless strain induced by cosmic expansion
- $T = E\varepsilon$= resulting tension per unit area

This medium is not assumed to be a classical material but a conceptual substrate whose properties influence gravitational and cosmological behavior.

A3. Cosmic Strain and Frozen-In Tension

As the universe expanded rapidly in its earliest moments, the medium stretched. If the expansion slowed sufficiently after the phase transition, the strain εwould become effectively "frozen," leaving a persistent tension:

$$T = E\varepsilon.$$

This tension is assumed to be uniform across space and constant in time after freeze-in.

A4. Derivation of the Gravitational Constant G

We propose that gravitational interactions arise from distortions of this medium. If a mass perturbs the tension field, the resulting force law can be shown to take the Newtonian form provided that:

$$G = \frac{1}{4\pi E\varepsilon}.$$

This relation suggests:

- A stiffer medium (large E) yields a smaller G.
- A larger frozen strain (large ε) also reduces G.

The observed value of $G(6.67 \times 10^{-11}\ \mathrm{m}^3 \cdot \mathrm{kg}^{-1} \cdot \mathrm{s}^{-2})$ would correspond to a particular combination of stiffness and strain set during the early universe.

This is not presented as a derivation from first principles but as a conceptual relation consistent with the assumed properties of the medium.

A5. Dark Energy as Frozen Tension

A uniform tension in a continuous medium behaves like a negative pressure. In cosmology, negative pressure contributes to accelerated expansion. If the tension $T$is constant, it acts similarly to a cosmological constant:

$$\rho_\Lambda c^2 = T,$$

where $\rho_\Lambda$is the effective dark-energy density.

Thus, the same tension that determines Galso produces a uniform outward “push” on cosmic scales.

A6. Predictions and Qualitative Consequences

Although speculative, the model implies several qualitative features:

A6.1 Early-Universe Variation in G

If the strain εaccumulated during rapid expansion, then before freeze-in:

$$G(t) = \frac{1}{4\pi E\varepsilon(t)}$$

would have been time-dependent.

A6.2 Constant Dark Energy After Freeze-In

Once the strain stopped evolving, the tension — and thus the effective dark-energy density — would remain constant.

A6.3 Possible Observational Signatures

- Slight deviations in early-universe gravitational behavior

- Subtle imprints in the cosmic microwave background
- Modified structure formation at large scales

These are qualitative suggestions rather than firm predictions.

A7. Discussion

This framework is intentionally simple. It does not attempt to replace general relativity or quantum field theory. Instead, it offers a conceptual unification: gravity and dark energy as two manifestations of a single physical property — tension in a stretched medium formed during the Big Bang.

The model's value lies in its simplicity and its suggestion that constants such as G may have deeper origins in early-universe physics.

A8. Conclusion

By assuming a continuous medium formed during a primordial phase transition, and by attributing to it a frozen-in tension resulting from cosmic expansion, we obtain a unified conceptual explanation for both the gravitational constant and dark energy. The relation

$$G = \frac{1}{4\pi E\varepsilon}$$

connects gravity to the medium's stiffness and strain, while the same tension acts as a uniform vacuum pressure driving cosmic acceleration. Although speculative, this framework provides a simple and coherent perspective on two of the universe's most puzzling features.