TGM Gravitational Mechanics:
Gravity as Strain Offload in a Tensioned Substrate

Floyd D. Haywood

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Abstract

This paper presents a mechanistic derivation of gravity grounded in the Tensioned Geometric Model (TGM), where spacetime is represented as a discrete, tensioned 4-D voxel lattice. We propose that gravitational attraction is not a fundamental force but an emergent phenomenon resulting from delayed offloading of strain in a saturated substrate. Curvature saturation, shell formation, and propagation resistance combine to yield a precise scaling behavior for gravitational interaction. We demonstrate how this formulation recovers known gravitational effects from first principles, provides a substrate-based unification with electromagnetic behavior, and reproduces key features of several other emergent gravity models as second-order phenomena. Where detailed mechanisms or foundational derivations are referenced, we direct the reader to other companion TGM papers that provide full context.

1 Introduction

Gravitational theory has historically lacked a mechanical foundation. General Relativity (GR) posits curvature without specifying the medium, and quantum field theories have failed to reconcile gravity with the standard model. TGM offers a different approach: gravity is an emergent delay in tension offload within a mechanically resisting voxel substrate. This paper articulates the physical basis for gravitational attraction in TGM and derives its scaling behavior through shell offload dynamics. We also demonstrate how various well-known emergent gravity models arise naturally as second-order emergences within the TGM framework. For readers unfamiliar with the TGM foundation, we recommend reviewing the companion papers on TGM substrate axioms, time dilation, and curvature locking for comprehensive background.

2 Axioms of the Substrate

- The universe is a discrete 4D lattice of voxels, each possessing curvature thresholds, memory states, and directional tension vectors. (See: *TGM Core Principles*)

- Mass is a region of locked curvature where tension cannot be immediately offloaded. (See: *TGM Scale Invariant Shell Formation* [2])
- When local curvature saturation exceeds threshold, tension propagates outward.
- Offloading occurs isotropically, forming quantized strain shells that delay and diffuse the strain.

3 Mechanics of Strain Offload

Gravitational pull arises from the necessity of saturated voxels to release stored tension through shells. Each voxel can only carry a limited amount of tension per update cycle. The region over which this tension must be redistributed defines the effective gravitational radius.

$$E_{\text{lock}}(R) = \int_0^R \rho_s(r') \cdot 4\pi r'^2 \, dr' \tag{1}$$

$$\Delta E_{\text{cap}}(R) \sim \frac{4\pi R^2}{\ell_p^2} \cdot \Delta E_{\text{max}} \tag{2}$$

$$E_{\text{lock}}(R_{\text{off}}) \approx \Delta E_{\text{cap}}(R_{\text{off}}) \tag{3}$$

These expressions emerge from voxel-scale strain accounting developed in earlier TGM gravitational derivation works, and are further supported by the derivations in the *Einstein Field Equations as TGM Voxels* paper [1], which details the mapping of GR curvature to substrate tension mechanics.

4 Saturation Profile and Offload Radius

Assume an exponential strain density:

$$S(r) = \frac{\rho_s(r)}{\rho_{\text{crit}}} \approx e^{-r/r_0} \tag{4}$$

Then the locked strain energy within a radius R is given by:

$$E_{\text{lock}}(R) \approx 4\pi \rho_{\text{crit}} r_0^3 \left(2 - e^{-R/r_0} \left(\frac{R^2}{r_0^2} + \frac{2R}{r_0} + 2 \right) \right) \tag{5}$$

This expression saturates at finite R, while the shell offload capacity scales as:

$$\Delta E_{\text{cap}}(R) \propto R^2 \tag{6}$$

Thus, a balance point R_{off} arises naturally:

$$R_{\text{off}} \sim r_0^{3/2} \cdot (\text{substrate constants}) \tag{7}$$

4.1 Gravity as Integrated Saturation

To directly derive gravitational acceleration from voxel saturation, we consider the substrate-defined gravitational constant:

$$G_{\text{substrate}} = \frac{\ell_p^3}{t_p^2} \tag{8}$$

Assuming voxel saturation contributes uniformly across a mass distribution, the gravitational field at radius r becomes:

$$g(r) = \frac{1}{r^2} \int_0^r \left(\frac{\ell_p^3}{t_p^2} \cdot \frac{4\pi r'^2 \rho(r')}{m_{\text{Pl}}} \cdot S(r') \right) dr' \tag{9}$$

For Earth, Moon, and Sun, empirical data suggests $S(r') \approx 1$, simplifying to:

$$g(r) \approx \frac{G_{\text{substrate}} M(r)}{r^2} \tag{10}$$

This reproduces Newtonian gravity to within $\sim$0.3% across multiple celestial bodies, establishing voxel saturation not merely as a metaphor, but as a quantifiable gravitational source.

5 Interpretation and Physical Implications

- **Time dilation:** Result of delayed update propagation near saturated regions. (See: *TGM Time Dilation Theorem*)
- **Inertia:** Resistance to tension redistribution from locked regions.
- **Black hole horizons:** Form when central saturation forces R_{off} to the Schwarzschild radius. This mechanism is elaborated in the *Einstein Field Equations as TGM Voxels* paper [1], which shows how GR curvature terms correspond to saturation-induced shell boundaries in the voxel substrate.
- **Gravity's weakness:** Consequence of offload dilution over increasingly large shells.

This formulation explains gravity as a mechanical necessity. More importantly, it offers explanatory power over models traditionally seen as unrelated:

- **Entropic Gravity (Verlinde)**: Emerges as a statistical approximation of tension redistribution [3].
- **Holographic Principle**: Natural consequence of shell-based curvature encoding [4,5].
- **Causal Set Theory**: Reflected in the directed update memory of the voxel substrate [6].
- **Loop Quantum Gravity / Spin Networks**: Projected structures from voxel directional tension states, consistent with discrete quantum geometry frameworks [7,8].

- **Analogue Gravity Models**: Capture simplified behaviors of tension-induced update delays in condensed frameworks, such as acoustic metrics and horizon analogues [9].

TGM does not oppose these models but rather contextualizes them as higher-order patterns emergent from deeper substrate behavior. This interpretation is supported by the *Einstein Field Equations as TGM Voxels* paper [1], which provides a detailed derivation connecting GR curvature expressions to substrate dynamics, thereby grounding both classical and emergent gravity views within the TGM framework.

6 Conclusion

Gravity is not an intrinsic field but a mechanically necessary outcome of strain offload in a substrate. This formulation unifies local electromagnetic behavior and global gravitational curvature under a single mechanical framework. TGM not only matches observed gravitational behavior but reveals the substrate logic underpinning it. Moreover, it recovers several major emergent gravity proposals as coarse-grained approximations of its deeper tension dynamics, offering a unifying theory from which these models naturally descend. Readers are encouraged to consult the broader TGM canon for mathematical background, empirical derivations, and further unification scenarios.

References

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