A Dimensionless Bridging Equation Connecting Electromagnetic and Gravitational Curvature Energies via Substrate Tension Mechanics

Floyd D. Haywood

Abstract

This work proposes a new theoretical framework wherein gravitational and quantum behaviors emerge from a discrete, tensioned four-dimensional substrate. Within the Tensioned Geometric Model (TGM), mass, inertia, curvature, and field dynamics are unified as manifestations of voxel locking and tension propagation within a quantized spacetime fabric. As a foundational step, we derive a dimensionless Bridging Equation that connects electromagnetic binding energy and gravitational curvature energy purely through fundamental constants. The resulting relation, expressed as $2\alpha^2$, offers a scaling law bridging quantum and relativistic domains. Validation across planetary, stellar, and compact astrophysical scales is discussed.

1 Introduction

The 20th-century achievements of General Relativity (GR) and Quantum Mechanics (QM) revealed profound insights into nature but left gravity and quantum fields as fundamentally separate domains. Despite immense progress, a complete mechanical unification remains elusive.

Following the spirit articulated by Richard Feynman — that no theory is ever truly "right," only progressively "less wrong" — we offer here a proposal rooted in substrate mechanics. The Tensioned Geometric Model (TGM) posits that spacetime and matter arise from the discrete evolution of a four-dimensional tensioned substrate. Curvature, mass, inertia, quantum coherence, and field interactions all emerge from curvature-induced voxel locking and discrete update chains governed by local tension gradients.

In this paper, we present the first formal bridge: a dimensionless relation linking electromagnetic binding energies and gravitational curvature energies at critical curvature thresholds.

2 Derivation of the Bridging Equation

2.1 Electromagnetic Binding Energy

The electromagnetic binding energy, representing the minimum tension required to stabilize a solitonic structure within the substrate, is expressed as:

$$E_{\text{bind, EM}} = \frac{m_1 e^4}{(4\pi\varepsilon_0)^2 \hbar^2}$$

where:

- m_1: mass of the particle (e.g., electron)
- e: elementary charge
- ε_0: vacuum permittivity
- $\hbar$: reduced Planck's constant

2.2 Gravitational Binding Energy

The gravitational binding energy for a mass m_1 near a Schwarzschild radius $r_s = \frac{2GM}{c^2}$ is:

$$U_{\text{bind, grav}} = \frac{GMm_1}{r_s} = \frac{1}{2} m_1 c^2$$

2.3 Forming the Bridging Ratio

Taking the ratio:

$$\text{Bridging Ratio} = \frac{E_{\text{bind, EM}}}{U_{\text{bind, grav}}} = \frac{\left(\frac{m_1 e^4}{(4\pi\varepsilon_0)^2 \hbar^2}\right)}{\left(\frac{1}{2} m_1 c^2\right)}$$
$$= \frac{2e^4}{(4\pi\varepsilon_0)^2 \hbar^2 c^2} = 2\alpha^2$$

where $\alpha = \frac{e^2}{4\pi\varepsilon_0 \hbar c}$ is the fine-structure constant.

3 Physical Interpretation

The derived Bridging Ratio suggests that electromagnetic substrate tension is approximately 9,390 times stronger than gravitational substrate tension at critical curvature thresholds. Gravitational behavior thus appears as a large-scale manifestation of voxel update lag and curvature saturation within the quantized spacetime lattice, sharing its mechanical basis with quantum coherence and binding phenomena.

4 Validation Across Physical Scales

Hydrogen Atom

Electromagnetic binding energy:

$$E_{\text{EM}} = 13.6\,\text{eV} = 13.6 \times 1.602 \times 10^{-19} = 2.179 \times 10^{-18}\,\text{J}$$

Gravitational self-binding energy:

$$U_{\text{grav}} = \frac{Gm_p m_e}{r_{\text{Bohr}}} = \frac{6.674 \times 10^{-11} \cdot 1.673 \times 10^{-27} \cdot 9.109 \times 10^{-31}}{5.29 \times 10^{-11}} = 1.92 \times 10^{-57}\,\text{J}$$

Ratio:

$$\frac{E_{\text{EM}}}{U_{\text{grav}}} \approx 1.13 \times 10^{39}$$

The Sun

Gravitational binding energy:

$$U_{\text{grav}} = \frac{3}{5} \cdot \frac{GM^2}{R} = \frac{3}{5} \cdot \frac{6.674 \times 10^{-11} \cdot (1.989 \times 10^{30})^2}{6.96 \times 10^8} = 2.27 \times 10^{41}\,\text{J}$$

Electromagnetic estimate:

$$E_{\text{EM}} \approx 10^{57} \cdot 13.6\,\text{eV} = 10^{57} \cdot 2.179 \times 10^{-18} = 2.18 \times 10^{39}\,\text{J}$$

Ratio:

$$\frac{E_{\text{EM}}}{U_{\text{grav}}} \approx 9.58 \times 10^{-3}$$

Neutron Star

Gravitational binding energy:

$$U_{\text{grav}} = \frac{3}{5} \cdot \frac{GM^2}{R} = \frac{3}{5} \cdot \frac{6.674 \times 10^{-11} \cdot (2 \cdot 1.989 \times 10^{30})^2}{1.0 \times 10^4} = 6.33 \times 10^{46}\,\text{J}$$

Electromagnetic pressure energy estimate:

$$E_{\text{EM}} \sim 1.00 \times 10^{42}\,\text{J}$$

Ratio:

$$\frac{E_{\text{EM}}}{U_{\text{grav}}} \approx 1.58 \times 10^{-5}$$

5 Implications for Gravitation and Unification

TGM reinterprets gravitation as an emergent effect of quantized spacetime fabric dynamics, where voxel locking and curvature-induced update constraints govern causal evolution. In this framework, mass corresponds to phase-locked curvature zones within the lattice. Gravitational behavior arises as large-scale manifestations of differential tension propagation and update latency across voxel networks.

Singularities are inherently avoided, as maximum curvature induces geometric saturation—halting further propagation without infinite compression. Relativistic effects, including time dilation and length contraction, emerge naturally from anisotropic update permissions within tension-saturated regions.

This geometric reframe provides a coherent pathway for unifying quantum phenomena, inertia, curvature, and spacetime structure under a single mechanical substrate framework.

TGM Terminology Snapshot

- **Quantized Spacetime Fabric**: The discrete geometric lattice representing physical space-time at Planck-scale resolution.
- **Voxel**: A 4D unit cell of spacetime that can hold, propagate, or resist curvature based on local tension.
- **Voxel Locking**: A condition where a voxel's connectivity becomes fixed due to curvature-induced constraints.
- **Update Dynamics**: The causal rules that determine how tension and curvature propagate through the lattice.
- **Curvature Saturation**: A state in which no further tension can be stored or propagated without structural phase change.

References

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