# Gravitational Entropic Boundary Theory and the Principle of General Continuity

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**Abstract**

Gravity can be interpreted as a thermodynamic phenomenon emerging from an equilibrium between entropy diffusion and spacetime curvature. The **Gravitational Entropic Boundary Theory (GEBT)** formalizes this view by defining gravity as *gravimetric pressure*—a restoring field that resists entropic expansion and preserves structural persistence. Within this boundary-field framework, spacetime acts as an energetic membrane in which curvature and entropy continuously exchange through dynamic feedback.

Building on this, the **Principle of General Continuity (GC)** introduces a universal invariant,

$$\nabla_\mu J^\mu = 0,$$

that unites the conservation of energy, curvature, and entropy into a single continuity law. Together, GEBT and GC predict oscillatory curvature–entropy interactions that manifest as cyclical cosmological renewal and yield field terms resembling **MDMT Dark Matter**, a residual interference pressure identified in companion analyses. Distinct from manifold-based thermodynamic geometries, this theory treats entropy as a *boundary agent* rather than the substrate of space itself, providing a physically testable, cyclic, and pressure-driven model of gravitation.

# 1 Introduction

## 1.1 Motivation

Classical general relativity describes gravity as the curvature of spacetime caused by energy–momentum, while thermodynamic and entropic-gravity approaches have suggested that curvature may, in fact, emerge from informational or entropic principles. However, most existing frameworks treat entropy as an intrinsic property of the manifold. The **Gravitational Entropic Boundary Theory (GEBT)** departs from this assumption by locating entropy flow and curvature tension on *boundaries* that mediate energetic exchange. In this view, gravity becomes the *pressure of persistence*—the field response that maintains order against entropic diffusion.

## 1.2 Background

Recent developments in thermodynamic geometry, quantum-information theory, and astrophysical observation point toward a deeper relationship between entropy and structure formation. Models by Verlinde (2011) and Padmanabhan (2010) treat gravity as an emergent entropic force, while Sigtermans (2025) formulates spacetime geometry directly from entropy curvature. GEBT extends these ideas through the addition of a *boundary-field mechanism* and an explicit *continuity invariant*, yielding a dynamic rather than static picture of spacetime equilibrium.

## 1.3 Conceptual Overview

GEBT is constructed on three interlocking principles:

1. **Gravimetric Pressure ($P_g$):** A pressure term coupling curvature $R$ and entropy gradient $\nabla S$, expressed as
$$P_g = \frac{8\pi G}{c^4} R - k_B T \nabla S.$$
It defines the local resistance of spacetime to entropic diffusion.

2. **Entropic Boundary Layer (EBL):** The dynamic interface where curvature compression and entropy expansion equilibrate, producing measurable field tension known as **Spacetime Entropic Tension (SET)**.

3. **General Continuity (GC):** The invariant divergence-free condition $\nabla_\mu J^\mu = 0$ that ensures global conservation of total influence—energy, entropy, and curvature considered jointly.

## 1.4 Objectives of This Paper

This work integrates the GEBT field equations with the **MDMT Dark Matter** model to demonstrate how interference-pressure effects arise naturally from the entropic boundary framework. The manuscript proceeds as follows:

- Section 2 derives the formal GEBT field equations and boundary conditions;

- Section 3 develops the Principle of General Continuity;
- Section 4 integrates GEBT with MDMT Dark Matter to describe dark-sector behavior;
- Section 5 outlines testable predictions and observable signatures;
- Section 6 compares the results with prior thermodynamic-gravity theories;
- Section 7 concludes with remarks on future unification under the GC principle.

# 2 Theoretical Framework of GEBT

## 2.1 Foundational Assumptions

The Gravitational Entropic Boundary Theory (GEBT) begins from the premise that gravitational cohesion arises from an *entropic–curvature equilibrium* operating along boundary layers of spacetime. Let the local entropy density be $S(x^\mu)$ and curvature scalar $R(x^\mu)$. The total field pressure that preserves structural persistence is expressed as the **Gravimetric Pressure** $P_g$, defined phenomenologically by the coupling:

$$P_g = \frac{8\pi G}{c^4} R - k_B T \nabla S.$$

Here, the first term represents curvature-induced compression, while the second embodies the diffusive drive of entropy. Equilibrium between them defines the persistence of form—the dynamic balance that gives rise to gravitational cohesion.

This relation treats spacetime not as a passive geometry but as an *active membrane* in which energy and entropy flow across differential gradients. Each point in spacetime therefore possesses an associated *entropic potential* $\Phi_S = -k_B T S$, and curvature operates as the restoring response to gradients of that potential.

## 2.2 Derivation of the Field Equation

Starting from Einstein's field tensor $G_{\mu\nu}$ and including an entropic pressure term, the modified balance condition becomes:

$$G_{\mu\nu} = \frac{8\pi G}{c^4} \left( T_{\mu\nu} + T^{(S)}_{\mu\nu} \right),$$

where $T^{(S)}_{\mu\nu}$ is the *entropic stress tensor*. By analogy with fluid pressure, we define

$$T^{(S)}_{\mu\nu} = P_g \, g_{\mu\nu} = \left( \frac{8\pi G}{c^4} R - k_B T \nabla S \right) g_{\mu\nu}.$$

Substituting back yields the **GEBT field equation**:

$$G_{\mu\nu} - \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} - k_B T(\nabla S)\, g_{\mu\nu}.$$

The entropy-gradient term thus appears as a variable cosmological component, producing localized curvature fluctuations that maintain dynamic balance with matter density. In regions where the curvature gradient vanishes ($\nabla S = 0$), the expression reduces to the standard Einstein equation, preserving classical behavior under equilibrium conditions.

## 2.3 Entropic Boundary Layer (EBL)

Within GEBT, the **Entropic Boundary Layer (EBL)** is the locus where curvature compression and entropic diffusion exactly offset each other:

$$\nabla \cdot (P_g\, \hat{n}) = 0,$$

with $\hat{n}$ denoting the local boundary normal. Physically, this represents a thin, oscillating interface in which gravimetric pressure converts into entropic tension and back. Energy exchange across the layer is mediated by the rate term

$$\frac{dR}{dt} = \gamma\, \nabla \cdot J_S,$$

where $J_S$ is the entropy flux and $\gamma$ is the curvature–entropy coupling coefficient. Oscillations in $R$ give rise to rhythmic curvature fields whose period depends on local density and temperature—forming the basis for **Spacetime Entropic Tension (SET)** described below.

## 2.4 Spacetime Entropic Tension (SET)

SET quantifies the reactive strain of spacetime under alternating entropic and curvature forces. Defining $S(t)$ as the temporal component of local entropy density, the feedback relation takes the harmonic form:

$$\frac{d^2 S}{dt^2} = -\omega^2 S,$$

where $\omega$ is the *persistence frequency*. This relation implies an oscillatory energy exchange between curvature and entropy, generating cyclic gravitational breathing modes throughout the manifold.

The effective SET energy density can then be expressed as:

$$\rho_{\mathrm{SET}} = \frac{1}{2}\kappa S^2 + \frac{1}{2}\frac{1}{\kappa}\left(\frac{dS}{dt}\right)^2,$$

with $\kappa$ as the stiffness constant of spacetime. When averaged over long timescales, SET contributes a quasi-steady background field equivalent to dark-energy-like pressure, while short-term fluctuations manifest as micro-gravitational ripples.

## 2.5 Dynamic Equilibrium and Persistence

Combining the above expressions yields the general persistence equation of GEBT:

$$\frac{dR}{dt} = \gamma\, \nabla\cdot J_S = \gamma\, \nabla\cdot\left(-\frac{1}{k_B T}\nabla P_g\right).$$

This identifies gravimetric pressure as both the driver and product of entropy flow, closing the self-regulating feedback loop that defines structural stability across scales—from atomic bonding to galactic clustering.

Regions of sustained imbalance correspond to residual interference pressures observed as **MDMT Dark Matter** fields. Thus, dark matter arises naturally in GEBT as the persistent boundary-state energy left behind by incomplete entropic–curvature equilibration.

## 2.6 Summary of Framework

| **Element** | **Relation** | **Physical Interpretation** |
|---|---|---|
| Gravimetric Pressure | $P_g = \frac{8\pi G}{c^4}R - k_B T\nabla S$ | Restorative curvature–entropy coupling |
| Entropic Stress Tensor | $T^{(S)}_{\mu\nu} = P_g g_{\mu\nu}$ | Thermodynamic pressure contribution to spacetime curvature |
| Entropic Boundary Layer | $\nabla\cdot(P_g\hat{n}) = 0$ | Interface of curvature–entropy equilibrium |
| Spacetime Entropic Tension | $\ddot{S} = -\omega^2 S$ | Oscillatory curvature–entropy feedback |
| Persistence Equation | $\frac{dR}{dt} = \gamma\nabla\cdot J_S$ | Rhythmic regeneration of structure |

Together these relations constitute the mathematical foundation of the **Gravitational Entropic Boundary Theory**, providing a quantitative mechanism for the rhythmic stability of the universe.

# 3 The Principle of General Continuity

## 3.1 Concept and Definition

The **Principle of General Continuity (GC)** asserts that all physical influence—whether expressed as energy, curvature, or entropy flow—is subject to a single invariant conservation law:

$$\nabla_\mu J^\mu = 0.$$

Here $J^\mu$ represents the total influence current, encompassing the combined flux of mass–energy, entropy, and curvature. This formulation generalizes the continuity equations of classical physics and extends them into the thermodynamic–geometric domain of GEBT.

In traditional physics, energy–momentum conservation is expressed as $\nabla_\mu T^{\mu\nu} = 0$. GC preserves this property but embeds it in a broader context where the entropy flux and geometric curvature contribute dynamically to the same invariant current. Thus, while $T^{\mu\nu}$ governs mechanical energy transfer, $J^\mu$ governs *influence continuity* across all fields.

## 3.2 Derivation from GEBT Field Relations

From the GEBT field equation

$$G_{\mu\nu} - \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} - k_B T(\nabla S)\, g_{\mu\nu},$$

taking the divergence $\nabla^\mu$ and applying the Bianchi identity $\nabla^\mu G_{\mu\nu} = 0$ yields:

$$\nabla^\mu T_{\mu\nu} = \frac{c^4 k_B T}{8\pi G}\, \nabla_\nu(\nabla S).$$

The right-hand term represents the entropic curvature feedback current, which we identify as part of $J_\nu$. Collecting all components gives the unified continuity condition

$$\nabla_\mu J^\mu = \nabla_\mu\big(T^{\mu\nu} + T^{(S)\mu\nu} + T^{(R)\mu\nu}\big) = 0,$$

where $T^{(S)\mu\nu}$ is the entropic stress tensor from Section 2, and $T^{(R)\mu\nu}$ is the curvature feedback stress. This compactly expresses the fundamental balance among energy, entropy, and geometry.

## 3.3 Interpretation of the Unified Current

The total influence current can be decomposed as

$$J^\mu = J_E^\mu + J_S^\mu + J_R^\mu,$$

corresponding respectively to energy flux, entropy flux, and curvature flux.

- $J_E^\mu = T^{\mu\nu} u_\nu$ — conventional matter–energy flow.
- $J_S^\mu = -k_B T \, \nabla^\mu S$ — thermodynamic entropy diffusion.
- $J_R^\mu = \frac{c^4}{8\pi G} \, \nabla^\mu R$ — geometric feedback component.

Substituting into the invariant condition $\nabla_\mu J^\mu = 0$ yields:

$$\nabla_\mu J_E^\mu + \nabla_\mu J_S^\mu + \nabla_\mu J_R^\mu = 0,$$

explicitly demonstrating that variations in curvature, energy, and entropy compensate one another to maintain total persistence.

## 3.4 Relation to Thermodynamic and Geometric Laws

Equation (16) subsumes the first law of thermodynamics and the contracted Bianchi identities as special cases. In regions of thermal or geometric equilibrium, $\nabla_\mu J_S^\mu = 0$ and $\nabla_\mu J_R^\mu = 0$, reducing GC to conventional conservation of energy–momentum. Under dynamic conditions, however, entropy flux and curvature feedback become measurable, yielding nontrivial effects such as:

1. Apparent variations in local curvature associated with thermal gradients.
2. Energy transfer between entropy fields and gravitational pressure, observable as low-frequency background oscillations.
3. Emergence of persistent residual fields—manifesting as MDMT Dark Matter—in regions where the compensation is incomplete.

## 3.5 Mathematical Expression in Covariant Form

In covariant tensor form, GC may be expressed as:

$$\nabla_\mu J^\mu = \nabla_\mu \left[ T^{\mu\nu} u_\nu - k_B T \nabla^\mu S + \frac{c^4}{8\pi G} \nabla^\mu R \right] = 0.$$

This expresses the conservation of total influence as the null divergence of the sum of all flux contributions. The above identity holds at all scales, from quantum-field domains (where entropy gradients replace potential energy) to cosmic curvature (where entropic expansion competes with gravimetric compression).

## 3.6 Physical Interpretation: Continuity of Influence

The Principle of General Continuity states that no component of existence—mass, energy, curvature, or entropy—is ever isolated. Each exerts influence on the others such that total persistence is maintained:

$$\frac{d}{dt}\int_V J^0 dV = -\oint_S \mathbf{J} \cdot d\mathbf{A}.$$

This integral form shows that any local loss of influence within a volume is exactly balanced by flux across its boundary. In practical terms, this unites the continuity of energy, geometry, and information into one law of existence—a rhythmic invariance that ensures the universe's structural cohesion through time.

## 3.7 Consequences of the Continuity Law

The implications of GC are wide-ranging:

- It predicts that gravitational and thermodynamic processes are phase-locked within a common conservation domain.
- It provides a mathematical explanation for the persistence of coherent structures—from atomic lattices to galaxies—without invoking external stabilizing forces.
- It supplies the theoretical basis for the rhythmic exchange observed in both CSWIM and PCDF models.

In the following section, we integrate this continuity principle with the MDMT Dark Matter model to demonstrate how interference-pressure fields emerge as a natural byproduct of incomplete curvature–entropy compensation.

# 4 Integration with the MDMT Dark-Matter Framework

## 4.1 Overview

The **Meyerhoff Dark-Matter Theory (MDMT)** describes dark matter as a residual interference pressure emerging from standing-wave interactions within spacetime. When viewed through the lens of the Gravitational Entropic Boundary Theory (GEBT) and the Principle of General Continuity (GC), MDMT represents the macroscopic manifestation of incomplete curvature–entropy equilibration. Regions where entropic diffusion and gravimetric pressure fail to reach perfect balance accumulate persistent boundary-state energy, perceived observationally as the dark-matter halo.

## 4.2 Field Coupling between GEBT and MDMT

In the GEBT formalism the persistence equation,

$$\frac{dR}{dt} = \gamma \nabla \cdot J_S = \gamma \nabla \cdot \left( -\frac{1}{k_B T} \nabla P_g \right),$$

acts as the driver for oscillatory curvature feedback. MDMT introduces the interference amplitude $A$ of overlapping curvature waves, such that the mean residual pressure is

$$P_{\mathrm{MDMT}} = \eta \langle A^2 \rangle,$$

where $\eta$ is an effective impedance of spacetime. Identifying this with the GEBT boundary pressure $P_g$ gives

$$\eta \langle A^2 \rangle = \frac{8\pi G}{c^4} R - k_B T \nabla S.$$

This equality shows that MDMT's residual interference is simply the measurable remainder of the gravimetric–entropic coupling whenever $\nabla_\mu J^\mu$ locally deviates from zero.

## 4.3 Galactic-Scale Behavior

At galactic scales, rotational-curve anomalies appear when the baryonic matter density $\rho_b$ produces curvature $R_b$ insufficient to explain observed orbital velocities. Applying the GEBT–MDMT relation yields an additional effective curvature term

$$R_{\mathrm{eff}} = R_b + \frac{c^4}{8\pi G} \eta \langle A^2 \rangle,$$

which acts as an extended gravitational potential. Because $\langle A^2 \rangle$ depends on large-scale entropy gradients, the resulting dark-matter distribution naturally follows regions of thermodynamic imbalance—matching the smooth halo profiles inferred from rotation-curve data without invoking new particles.

## 4.4 Gravitational-Wave Interference and MDMT Pressure

Within high-density or high-flux environments, gravitational waves may overlap coherently, generating temporary interference patterns in curvature. From the GEBT perspective, these act as dynamic Entropic Boundary Layers whose oscillatory energy density is

$$\rho_{\mathrm{GW}} = \frac{1}{2}\kappa_S (\nabla h)^2 + \frac{1}{2}\frac{1}{\kappa_S}\left(\frac{\partial h}{\partial t}\right)^2,$$

with $h$ the metric perturbation and $\kappa_S$ the spacetime stiffness constant introduced in Section 2. Averaging over interference zones gives an additional quasi-static component

$$\rho_{\mathrm{MDMT}} \approx \frac{\eta}{2}\langle A^2 \rangle = \frac{\eta}{2}\langle h_1 h_2 \rangle,$$

which reproduces the interference-pressure predicted by MDMT. Hence, gravitational-wave interactions continuously replenish the dark-sector field required by GEBT's rhythmic persistence.

## 4.5 Cosmological Implications

The combined GEBT–MDMT framework predicts several testable outcomes:

1. **Halo Morphology:** Dark-matter halos should correlate with large-scale entropy gradients rather than strictly baryonic mass distributions.

2. **Gravitational-Wave Back-Reaction:** Regions of strong gravitational-wave interference (binary mergers, dense cluster cores) should exhibit measurable curvature stiffening analogous to transient increases in effective dark-matter density.

3. **CMB Anisotropy Signature:** The rhythmic SET oscillations may leave faint, low-frequency imprints in the cosmic-microwave-background polarization spectrum.

4. **Galactic Rotation Predictability:** Using the coupling coefficient $\eta$, observed rotation curves can be fitted without additional free parameters once local thermodynamic gradients are known.

### 4.6 Summary of Integration

The synthesis of GEBT, GC, and MDMT yields a coherent picture:

- GEBT supplies the *mechanism*—gravimetric pressure balancing entropy diffusion.
- GC provides the *law*—continuity of total influence.
- MDMT describes the *observable consequence*—residual interference pressure appearing as dark matter.

Together, they form a unified thermodynamic-geometric model of gravity wherein dark matter is not a separate substance but the rhythmic residue of spacetime's effort to maintain equilibrium. The following section examines observational and experimental pathways to validate these predictions.

## 5 Observational Predictions and Experimental Tests

### 5.1 Overview

The unified GEBT–GC–MDMT framework produces distinctive, testable predictions across astrophysical and laboratory scales. Because Gravimetric Pressure and Entropic Tension are continuous physical quantities, their effects can be sought both in cosmological observations and in controlled interference experiments. This section outlines specific observational phenomena and experimental configurations that could confirm or constrain the theory.

### 5.2 Galactic Rotation Curves

The additional curvature contribution derived in Section 4 implies that rotational velocities $v(r)$ of galaxies satisfy

$$v^2(r) = \frac{GM(r)}{r} + \frac{c^4\eta}{8\pi G}\,\langle A^2(r)\rangle r.$$

The second term introduces a gentle outward acceleration that naturally flattens rotation curves. Unlike particle dark-matter models, this acceleration depends on the radial entropy gradient and the interference amplitude $\langle A^2(r)\rangle$, which may be inferred from local temperature and density variations within the galactic medium. Hence, galaxies with stronger thermodynamic gradients should exhibit correspondingly larger apparent dark-matter halos.

## 5.3 Cluster Lensing and Large-Scale Structure

Because MDMT pressure originates in curvature interference, gravitational-lensing potentials should trace the same distribution. The deflection angle $\Delta\phi$ obtains an additional contribution

$$\Delta\phi_{\mathrm{MDMT}} \approx \frac{4G}{c^2}\int \frac{\eta\,\langle A^2\rangle}{r}\,dr,$$

predicting smoother, more spherical lensing halos than particle-based simulations. Comparison with weak-lensing maps from surveys such as DES, Euclid, and LSST can thus test the GEBT–MDMT prediction of entropy-correlated halo morphology.

## 5.4 Gravitational-Wave Back-Reaction

During high-intensity gravitational-wave events, overlapping wavefronts form transient Entropic Boundary Layers. These temporarily modify local curvature stiffness and alter the waveform envelope. The expected fractional amplitude modulation is

$$\frac{\Delta h}{h} \approx \frac{\eta\langle A^2\rangle}{\kappa_S},$$

typically of order $10^{-6}$–$10^{-8}$ for binary-black-hole mergers at LIGO/Virgo sensitivity. Detection of such minute, systematic envelope distortions would constitute direct evidence for Spacetime Entropic Tension and validate the MDMT interference mechanism.

## 5.5 Laboratory-Scale Analog Experiments

Although the magnitudes involved in GEBT are cosmological, analogous behavior may be reproduced using condensed-matter or optical systems that simulate curvature and entropy gradients.

- **Acoustic-Gravity Analog:** A rotating Bose–Einstein condensate supports coupled density and temperature oscillations that emulate $R$ and $S$ fields. Measuring persistent boundary pressure in such systems could mimic the Gravimetric Pressure equilibrium.
- **Optical-Interference Cavities:** Crossed high-finesse cavities can create standing electromagnetic fields whose energy density gradients follow equations formally identical to GEBT's persistence relation. The residual cavity pressure, measurable via radiation-pressure sensors, provides a laboratory-scale analog of MDMT interference pressure.
- **Thermal-Membrane Resonators:** Graphene membranes with engineered temperature gradients exhibit oscillatory tension comparable to SET. Measuring phase-locked

oscillations between curvature (deflection) and temperature could test GC in a controlled setting.

### 5.6 Cosmological Rhythmic Signatures

The global SET oscillations predicted by GEBT imply a subtle periodic modulation of cosmic expansion. If the persistence frequency $\omega$ lies in the range $10^{-18}$–$10^{-16}\,\mathrm{s}^{-1}$, corresponding to multi-gigayear periods, its imprint may appear as low-frequency modulation in supernova-based Hubble-diagram residuals or in large-scale temperature anisotropies of the cosmic microwave background. Future surveys such as Roman and CMB-S4 could detect these long-term rhythmic patterns.

### 5.7 Prospective Measurements and Data Cross-Checks

To evaluate these predictions, the following approaches are suggested:

1. Correlate galactic temperature maps (e.g., from *Planck*) with rotation-curve anomalies to test entropy–curvature alignment.
2. Search gravitational-wave catalogs for coherent envelope modulations consistent with predicted $\Delta h/h$ values.
3. Compare dark-matter surface-density profiles derived from lensing with entropy-field reconstructions from intracluster medium data.

### 5.8 Summary

The GEBT–GC–MDMT framework offers a concrete observational pathway: thermodynamic gradients produce measurable curvature effects that manifest as dark-matter-like phenomena and rhythmic gravitational signatures. Successful detection of any of these signals would not only validate the theoretical model but also demonstrate that gravity, entropy, and geometry are dynamically coupled aspects of a single universal rhythm.

## 6 Comparative Discussion and Context

### 6.1 Relation to Prior Thermodynamic Gravity Models

The Gravitational Entropic Boundary Theory (GEBT) situates itself within a lineage of thermodynamic and informational approaches to gravitation while introducing two essential refinements: the *boundary-field mechanism* and the *Principle of General Continuity (GC)*.

Whereas Padmanabhan's equipartition framework and Verlinde's entropic-force model regard entropy as an intrinsic property of spacetime, GEBT reinterprets entropy as a *boundary agent* mediating energy exchange between regions of differing curvature. This adjustment restores geometric symmetry and provides a direct, measurable term for the feedback pressure that stabilizes structures.

Sigtermans (2025) derived quantum and gravitational structure from thermodynamic geometry using entropy curvature as a first principle. GEBT shares the recognition of entropy's generative role but diverges in topology and mechanism: Sigtermans embeds entropy within manifold geometry itself, while GEBT confines it to interactive boundaries governed by Gravimetric Pressure and the GC invariant. Consequently, GEBT remains consistent with general relativity under equilibrium conditions yet extends its domain to describe non-equilibrium rhythmic behavior.

## 6.2 Comparison with Quantum and Emergent Frameworks

Quantum gravity programs such as loop or causal-set theory attempt to quantize geometry directly. GEBT, by contrast, interprets quantum discreteness as a natural consequence of entropic boundary segmentation—the microscopic rhythm by which curvature and entropy alternate dominance. The resulting persistence frequency $\omega$ defines quantized action intervals without imposing particle mediation. Similarly, emergent-gravity and holographic duality approaches find new context in GC: the conservation of total influence serves as the macroscopic analog of microscopic information conservation across holographic boundaries.

## 6.3 Position within Unified-Field Development

Within the broader *Unified Field Rhythm* research, GEBT and GC constitute the gravitational–thermodynamic sector that interfaces with the electromagnetic and plasma-field behaviors described by PCDF and CSWIM. Together these frameworks express the same rhythmic law under different manifestations of influence, each preserving $\nabla_\mu J^\mu = 0$ in its respective domain. GEBT thus provides the gravitational anchor that ties the entire unified theory to observable cosmology.

## 6.4 Validation and Companion Work

A complete set of validation studies—including quantitative comparisons with Sigtermans' thermodynamic geometry, Verlinde's entropic-gravity derivation, and empirical datasets on galactic rotation and gravitational-wave spectra—will be presented separately in the document *"Validation and Comparative Analysis of the Gravitational Entropic Boundary The-*

*ory"*. That companion paper expands on the field tests, parameter correlations, and mathematical derivations summarized in this work. References to specific datasets and parameter fits will appear therein to preserve the conceptual focus of the present paper.

### 6.5 Implications for Cosmology

By reconciling curvature, entropy, and energy flow under one continuity law, GEBT reframes cosmological evolution as a rhythmic exchange rather than a singular expansion. Dark energy and dark matter become complementary expressions of entropic–curvature oscillation. The universe, in this picture, is a self-regulating system maintaining long-term equilibrium through alternating phases of compression and diffusion.

## 7 Conclusions and Future Work

### 7.1 Summary of Findings

This paper has introduced the **Gravitational Entropic Boundary Theory (GEBT)** and the **Principle of General Continuity (GC)** as unified descriptors of gravitational persistence. Key results include:

1. Derivation of the *Gravimetric Pressure* relation coupling curvature and entropy gradients;
2. Definition of the *Entropic Boundary Layer (EBL)* as the site of curvature–entropy equilibrium;
3. Identification of *Spacetime Entropic Tension (SET)* as the oscillatory component governing rhythmic stability;
4. Formulation of the *General Continuity* law uniting energy, entropy, and curvature conservation;
5. Integration of GEBT with *MDMT Dark Matter*, demonstrating dark matter as residual boundary energy.

### 7.2 Theoretical and Observational Outlook

Future work will refine the mathematical coupling coefficients linking Gravimetric Pressure, Entropic Tension, and MDMT pressure. Numerical simulations are planned to model galactic rotation and lensing under varying entropy gradients. Laboratory analog experiments—particularly optical and acoustic interference systems—will explore measurable expressions of Spacetime Entropic Tension. Long-baseline gravitational-wave data may reveal envelope modulations predicted by the GC law.

### 7.3 Continuation and Unification

The next stage of the Unified Field Rhythm project will extend GC to the electromagnetic and plasma domains, producing a full-field continuity model that merges gravitational, thermal, and electromagnetic interactions under one rhythmic invariant. Parallel publication of the companion validation document will secure empirical grounding and provide an accessible reference for ongoing research collaborations.


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## Conflict of Interest Statement

The author declares no competing financial interests. All theoretical constructs and terminology (GEBT, GC, MDMT) are original and patent-documented where applicable.

## Data Availability

No new datasets were generated for this study. All comparative and validation data referenced will be provided in the companion document and supplementary materials.


## Keywords

Gravimetric Pressure; Entropic Boundary Layer; General Continuity; Spacetime Entropic Tension; MDMT Dark Matter; Unified Field Rhythm; Thermodynamic Gravity.


# Companion and Citation Information

Further quantitative derivations, data correlations, and comparative studies appear in the companion paper:

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BibTeX citation keys are provided in the shared 'references.bib' file.

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