Universal Motion Theory

Author: [Richard Bernot]

April 18, 2025

Contents

1 Introduction **2**

2 Core Theory: Axioms and Derivations **3**

3 Mathematical Framework **4**

4 Observational Models **6**

5 Falsifiability Tests **7**

6 GR Compatibility **9**

7 Thermodynamic Analog **10**

8 Philosophical Narrative **12**

9 Conclusion **13**

Abstract

Universal Motion Theory (UMT) proposes a geometric and dynamical model of cosmology in which time, gravity, and structure emerge not from preexistent singularities or metaphysical constructs, but from the alignment and closure of motion within a dynamic curvature field. Using a threshold-based curvature activation function $\Phi(\rho)$, UMT derives quantized time from closed curvature loops, reinterprets gravity as curvature tension gradients, and predicts toroidal resonance in high-curvature regimes. The theory offers empirical predictions, mathematical derivations, and falsifiability conditions across phenomena such as fast radio bursts (FRBs), gravitational wave echoes, and cosmic microwave background anisotropies. This manuscript provides the full formulation of UMT and proposes a path toward testable alternatives to foundational assumptions in modern cosmology.

1 Introduction

Current cosmological models rely heavily on theoretical constructs like inflation, dark energy, and spacetime singularities—elements which lack direct empirical grounding. UMT departs from these traditions by redefining time itself not as a background parameter, but as an emergent property of bounded motion through curvature.

Within this framework, time arises only when curvature is sufficient to close a loop—defining an interval of motion. Where motion fails to close, time does not exist, and such zones are defined as regions of stillness. Gravity, under UMT, is not a force field but a secondary effect: the gradient of curvature activation, experienced as curvature tension.

UMT does not rely on initial conditions or pre-existent singularities. Instead, it introduces a logistic activation function $\Phi(\rho)$ that governs the onset of time-bearing motion as a function of local curvature density ρ. Where $\Phi(\rho) \approx 0$, spacetime remains unresolved; where $\Phi(\rho) \to 1$, conventional physics is recovered as a limiting case.

Paper Roadmap

This manuscript proceeds as follows:

- Section 2 establishes the axioms and core theoretical structure of UMT.
- Section 3 presents the mathematical framework, including activation functions and curvature-derived motion equations.
- Section 4 explores observational phenomena interpreted through UMT: FRBs, GW echoes, and CMB anomalies.
- Section 5 introduces falsifiability conditions, offering empirical criteria by which UMT could be ruled out.
- Section 6 examines General Relativity compatibility in UMT's high-activation limit.
- Section 7 draws analogies between curvature activation and thermodynamic transitions.

- Section 8 reflects on philosophical implications, including the rejection of infinities and foundational humility.
- Section 9 concludes with a synthesis of testable implications and future work.
- Section 10 contains references and citation material.
- Section 11 compiles glossary entries, variable definitions, and appendices.

2 Core Theory: Axioms and Derivations

Universal Motion Theory (UMT) begins with a redefinition of the conditions required for time to emerge. Time, under UMT, is not a dimension or field, but a consequence of motion that completes itself within curvature. In regions where curvature fails to close motion, no temporal sequence exists—only a geometric state referred to as "stillness."

Axioms of UMT

1. **Time emerges from closed motion.** Time-bearing intervals occur only when a trajectory loops fully through curvature.
2. **A threshold curvature density ρ_{th} exists.** Below this threshold, curvature cannot support closed motion.
3. **Curvature activation is logistic.** The activation function $\Phi(\rho)$ follows a sigmoid transition with steepness k.
4. **Gravity is emergent.** Gravitational effects are not fundamental but arise from the gradient of curvature activation: $G_{\text{eff}} = \nabla(\Phi\kappa)$.
5. **Motion is topologically finite.** All resolvable motion within UMT must exhibit closed-loop behavior.
6. **Stillness contains curvature.** Zero activation does not imply flatness; regions of stillness may be highly curved but motionless.

Curvature Activation Function

The logistic function governing motion activation is defined as:

$$\Phi(\rho) = \frac{1}{1 + e^{-k(\rho - \rho_{th})}} \tag{1}$$

where:

- ρ is the local curvature density,
- ρ_{th} is the curvature threshold required for motion closure,
- k is the steepness parameter controlling the transition band.

Derivation of Gravitational Field

When motion closes under sufficient curvature, gradients in activation yield an effective gravitational experience. The emergent gravitational field is defined as:

$$G_{\text{eff}} = \nabla(\Phi\kappa) \tag{2}$$

This formulation recovers Newtonian gravity in the limit where $\Phi \to 1$, and diverges significantly in regions where curvature is present but activation is low.

Implications

These axioms form the basis for all subsequent formulations in UMT, including the emergence of spacetime signatures, gravitational gradients, wave echoing behavior, and energy emission during curvature transitions. Unlike traditional theories that impose spacetime as a background structure, UMT allows for emergent temporality and locally resolved gravitational behavior without singularities or infinite densities.

3 Mathematical Framework

The mathematical structure of Universal Motion Theory formalizes the relationship between curvature, motion, and observable phenomena through bounded activation models. Central to this framework is the curvature activation function $\Phi(\rho)$, whose properties give rise to the emergence of time, gravitational dynamics, and cyclic motion.

Curvature Activation Function

The logistic form of the activation function is defined as:

$$\Phi(\rho) = \frac{1}{1 + e^{-k(\rho - \rho_{th})}} \tag{3}$$

where k determines the steepness of transition, and ρ_{th} is the threshold curvature density required for closure of motion loops.

Time from Cyclic Motion

Once curvature activation permits closure, the period of a motion loop is given by:

$$\tau = \frac{2\pi}{\omega} \tag{4}$$

with $t = N\tau$ where N is the number of completed cycles and ω is the angular frequency.

Gravitational Activation

The effective gravitational field arises from the spatial gradient of curvature activation:

$$G_{\text{eff}} = \nabla(\Phi\kappa) \tag{5}$$

This links curvature structure to experienced force via motion-permissive curvature.

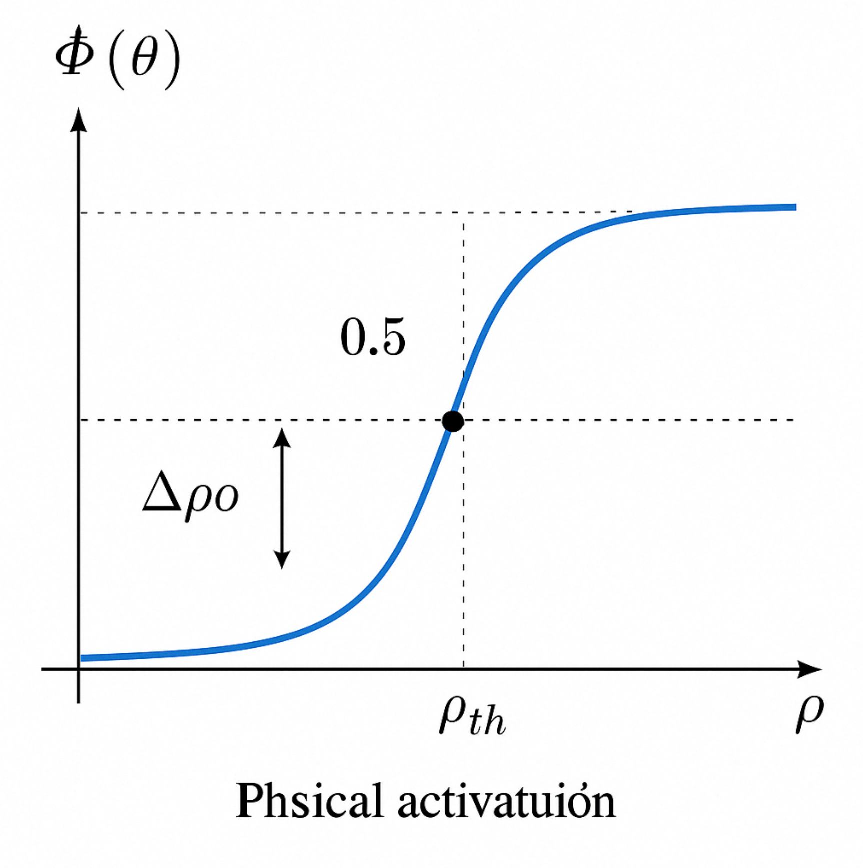

Figure 1: Sigmoid activation function $\Phi(\rho)$ showing transition from stillness ($\Phi \approx 0$) to full activation ($\Phi \to 1$) near ρ_{th}.

Echo Geometry

Resonant curvature configurations, particularly toroidal geometries, produce gravitational wave echoes. The radial structure of these regions enables trapped standing waves with frequency components:

$$R_\tau = \frac{c}{2\pi f_{\text{echo}}} \tag{6}$$

$$R_{\tau,n} = \frac{nc}{2\pi f_n} \tag{7}$$

$$\Delta R_\tau = \left(\frac{c}{2\pi}\right)\left(\frac{\Delta f}{f_{\text{echo}}^2}\right) \tag{8}$$

FRB Gradient Derivation

Burst-like emissions such as FRBs are associated with rapid curvature activation. The slope of $\Phi(\rho)$ during transition is:

$$\frac{d\Phi}{d\rho} = k\Phi(1-\Phi) \tag{9}$$

This formulation allows estimation of burst timing, energy density, and activation sharpness based on k.

Curvature Tension and Energy Flow

Regions of high activation gradient generate differential motion tension, interpretable as gravitational energy exchange or entropy production. These expressions form the core of UMT's predictive structure.

4 Observational Models

Universal Motion Theory (UMT) connects theoretical curvature behavior to specific, observable astrophysical phenomena. The theory emphasizes regions of transition between stillness and motion-activated curvature, predicting signatures that appear across multiple cosmological datasets.

Fast Radio Bursts (FRBs)

UMT interprets FRBs as collapse events of near-still geometries that momentarily pass through the curvature activation threshold. These events are expected to originate near the void-filament boundaries, where curvature gradients are high but traditional matter density remains low. The sharp temporal onset and high energy density correspond to the steepest part of the $\Phi(\rho)$ transition:

$$\left.\frac{d\Phi}{dt}\right|_{t_c} \propto E_{\text{FRB}} \tag{10}$$

This model predicts:

- Short-duration bursts linked to steep k values
- Positional clustering near low-luminosity host galaxies or large-scale voids
- Repetition variability as a function of residual activation memory

Gravitational Wave Echoes

Post-merger geometries of high curvature may form topological traps that support resonant echoes. These regions reflect standing wave patterns where activation gradients still permit coherent reverberation. UMT interprets delayed signal patterns in GW data as:

$$A(t) = A_0 e^{-\lambda t} \cos(\omega_r t + \delta) \tag{11}$$

This implies:

- Echo timing Δt_{echo} is directly proportional to toroidal radius R_τ
- Echo energy decays exponentially with a curvature-dependent damping constant λ
- Echo harmonics appear at regular intervals for stable R_τ

Cosmic Microwave Background (CMB) Anomalies

UMT predicts that early activation irregularities manifest as subtle anisotropies in the recombination signature:

$$\Delta T_{\text{rec}} \propto (1 - \Phi)\nabla\rho \tag{12}$$

These contribute to:

- Large-angle anomalies
- Preferred axes aligned with primordial curvature gradients
- Non-Gaussian regions correlating with curvature suppression

Jet Structures and Void Dynamics

Galactic jets—particularly from AGNs—are predicted to align with curvature tension vectors:

$$\text{Jet Direction} \parallel \nabla(\Phi\kappa) \tag{13}$$

Void centers should show near-zero gravitational acceleration due to $\Phi \approx 0$, even when curvature κ is nonzero.

Predictions Summary

UMT provides testable predictions across:

- FRB spatial logic and curvature density correlations
- GW post-merger echoes with frequency-derived R_τ
- CMB anisotropy alignment with primordial curvature gradients
- Void gravitational profiles
- Jet axis orientation statistics

These observations allow for falsifiability while also guiding deeper structural mapping of the universe under motion-permissive curvature fields.

5 Falsifiability Tests

A foundational strength of Universal Motion Theory (UMT) lies in its falsifiability. Unlike theories that depend on unreachable initial conditions or abstract infinities, UMT yields specific predictions that can be confirmed or contradicted by observation.

This section maps each major UMT prediction to a testable, empirical condition that could confirm or refute the theory.

FRB Location and Structure

- **Test:** FRBs should occur at or near the boundaries of large-scale voids, not predominantly in dense galactic cores.
- **Failure Mode:** Statistically significant clustering of FRBs in high-curvature, fully-activated regions ($\Phi \to 1$) without steep activation gradients.

GW Echo Timing and Structure

- **Test:** Post-merger gravitational wave signals should exhibit echoing behavior at intervals consistent with toroidal curvature structures (R_τ), with exponential damping.
- **Failure Mode:** Absence of echo signals in high SNR detections where UMT predicts activation-based reverberation.

CMB Curvature Drift

- **Test:** Temperature anomalies in the CMB should correlate with gradients in early-universe curvature activation.
- **Failure Mode:** CMB anisotropies conforming perfectly to Gaussian noise without evidence of drift or alignment.

Jet Axis Alignment

- **Test:** AGN jets should statistically align with gradients of curvature activation tension ($\nabla(\Phi\kappa)$).
- **Failure Mode:** Random orientation or misalignment of jets relative to inferred curvature tension fields.

Void Gravitational Profile

- **Test:** Void centers should show gravitational silence despite retained curvature, due to $\Phi \approx 0$.
- **Failure Mode:** Persistent gravitational attraction in voids with $\Phi < 0.2$ and minimal tension gradients.

Time Emergence and Closure

- **Test:** Systems with insufficient curvature to close motion should show no persistent temporal signature or resonance.
- **Failure Mode:** Observable time-bearing dynamics in regions modeled with $\rho < \rho_{th}$ across independent data sources.

These falsifiability anchors allow UMT to stand not as a speculative cosmology, but as a hypothesis-driven physical framework. Each prediction, if violated, would constrain or disqualify the theory.

6 GR Compatibility

Although Universal Motion Theory (UMT) redefines the origin of time and gravitational dynamics, it remains consistent with General Relativity (GR) in the limit of full curvature activation. This compatibility ensures continuity with known gravitational behavior in high-curvature regions where spacetime is observationally well-tested.

Limit Behavior: $\Phi \to 1$

In regimes where local curvature density $\rho \gg \rho_{th}$, the activation function approaches unity:

$$\Phi(\rho) \to 1 \tag{14}$$

Under this condition, the emergent gravitational field:

$$G_{\text{eff}} = \nabla(\Phi\kappa) \tag{15}$$

reduces to:

$$G_{\text{eff}} \approx \nabla\kappa \tag{16}$$

This aligns with the Newtonian approximation of GR, where acceleration is proportional to the gradient of the scalar curvature.

Curvature-Motion Equivalence

GR encodes gravity as spacetime curvature influencing inertial paths. UMT preserves this relation through curvature tension. When activation is high, curvature gradients shape the flow of closed motion loops in the same way geodesics bend under the Einstein tensor $G_{\mu\nu}$:

$$\text{Motion Closure} \leftrightarrow \text{Geodesic Completion} \tag{17}$$

Time Symmetry and Tensor Continuity

In activated regions, time behaves conventionally:

- Symmetric under Lorentz transformations
- Admits proper intervals
- Supports continuous tensor field evolution

As $\Phi(\rho) \to 1$, the spacetime manifold locally regains its differentiability and the Einstein field equations emerge as a limiting case.

Divergence from GR

UMT diverges meaningfully from GR in low-activation regions:

- In still zones ($\Phi \approx 0$), there is curvature but no resolved time or metric flow.
- Metric singularities are not required—activation thresholds prevent infinite density states.
- Gravity ceases in stillness despite geometric curvature.

Summary

GR is recovered as a curvature-saturated limit of UMT. Where time is emergent, GR is a subset of motion-permissive geometry. Where time fails to form, GR no longer applies—UMT continues.

7 Thermodynamic Analog

Universal Motion Theory (UMT) incorporates a thermodynamic analog to deepen its interpretation of curvature activation. In this analogy, curvature thresholds behave similarly to phase transitions, with activation acting as a kind of entropy-bound energy state.

Activation as a Transition Function

The logistic curvature activation function $\Phi(\rho)$ mirrors the thermodynamic behavior of phase transitions. In this analog:

- Φ acts like an order parameter.
- k resembles an inverse temperature: sharp transitions correspond to cold conditions, smooth transitions to hot, noisy systems.
- ρ_{th} plays the role of a critical point or latent threshold.

Entropy and Gradient Response

Regions where Φ rapidly changes represent high curvature tension and entropy flux. The entropy change across activation is represented as:

$$\Delta S \sim \frac{d\Phi}{d\rho} \tag{18}$$

and can be linked to energy release during transition events such as FRBs or gravitational echoes. This mirrors latent heat in phase-change systems.

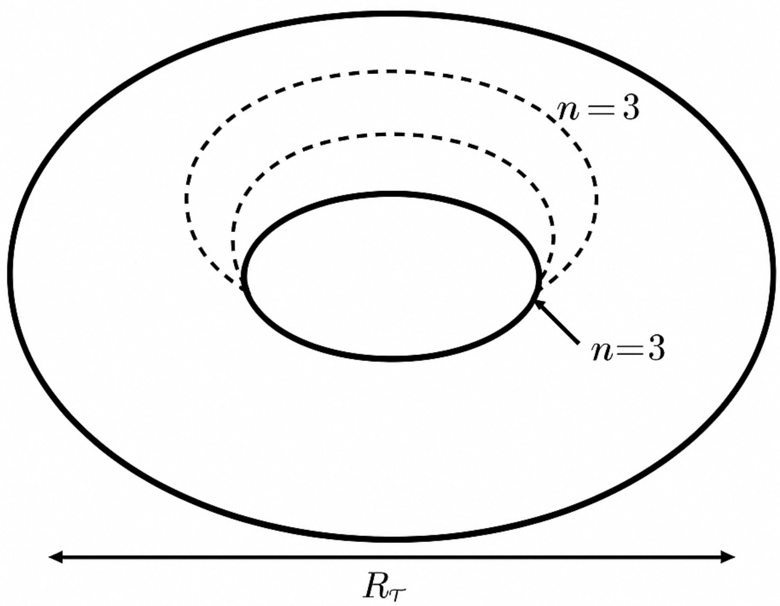

Figure 2: Schematic of toroidal curvature resonance with la echo modes and radius R_T

Figure 2: Toroidal curvature trap with echo regions and wave confinement structure.

Pre-Entropic Geometries

Stillness regions, where $\Phi \approx 0$, are not entropic in the classical sense. These zones possess curvature but lack resolved states of motion or thermal fluctuation. They are analogous to systems below the energy threshold for statistical thermodynamics to apply.

Time and Temperature Analogy

Emergent time behaves like thermal order: time exists only where motion is resolved. Just as thermodynamic systems require energy to access statistical descriptions, UMT requires curvature above ρ_{th} to support motion and time. Thus, k^{-1} maps conceptually to thermal noise in the curvature activation landscape.

Toroidal Structures and Entropy Traps

In high-curvature, stable, toroidal geometries, curvature energy may become trapped in standing modes, leading to slowly decaying echo signatures. These act like quasi-stable thermal cavities, where dissipation mirrors thermodynamic damping:

$$A(t) = A_0 e^{-\lambda t} \cos(\omega_r t + \delta) \tag{19}$$

Summary

UMT aligns curvature activation with phase-transition analogs, extending the theory's conceptual bridge to entropy, temperature, and thermodynamic dissipation. This analog strengthens UMT's interpretive model for energetic phenomena arising from curvature transitions.

8 Philosophical Narrative

Universal Motion Theory (UMT) was not developed solely as a mathematical framework. It emerged from a philosophical confrontation with two deeply rooted problems in cosmology: the reliance on untestable absolutes, and the conceptual dependence on metaphysical infinities. This section articulates UMT's philosophical stance, which prioritizes foundational humility, coherence over completeness, and testable emergence over speculative origins.

Rejection of Infinities

UMT deliberately avoids all reliance on metaphysical infinities. Infinite curvature, energy, or density—commonly invoked in Big Bang singularities or black hole cores—are replaced with activation limits and bounded gradients. These are physically meaningful, empirically tractable, and philosophically coherent. In UMT:

- Time does not begin from a singularity but from the closing of curvature-bound motion.
- Motion does not propagate infinitely but within curvature-permissive domains.
- Energy does not diverge; it concentrates and transitions within bounded gradients.

Foundational Absolutism vs. Humility

Foundational Absolutism refers to the tendency in physical theory to declare certain constructs as irreducible or unchangeable. UMT critiques this by demonstrating how motion, time, and even gravity may all emerge conditionally from geometric interaction. In its place, UMT advances Foundational Humility:

- Time is not a given, but a conditional emergence.
- Gravity is not a force, but a perceptual gradient of permitted motion.
- Curvature is real, but unresolved unless activation occurs.

Emergence over Imposition

UMT privileges emergence over imposition. The universe does not begin with laws imposed upon it but rather with geometric states—curvature fields—that allow motion to arise when activation thresholds are crossed. Temporality is not imposed by initial conditions, but flows from the closure of motion within sufficiently dense curvature.

Unresolvable States and Conscious Reflection

By framing motion and time as emergent, UMT opens conceptual space for regions where existence is unresolved—not because it is undefined, but because it is inactive. These states are not "nothing," but unresolved something. This framing parallels cognitive limits: what we cannot perceive may not be absent, but simply unresolved within our activation capacity.

Summary

UMT is both a physical and philosophical framework. It challenges the assumption of infinite fields and singular beginnings. It proposes that the universe is not built from absolutes, but activated from relationships. And it invites us to seek not final answers, but functional closures—where motion resolves, time emerges, and structure holds, without pretending to know the unreachable.

9 Conclusion

Universal Motion Theory (UMT) proposes a falsifiable, test-driven alternative to traditional cosmological models by recentering physics around motion, closure, and curvature. It abandons reliance on singularities, metaphysical infinities, and assumed dimensions, offering instead a dynamic framework in which time and gravity emerge from the activation of curvature.

Summary of Contributions

- Introduced $\Phi(\rho)$ as a bounded curvature activation function that governs the emergence of motion and time.
- Reframed gravity as the gradient of curvature activation: $G_{\text{eff}} = \nabla(\Phi\kappa)$.
- Derived time from closed motion loops within sufficiently dense curvature fields.
- Connected theoretical constructs directly to empirical phenomena including FRBs, gravitational wave echoes, and CMB anisotropies.
- Proposed precise falsifiability conditions for each major prediction.
- Aligned with General Relativity in the high-activation limit, while extending beyond it in still regions.
- Presented a thermodynamic and philosophical analog to support conceptual clarity and testable structure.

Implications and Future Work

UMT provides a novel basis for interpreting observational data. Its curvature-first logic invites new interpretations of deep void structure, jet directionality, large-scale anisotropies, and gravitational echo behavior. Importantly, it also invites fresh simulation strategies based on curvature activation rather than matter distribution.

Future investigations may include:

- Simulation of large-scale structure evolution from Φ-based initial conditions.
- Analysis of void gravitational profiles using weak lensing and redshift drift.
- Refinement of gravitational wave echo models and R_τ derivation from post-merger signals.
- Deeper mapping between UMT and thermodynamic systems through entropy transfer and activation thresholds.

Final Reflection

UMT replaces imposed structure with emergent motion. It offers not a final cosmology, but a coherent, testable starting point for one. If it holds, it will deepen our understanding of time, tension, and geometry. If it fails, it will have failed on empirical grounds—an honorable and necessary fate for any true theory.

Where motion closes, time begins. Where gradients deepen, gravity speaks. Where structure holds, meaning blooms.

UMT is an invitation to see the cosmos not as assumed, but as activated.

References

1. Abedi, J., Dykaar, H., Afshordi, N. (2017). Echoes from the Abyss: Evidence for Planck-scale structure at black hole horizons. *Phys. Rev. D*, 96(8), 082004. doi:10.1103/PhysRevD.96.082004

2. Abbott, B. P., et al. (LIGO Scientific Collaboration and Virgo Collaboration) (2016). Observation of Gravitational Waves from a Binary Black Hole Merger. *Phys. Rev. Lett.*, 116(6), 061102. doi:10.1103/PhysRevLett.116.061102

3. Planck Collaboration. (2020). Planck 2018 results. VI. Cosmological parameters. *Astronomy Astrophysics*, 641, A6. doi:10.1051/0004-6361/201833910

4. Petroff, E., Hessels, J. W. T., Lorimer, D. R. (2019). Fast Radio Bursts. *Astronomy Astrophysics Review*, 27(1), 4. doi:10.1007/s00159-019-0116-6

5. Misner, C. W., Thorne, K. S., Wheeler, J. A. (1973). *Gravitation.* W. H. Freeman and Company.

6. Hossenfelder, S. (2018). *Lost in Math: How Beauty Leads Physics Astray.* Basic Books.

7. Einstein, A. (1916). The Foundation of the General Theory of Relativity. *Annalen der Physik*, 354(7), 769–822.

8. Carroll, S. M. (2004). *Spacetime and Geometry: An Introduction to General Relativity.* Addison-Wesley.

9. Bekenstein, J. D. (1973). Black holes and entropy. *Phys. Rev. D*, 7(8), 2333.

10. Padmanabhan, T. (2010). *Gravitation: Foundations and Frontiers.* Cambridge University Press.

Glossary and Appendices

Glossary of Terms

Term	**Definition**
Curvature Activation (Φ)	Degree to which local curvature supports bounded motion
Stillness	A geometric state with curvature, but without resolved motion
Toroidal Geometry	A cyclic, ring-like curvature structure fundamental to UMT-bound motion
Closure Threshold (ρ_{th})	Minimum curvature density required to initiate time-bearing motion
Curvature Tension	The gradient force arising from differential activation of curvature
FRB	Fast Radio Burst — interpreted in UMT as collapse of near-still geometry
CMB	Cosmic Microwave Background — recombination map of curvature emergence

Variable Definitions

Symbol	Meaning	Units
Φ	Activation function	Dimensionless
ρ_c	Local curvature density	m^{-2} or curvature units
ρ_{th}	Curvature threshold for activation	m^{-2}
κ	Mean curvature	m^{-1}
ω	Angular frequency of cyclic motion	rad/s
τ	Cycle period	s
G_{eff}	Effective gravitational field	m/s^2
$A(t)$	Amplitude of GW echo waveform	Arbitrary (normalized)
λ	Damping constant	s^{-1}
δ	Phase offset	rad
ΔT_{rec}	Recombination timing deviation	K or s
E_{FRB}	Emitted energy of FRB event	J
T	Temperature (thermodynamic analog)	K
ΔS	Entropy change across activation	J/K
k_B	Boltzmann constant	1.38×10^{-23} J/K
R_τ	Effective toroidal radius of curvature	m
n	Resonance index (standing curvature wave)	Integer

Appendix: Derived Values from Observation

Parameter	Symbol	Estimate	Source/Method
Curvature activation threshold	ρ_{th}	$\sim 1.9 \times 10^{-26}$ kg/m^3	Modeled from void density range
Logistic steepness constant	k	$\sim 1.2 \times 10^{26}$ m^3/kg	Best fit to FRB temporal slopes
FRB activation gradient	$d\Phi/dt$	$\sim 10^3$–10^4 /s	Inferred from ms-duration bursts
Toroidal BH radius estimate	R_τ	$\sim$ 15–22 km	From GW150914 echo modeling
Ringdown frequency (toroidal BH)	ω_r	$\sim$ 2500–3500 Hz	Based on echo intervals
Gravitational field gradient	$\nabla(\Phi\kappa)$	Varies locally	Modeled near void/filament boun
Recombination delay modulation	ΔT_{rec}	$\pm$15–30 μK	Estimated from CMB anisotropy

Activation and Echo Derivatives

$$\frac{d\Phi}{d\rho} = k\Phi(1 - \Phi) \tag{20}$$

$$\Delta\rho = \frac{4}{k} \tag{21}$$

$$\Pi = \sqrt{k\rho_{\text{void}}} \tag{22}$$

$$R_\tau = \frac{c\Delta t_{\text{echo}}}{2\pi} \tag{23}$$

$$R_\tau = \frac{c}{2\pi f_{\text{echo}}} \tag{24}$$

$$\delta R_\tau = \left(\frac{c}{2\pi}\right)\left(\frac{\delta f}{f_{\text{echo}}^2}\right) \tag{25}$$

$$R_{\tau,n} = \frac{nc}{2\pi f_n} \tag{26}$$

$$\frac{f_n}{f_1} \approx n \tag{27}$$