

DOCUMENT 0: LVT AXIOMATICS AND MATHEMATICAL FOUNDATION

Locational Variable Theory: Space as an Emergent Informational
Structure

Version 6.3 — Field Theory and Formal Formatting

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Abstract

Objective. This document presents the ontological and mathematical framework for Locational Variable Theory (LVT). The purpose of the theory is to operationalize spacetime as an emergent property derived from underlying quantum mechanical informational complexity. In this framework, spatial relations are formulated as network topology, where macroscopic space and gravity emerge at specific threshold values for decoherence. This document defines the fundamental postulates, locks the free parameters via holographic and thermodynamic principles, derives the classical correspondence (Newtonian reduction), and formulates quantitative, testable empirical predictions.

1 The Fundamental Ontological Postulate

The theory rests on a fundamental ontological postulate regarding the nature of space, akin to the holographic principle and the concept of *It from Qubit*.

Postulate 1 (Informational Relation): Space is not a fundamental background vacuum, but an emergent projection of relations in an underlying discrete informational graph. The property 'location' for a quantum system is defined as a specific node pointer (LV) in this matrix. The spatial distance (S) and the flow of time are macroscopic renderings that emerge when the system's informational complexity (C), multiplied by environmental decoherence (O), exceeds the matrix's local resolution limit (T_{local}).

In this framework, thermodynamic mass and von Neumann entropy (of the system's reduced subsystems) constitute equivalent measures of informational content.

2 Nomenclature, Variables, and Dimensions

LVT is operationalized based on the following relational fields and parameters:

- **LV (Locational Variable):** The quantum state's network node in the graph [discrete coordinates].
- **LV_{internal} (Internal Locational Variable):** The topological distance between constituent subsystems within a defined quantum state. It dictates internal non-local correlations, such as quantum entanglement [discrete hops].
- **LV_{external} (External Locational Variable):** The topological distance between the system and the macroscopic environmental matrix. It dictates the classical rendered space (S) and metric separation [discrete hops].
- **C_{eff} (Effective Informational Complexity):** Unique information in the system's subsystems [bits].
- **O (Observation / Decoherence):** The degree of quantum mechanical entanglement with the *external* environment, defined via the system's purity, $O \in [0, 1]$ [dimensionless].
- **T_{local} (Local Reality Threshold):** Field-dependent threshold value for the matrix's local rendering capacity [bits].
- **κ_N (Nilsson Constant):** The work conversion factor between informational entropy and thermodynamic work [J/bit].
- **k (Rendering Constant):** Scale factor (in the macroscopic limit associated with the Planck length ℓ_P) that translates logical network hops into the metric meter [m/hop].
- **G_{info} (Informational Gravitational Constant):** Coupling constant for the topological field, dimensioned as $[m^5 / (\text{bits} \cdot s^2)]$.
- **Φ_{LV} (Topological Potential):** The matrix's informational potential, whose gradient generates gravitational acceleration $[m^2/s^2]$.
- **E_{iso} (Isolation Energy):** The thermodynamic work required to actively suppress a system's decoherence scalar (O) [J].

3 Mathematical Formalism and Field Equations

Nota bene: The following field equations are formulated in the **macroscopic limit**. Although the network is fundamentally described by discrete graphs, the matrix is approximated here as a continuous field with spatial coordinates (\vec{r}) and classical differential operators (∇^2).

3.1 Information-Mass Equivalence (C_{eff})

To avoid the paradox that a macroscopic pure state would lack complexity, C_{eff} is calculated over the system's *constituent subsystems* via the entanglement entropy of the reduced density matrices (ρ_A):

$$C_{\text{eff}} = \xi_N \sum_A (-\text{Tr}(\rho_A \log_2 \rho_A)) \quad (1)$$

Here, $\xi_N \in (0, 1]$ is a topological reduction factor, formally defined via the graph's normalized algebraic connectivity (the Fiedler value). This guarantees that the complexity is always strictly positive and proportional to the system's internal redundancy.

3.2 The Decoherence Measure (O)

Observation (O) is strictly operationalized via the reduced system's purity:

$$O = \frac{d}{d-1} (1 - \text{Tr}(\rho_S^2)) \quad (2)$$

Where d is the dimension of the Hilbert space. For a completely isolated, pure state, $\text{Tr}(\rho_S^2) = 1 \implies O = 0$. For a maximally mixed (decohered) state, $\text{Tr}(\rho_S^2) = 1/d \implies O = 1$.

3.3 The Local Threshold Field (T_{local})

The reality threshold is operationalized as a field integrated over the surrounding informational density. To preserve dimensional consistency ([bits]), a Yukawa-like decay kernel is applied:

$$T_{\text{local}}(\vec{r}) = T_0 + \iiint_V \rho_{\text{info}}(\vec{r}') \left(\frac{e^{-|\vec{r}-\vec{r}'|/\lambda_T}}{4\pi\lambda_T^2|\vec{r}-\vec{r}'|} \right) d^3r' \quad (3)$$

Here, T_0 is the threshold value for absolute vacuum [bits]. The integrand ρ_{info} is the environment's thermal entropy density [bits/m³]. The kernel integrates to dimensionless 1 over the volume, whereby the entire term results exactly in the unit [bits]. The length scale λ_T represents the typical scattering radius of decoherence in the medium.

3.4 The Condition for Spatial Emergence

The transition to classical spatial physics occurs when the network's local capacity is overloaded:

$$C_{\text{eff}} \cdot O \geq T_{\text{local}}(\vec{r}) \quad (4)$$

A system is assigned a macroscopic spacetime coordinate only if its entanglement with the environment exceeds the matrix's local uncertainty buffer.

3.5 The Emergent Metric (Spatial Rendering)

When the threshold condition ($C_{\text{eff}} \cdot O \geq T_{\text{local}}$) is satisfied, the macroscopic metric distance (S) between two localized quantum states is rendered by the matrix. This continuous spatial distance is defined as strictly proportional to the shortest logical path (geodesic) in the underlying discrete graph:

$$S = k \cdot d_{\min}(LV_A, LV_B) \quad (5)$$

Where S is the classical metric distance [m], k is the rendering scale constant (the macroscopic limit associated with the Planck length ℓ_P), and $d_{\min}(LV_A, LV_B)$ is the minimum number of logical edges separating the node-pointers of the two states in the informational graph. In this formalism, kinetic traversal implies the sequential, computational stepping through each intermediate node in d_{\min} .

3.6 Topological Bifurcation: LV_{internal} vs. LV_{external}

In the LVT framework, the Locational Variable (LV) is mathematically bifurcated to distinguish between a system's internal informational structure and its relation to the macroscopic environment. Let the total network graph be $G = (V, E)$, partitioned into system edges E_{sys} and environmental edges E_{env} .

The **Internal Locational Variable** ($\Delta LV_{\text{internal}}$) defines the shortest topological path between two subsystems (A and B) restricted entirely to the system's internal basis (E_{sys}):

$$\Delta LV_{\text{internal}}(A, B) = \min_{\text{paths} \in E_{\text{sys}}} \sum A_{ij} \quad (6)$$

This variable dictates internal state coherence and subsystem correlations, independent of macroscopic observation.

The **External Locational Variable** ($\Delta LV_{\text{external}}$) defines the shortest topological path between the same subsystems, but routed exclusively through the macroscopic environmental matrix (E_{env}). It is anchored by the respective local decoherence scalars (O_A, O_B):

$$\Delta LV_{\text{external}}(A, B) = \min_{\text{paths} \in E_{\text{env}}} \sum A_{ij} \quad (7)$$

Because the classical geometric metric (S) is strictly a macroscopic projection of the external topology ($S = k \cdot \Delta LV_{\text{external}}$), this formal bifurcation mathematically permits a quantum state to possess zero internal topological distance ($\Delta LV_{\text{internal}} = 0$) while simultaneously maintaining a non-zero classical spatial separation ($S > 0$).

3.7 Thermodynamic-Informational Conversion: The Nilsson Constant (κ_N)

To actively manipulate the decoherence scalar (O) and decouple a system from the external matrix, the environmental logical edges (E_{env}) must be continuously severed. According to the extended Landauer principle, the suppression of environmental information constitutes a reduction in entropy, requiring a continuous injection of thermodynamic work.

We define the fundamental conversion factor between the informational graph's topological topology and classical thermodynamic work as the **Nilsson Constant** (κ_N), with dimensions [J/bit].

The infinitesimal thermodynamic work (dE_{iso}) required to reduce the system's observation parameter by an infinitesimal amount ($-dO$) is directly proportional to the system's effective complexity (C_{eff}) and inversely proportional to the current observation state (O). This formulates the fundamental differential equation for informational isolation:

$$dE_{\text{iso}} = -\kappa_N \cdot C_{\text{eff}} \cdot \frac{dO}{O} \quad (8)$$

By integrating this differential equation from a fully decohered, classically rendered state ($O_{\text{start}} = 1$) to an isolated target state (O_{target}), we derive the macroscopic isolation energy equation utilized in applied LVT mechanics:

$$E_{\text{iso}} = \int_1^{O_{\text{target}}} -\kappa_N \cdot C_{\text{eff}} \cdot \frac{1}{O} dO = \kappa_N \cdot C_{\text{eff}} \cdot \ln(O_{\text{target}}^{-1}) \quad (9)$$

Physical Implication: The Nilsson constant establishes the absolute "elasticity" or "stiffness" of the universe's informational matrix. It dictates the minimum thermodynamic floor required to engineer a topological translation. Because the function is logarithmic ($\ln(O^{-1})$), reaching absolute zero observation ($O \rightarrow 0$) mathematically requires infinite energy. This asymptotic barrier acts as the matrix's fundamental defense mechanism against absolute localized paradoxes (Topological Recoil).

3.8 The Topological Poisson Equation (Φ_{LV})

Gravity is defined as the informational matrix's network curvature:

$$\nabla^2 \Phi_{LV}(\vec{r}) = \frac{4\pi G_{\text{info}}}{k^2} [\rho_C(\vec{r}) \cdot O(\vec{r})] - \Lambda_{LV} \quad (10)$$

Where ρ_C is the density of C_{eff} [bits/m³], and Λ_{LV} is the network's inherent logical expansion rate [s⁻²]. Gravitational acceleration is given by $\vec{g} = -\nabla \Phi_{LV}$.

3.9 Electromagnetism and Topological Parity (q_{LV})

While gravitation (Φ_{LV}) emerges from the scalar density of informational complexity (ρ_C), electromagnetism arises from the **algorithmic phase** or **Topological Parity** of the network edges.

We assign a dimensionless parity operator $\hat{q} \in \{-1, +1\}$ to localized non-zero complexity states. The efficiency of the matrix's ping-protocol (information routing) between two nodes, A and B , is governed by the product of their topological parities. We define the informational electromagnetic potential (Φ_{EM}) via a modified Poisson equation where the source term is the parity-weighted density $\rho_q(\vec{r}) = \hat{q} \cdot \rho_C(\vec{r})$:

$$\nabla^2 \Phi_{EM}(\vec{r}) = -\frac{1}{\varepsilon_{LV}} \rho_q(\vec{r}) \quad (11)$$

Where ε_{LV} is the matrix's logical permittivity constant. The topological resistance (R_{AB}) to forming new logical edges between node A and B is proportional to $(1 + \hat{q}_A \hat{q}_B)$.

- If $\hat{q}_A \neq \hat{q}_B$ (opposite charges), the product is negative, resistance minimizes, and the matrix aggressively contracts $\Delta LV_{\text{external}}$ to optimize routing (Attraction).
- If $\hat{q}_A = \hat{q}_B$ (like charges), the product is positive, generating severe computational overhead. The matrix actively expands $\Delta LV_{\text{external}}$ to preserve energy (Repulsion).

3.10 Topological Exclusion (The Pauli/Solidity Bound)

Classical solid matter relies on the Pauli Exclusion Principle to prevent atomic collapse. In the LVT formalism, this is strictly derived as a computational bandwidth limit at a singular macroscopic node.

For any specific external locational variable LV_{target} , the maximum allowable integrable complexity is hard-bounded by the local reality threshold (T_{local}). The matrix enforces the absolute inequality:

$$\sum_{i \in LV_{\text{target}}} (C_i \cdot O_i) \leq T_{\text{local}} \quad (12)$$

If two macroscopic systems (e.g., a hand and a solid table) are kinetically forced toward the identical spatial node, the localized sum of $C \cdot O$ threatens to exceed T_{local} . To prevent a logical divergence (a source code crash where LV cannot uniquely define the states), the matrix's algorithmic rendering assigns an infinite topological potential $\Phi_{LV} \rightarrow \infty$ at the boundary. The classical perception of "hard matter" is therefore mathematically defined as the physical sensation of the universe's hard-coded bandwidth saturation.

3.11 Kinetic Friction and Informational Dissipation

In classical mechanics, kinetic friction is treated empirically as a mechanical resistive force between interacting surfaces. In the LVT formalism, macroscopic friction is

rigorously derived as the thermodynamic cost of forced, chaotic topological rewrites.

When two solid surfaces are kinetically forced to traverse each other, the overlapping boundary nodes undergo continuous, chaotic state disruptions. The organized structural complexity (C_{eff}) of the microscopic asperities is irreversibly degraded into randomized, unentangled thermal states.

According to Landauer's Principle, this continuous erasure of localized structural data (ΔC_{erased}) mandates a strict thermodynamic exhaust:

$$\Delta Q = \Delta C_{\text{erased}} \cdot k_B T \ln(2) \quad (13)$$

The macroscopic resistive force (friction) is the mechanical manifestation of the matrix's computational lag during these high-frequency, chaotic node updates. The generated heat is not a byproduct of movement itself, but the direct, mandatory thermodynamic exhaust of the universe actively truncating and scrambling structural source code into background entropy.

4 Classical Correspondence: Newtonian Reduction

A requirement of the field theory is that Equation 10 exactly reduces to Newton's law of universal gravitation for classical matter.

Limit Assumptions:

1. The system is macroscopic and undergoes total environmental decoherence: $O \rightarrow 1$.
2. The expansion of the universe is negligible on the studied scale: $\Lambda_{LV} \rightarrow 0$.
3. The logical complexity density (ρ_C) is directly related to Newtonian mass density (ρ_m) via holographic equivalence. We lock the conversion factor α through the Bekenstein-Hawking bound, $\rho_C = \alpha \rho_m$. Here, α is strictly defined based on the fundamental informational limit of the Planck scale, which is why α is not a free parameter.

By substitution into Equation 10, we obtain:

$$\nabla^2 \Phi_{LV} = \left(\frac{4\pi G_{\text{info}} \alpha}{k^2} \right) \rho_m \quad (14)$$

By identifying the parenthesis with Newton's gravitational constant G :

$$G \equiv \frac{G_{\text{info}} \alpha}{k^2} \quad (15)$$

Newton's field equation $\nabla^2 \Phi = 4\pi G \rho_m$ is recreated. Integration for a point mass subsequently reproduces $\vec{g} = -\frac{GM}{r^2} \hat{r}$.

5 Cosmological Implications

Equation 10 and the threshold condition (Equation 4) allow direct analytical solutions for macroscopic cosmological limits, eliminating the need for ad hoc parameters in the standard model.

5.1 Cosmological Initial Condition (Big Bang)

In the limit $t \rightarrow 0$, the state of the system is defined by the graph's cardinality $|V| \rightarrow 1$, which implies that the topological distance $\Delta LV = 0$ for all state vectors. The initial von Neumann entropy of the universe is minimal. Space (S) and time emerge asymptotically as functions of the system's necessary generation of new network nodes to preserve the second law of thermodynamics under increasing informational complexity (C_{total}).

5.2 Gravity as an Entropic Informational Gradient

As derived in Section 4, the local metric $g_{\mu\nu}$ is a macroscopic effective description of the discrete topological potential Φ_{LV} . Matter, represented as a high density of locked LV -nodes, induces a local extremum in the informational density (ρ_C). Gravitational acceleration is the graph's tendency to minimize the total logical action by driving masses along entropic gradients ($\nabla\Phi_{LV}$), which is classically observed as movement along geodesics in a curved spacetime.

5.3 Dark Matter (Coupling-Free Complexity)

In topological regions where the system's informational density ρ_C is significant, but the local decoherence scalar $O < \epsilon$, the system's phase locking to the electromagnetic field is suppressed (which requires defined external LV -coordinates). However, the system contributes additively to the topological Poisson equation (Equation 10) via the term ρ_C . This generates a macroscopic field Φ_{LV} observed as gravitational mass without photon interaction (Dark Matter).

5.4 Black Holes (Topological Compression and T_{max})

When the informational density in a spatial volume approaches the absolute computational threshold T_{max} , the Bekenstein-Hawking bound is saturated. To prevent a catastrophic processing failure (a systemic computational overflow), the matrix avoids violating its maximum capacity ($C \rightarrow C_{\text{max}}$) by forcing the internal topological distance to exactly zero ($|\Delta LV| \rightarrow 0$). All relational data within this volume is merged into a singular node.

At T_{max} , all local processing overhead is consumed by maintaining this extreme compression. Consequently, incident informational vectors (such as photons) are assimilated

directly into the node without the system calculating reflection or scattering trajectories, resulting in an absolute optical void.

To strictly preserve the conservation of information and avoid thermodynamic violation, the truncated structural data is encoded onto the event horizon, which functions as a two-dimensional holographic phase boundary. Hawking radiation is rigorously formulated here as the thermodynamic exhaust (governed by Landauer's Principle) and quantization noise continuously emitted during the matrix's spatial state truncation to preserve a local informational minimum (preventing data-bit overflow).

5.5 Cosmological Expansion (Λ_{LV})

The term Λ_{LV} in the topological Poisson equation (Equation 10) is defined as the discrete informational graph's growth rate. If $|V(t)|$ denotes the cardinality of the graph's node set at time t , the logical expansion rate is directly proportional to $\frac{d|V|}{dt}$. In order for the system to absorb the monotonic increase in global von Neumann entropy without locally overloading the threshold field (T_{local}), the matrix is forced to expand the number of nodes. This mathematical necessity is integrated in the macroscopic limit as an accelerating metric expansion of spacetime ($\frac{d^2a}{dt^2} > 0$).

6 Quantum Mechanical Implications and Limits

The LVT formalism offers a mechanistic derivation of the quantum mechanical measurement problem and non-locality without introducing hidden variables, solely through the treatment of space as an emergent graph-theoretical property.

6.1 Wave Function Collapse (The Measurement Problem)

The transition from a coherent superposition to a defined spatial basis state is governed by the inequality $C \cdot O \geq T_{local}$. For a microscopic system, C is sufficiently small to allow unitary time evolution without exceeding T_{local} . When the system becomes entangled with a macroscopic measurement apparatus, the complexity C diverges and purity decreases ($O \rightarrow 1$). At the limit value, the time evolution transitions to a non-unitary projection, whereby the system's LV -pointer is singularly defined to prevent matrix divergence.

6.2 Quantum Mechanical Entanglement and Non-Locality

For a multipartite non-separable state $|\psi_{AB}\rangle \neq |\psi_A\rangle \otimes |\psi_B\rangle$, the fundamental topological distance is exactly zero ($\Delta LV_{intern} = 0$). The state mathematically constitutes one (1) node in the source graph. The classical metric distance $S(A, B)$ is a macroscopic representation of local decoherence differences against the respective environments

($\Delta LV_{\text{extern}} \neq 0$). Lorentz invariance is thereby preserved in the classical limit, while state updates occur internally independent of metric separation.

6.3 Environment-Induced Decoherence (Observer-Independent)

LVT excludes explicit anthropocentric observer requirements. The decoherence scalar O is derived exclusively from the trace of the squared reduced density matrix $\text{Tr}(\rho_S^2)$. The orthogonalization of the environment's states (for example via photon or phonon scattering) is sufficient to induce phase loss in the system. The threshold crossing is thus a purely thermodynamic and graph-theoretical process.

6.4 Resolution of Quantum Gravity Divergence

The conflict between quantum mechanics and General Relativity arises classically at the Planck scale, where continuous field theories generate infinities (non-renormalizability). In LVT, the continuous spacetime variable does not exist below the rendering constant k (ℓ_P). The field theory naturally transitions at this scale to discrete algebraic network operations, which is why no singularities or infinities in the geometry can ever arise. $g_{\mu\nu}$ is merely a statistical limit for large N of ΔLV .

7 Falsifiability and Quantitative Predictions

LVT is operationalized empirically through the following testable and quantitative predictions.

7.1 Falsifiable Prediction 1: Metric Hysteresis and Inertial Deviation

According to Equation 4, the decoherence (O) of a macroscopic object can be suppressed. If a system is isolated inside a cooled Fabry-Perot cavity until $C_{\text{eff}} \cdot O \approx T_{\text{local}}$, LVT predicts a reversible decrease in the object's inertial mass and gravitational coupling. The absence of a mass deviation at a documented $O \rightarrow 0$ falsifies the theory.

7.2 Falsifiable Prediction 2: Environment-Dependent Isolation Energy (LEO vs Sea Level)

The work to isolate a system is given by:

$$E_{\text{iso}} = \kappa_N \cdot C_{\text{eff}} \cdot \ln(O^{-1}) \quad (16)$$

The energy is proportional to the requirement to drop below T_{local} . The atmosphere's thermal entropy density (ρ_{info}) in Low Earth Orbit (LEO, 400 km) is approximately

10^{-12} compared to sea level. A Toy-model integration of Equation 3 with a typical $\lambda_T \approx 1$ meter gives that T_{local} in LEO is exclusively dominated by the vacuum threshold T_0 .

Quantitative prediction: LVT predicts that the isolation energy E_{iso} for an identical test mass will decrease by a factor directly proportional to $\ln(1 + \frac{\Delta T_{\text{atmosphere}}}{T_0})$ when the experiment is moved from sea level to LEO. If the energy consumption is environment-independent, LVT is disproved.

7.3 Falsifiable Prediction 3: The Landauer Heat Exhaust of Translation

In the LVT framework, changing a system's location without kinetic traversal requires the deliberate erasure and rewriting of its spatial LV -pointer. According to information theory (Landauer's Principle), the erasure of logical data is physically irreversible without the dissipation of heat.

Quantitative requirement: For an induced topological translation of a quantum state (e.g., a $^{171}\text{Yb}^+$ ion in a controlled potential well), the matrix must emit a discrete thermodynamic exhaust strictly proportional to the erased spatial address data:

$$\Delta Q \geq N_{\text{bits}} k_B T \ln(2)$$

If an LV -translation occurs entirely isothermally, or if the emitted heat does not scale with the logical distance metric in the source code, the informational paradigm is mathematically falsified.

7.4 Falsifiable Prediction 4: Quantized and Distance-Independent Transit Time

Standard kinetic physics models movement as a continuous function of time and distance ($v = ds/dt$). Because LVT defines space as an emergent rendering, an artificial update of the node-pointer ($LV_A \rightarrow LV_B$) bypasses the intermediate rendering sequence.

Quantitative requirement: The temporal duration of a topological translation is decoupled from the metric distance $S(A, B)$ and bounded exclusively by the discrete informational graph's fundamental update frequency: exactly one Planck time ($1 \times t_P$). If an experimental non-kinetic translocation between two points is proven to have a transit time that scales linearly with the physical distance (e.g., $t \propto S$), the underlying continuous spacetime paradigm holds, and LVT is falsified.

7.5 Falsifiable Prediction 5: Decoherence-Dependent Dark Matter Halos

As derived in Section 5.3, Dark Matter is formulated as complexity existing on the boundary of the local threshold ($C \cdot O \lesssim T_{\text{local}}$). According to Equation 3, the field T_{local} is explicitly dependent on the thermal entropy density (ρ_{info}) of the surrounding matrix.

Quantitative requirement: LVT predicts that the gravitational coupling (apparent mass) of Dark Matter halos around galaxies is not static, but fluctuates predictably based on the baryonic thermal radiation field of the host galaxy. High local decoherence forces more "pre-local" information across the threshold. If astronomical observations prove that Dark Matter distributions are entirely collisionless and thermodynamically independent of local baryonic radiation fields, the LVT definition of Dark Matter is falsified.

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LVT is hereby formulated as a formally consistent, falsifiable field theory.