Tension Theory, The Theory of Everything - Paper v0.1

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Abstract

This paper proposes a foundational model in which **tension** is treated as the primary primitive underlying physical, informational, and computational structure. The model assumes a finite capacity for memory and local state updates, from which form, time, and causality emerge as secondary effects. Unlike prevailing frameworks that rely on continuous global states or infinite precision, this approach constrains all evolution to discrete, local interactions governed by informational cost.

In this framework, **time** is not a fundamental dimension but the result of irreversible state transitions under memory limitation. **Space** arises as relational structure within a graph of interacting states. **Particles and fields** are stable or quasi-stable configurations of tension gradients, maintained through constrained update rules. Observation corresponds to selective state coupling rather than external measurement.

The theory aims to reconcile elements of physics and computation by modeling reality as a locally updating system with bounded memory, avoiding the need for global wave functions, continuous manifolds, or observer-dependent collapse. It provides a basis for simulation-first physics, where predictions are derived from executable rules rather than closed-form solutions.

The paper outlines core postulates, formal definitions, and a minimal state-transition model, then demonstrates how known physical phenomena can emerge from these constraints. Finally, it identifies testable predictions and open problems, positioning the theory as a candidate framework for unifying physical law with information-theoretic limits.

1. Motivation

Current physical theories describe reality using global mathematical objects: continuous space-time manifolds, wave functions defined over configuration space, or fields requiring infinite precision. These formalisms are powerful but structurally misaligned with how physical systems appear to operate: locally, discretely, and under finite resource constraints. They describe outcomes accurately while remaining agnostic about the *mechanism* by which reality updates itself.

A central limitation is the absence of **memory cost** as a first-class concept. Existing models implicitly assume unlimited storage of state, perfect reversibility, or access to global information. This assumption conflicts with both physical intuition and computational realism. Any system capable of evolving must store state, update it, and discard alternatives. These operations are not free.

Relatedly, **time** is typically assumed as a background parameter rather than explained. In most frameworks, time exists prior to change, rather than emerging from it. This leads to unresolved tensions around irreversibility, entropy, and causality, which are treated as secondary principles rather than consequences of deeper constraints.

Quantum mechanics introduces probabilistic behavior and non-local correlations but relies on a global wave function and external measurement postulates. Relativity replaces absolute frames with geometric structure but presumes a continuous manifold unaffected by informational limits. Information theory quantifies cost and entropy, yet is usually layered *on top of* physics instead of grounding it.

This paper is motivated by the hypothesis that these difficulties share a common source: the lack of a primitive that simultaneously accounts for **locality, cost, constraint, and persistence**. We propose that primitive to be **tension**—a measure of constrained informational difference between states that governs how and whether updates can occur.

By introducing tension as the organizing principle, memory finiteness becomes foundational rather than incidental. State evolution becomes inherently local. Irreversibility follows from constrained update paths. Time emerges as ordered state change. Structure and form arise not from predefined geometry, but from the accumulation and stabilization of tension gradients.

The goal is not to modify existing theories, but to underlay them with a model that explains *why* their effective laws appear, and *where* they break. The motivation is constructive: to define a minimal, executable framework capable of generating known physics while remaining compatible with computational limits and simulation-based reasoning.

2. Core Postulates

The theory is built on the following postulates. They are assumed, not derived. All subsequent structure follows from them.

Postulate 1 — Finite Memory

Any system capable of evolution has a finite capacity to store state. No global, lossless, or infinite memory exists.

Postulate 2 — Local State

State is defined locally. A system has no access to total or global configuration, only to adjacent or coupled states.

Postulate 3 — Cost of Update

Any state transition has a non-zero cost. Cost is informational and expressed as tension. Zero-cost change is impossible.

Postulate 4 — Tension as Primitive

Tension is the fundamental quantity governing state evolution. It represents constrained informational difference between states and determines allowable transitions.

Postulate 5 — Discrete Updates

All evolution occurs through discrete update steps. Continuity is an emergent approximation, not a fundamental property.

Postulate 6 — Irreversibility

State updates are generally irreversible due to memory limits and cost asymmetries. Perfect reversibility requires infinite memory and is therefore excluded.

Postulate 7 — Relational Structure

There is no absolute space or background geometry. Structure arises from relations between states and the persistence of tension gradients.

Postulate 8 — Emergent Time

Time is not fundamental. It emerges as the ordering of irreversible state updates under finite memory constraints.

Postulate 9 — Observation as Coupling

Observation is a physical interaction between states that redistributes tension. There is no external observer or special measurement rule.

Postulate 10 — Stability via Constraint

Persistent forms correspond to configurations where tension gradients locally balance under update rules. Instability corresponds to unresolved or propagating tension.

These postulates define a closed system: finite memory, local interaction, constrained change. No additional assumptions about continuity, probability, or geometry are introduced.

3. Definitions

This section defines the minimal primitives used throughout the paper. All terms are internal to the model and do not rely on external physical interpretation.

State

A state is a finite description of a system at a given update step. It contains only locally accessible information and is constrained by finite memory.

Node

A node is a locus of state. It stores a local state and participates in update rules through its relations to other nodes.

Edge

An edge is a relation between two nodes. It defines possible interaction, information exchange, and tension comparison. Edges do not imply spatial distance.

Graph

A graph is the total relational structure formed by nodes and edges. It represents all possible local interactions. The graph may change over updates.

Memory

Memory is the capacity of a node to store state information across updates. Memory is finite and bounds reversibility, precision, and future evolution.

Update

An update is a discrete transition from one state to another. Updates occur locally, affect a node and its adjacent edges, and incur cost.

Tension

Tension is a scalar or vector quantity defined on edges and nodes, representing constrained informational difference between connected states. Tension quantifies both cost and pressure for change.

Tension Gradient

A tension gradient is a directional difference in tension across edges. It determines the preferred direction and magnitude of state updates.

Cost

Cost is the irreducible expenditure associated with an update. Cost is measured in tension units and cannot be eliminated, only redistributed.

Constraint

A constraint is any limitation imposed by finite memory, local access, or update cost that restricts allowable state transitions.

Persistence

Persistence is the maintenance of a state or configuration across multiple updates. Persistence requires continuous tension balance.

Form

Form is a persistent configuration of states and edges that remains stable under local updates. Form is emergent and not predefined.

Irreversibility

Irreversibility is the property that a prior state cannot be reconstructed exactly from the current state due to memory loss and asymmetric cost.

Observation

Observation is an interaction between nodes that alters state and redistributes tension. Observation is not passive and has cost.

These definitions are intentionally minimal. No probabilistic, geometric, or semantic assumptions are embedded. All higher-level phenomena must be expressible using only these primitives and their update rules.

4. Formal Model

This section specifies the minimal executable structure implied by the postulates and definitions.

4.1 System Structure

The system is defined as a time-indexed sequence of graphs:

$$\mathcal{G}(k) = (V(k), E(k), S(k), T(k))$$

where:

$$k \in \mathbb{N}$$

- is the update index

$$V(k)$$

- is the set of nodes

$$E(k) \subseteq V(k) \times V(k)$$

- is the set of edges

$$S(k) = s_i(k)$$

- is the set of local node states

$$T(k) = t_{ij}(k)$$

- is the set of tensions on edges

No global state exists beyond this structure.

4.2 Local State

Each node

$$i \in V$$

has a local state:

$$s_i(k) \in \Sigma_i$$

where:

$$\Sigma_i$$

is finite due to memory limits:

$$|\Sigma_i| < \infty$$

State precision and history are bounded by memory. Older information may be overwritten or compressed.

4.3 Tension Function

For any edge

$$(i, j) \in E$$

tension is defined as:

$$t_{ij}(k) = \tau\big(s_i(k), s_j(k)\big)$$

where:

$$\tau$$

is a constrained informational difference function.

Properties:

$$(t_{ij}(k) \geq 0)$$

$t_{ij}(k) = 0$	only if no update is possible
$t_{ij}(k)$	increases with incompatible or divergent states

The exact form of: τ is model-dependent but must be computable locally.

4.4 Update Rule

Updates occur locally and discretely.

For each node: i

$$s_i(k+1) = F_i\Big(s_i(k), s_j(k) : j \in \mathcal{N}(i), t_{ij}(k)\Big)$$

Where:

- $\mathcal{N}(i)$ are neighbors of: i
- F_i is a local update function
- F_i is memory-bounded and non-invertible in general

No node has access to global graph information.

4.5 Cost and Irreversibility

Each update incurs cost:

$$C_i(k) > 0$$

Cost is proportional to tension reduction or redistribution:

$$C_i(k) \propto \Delta T_i(k)$$

where ΔT_i is the local change in tension.

Because memory is finite:

$$H\Big(s_i(k+1)\Big) < H\Big(s_i(k)\Big) + \text{input}$$

Exact reversal of prior states is generically impossible.

4.6 Graph Evolution

Edges and nodes may be created or removed:

$$E(k+1) \neq E(k), \quad V(k+1) \neq V(k)$$

Graph evolution is driven by sustained tension gradients or collapse of inactive relations.

Topology is emergent.

4.7 Stability Condition

A configuration is locally stable if, for all nodes:

$$\sum_{j \in \mathcal{N}(i)} \nabla t_{ij}(k) \approx 0$$

under admissible updates.

Stable configurations correspond to persistent forms.

Unbalanced gradients propagate updates.

This model defines a closed, local, finite system.

No continuous time, global wave function, or external observer is required.

All higher-level phenomena must be derived from these rules.

5. Emergence

This section describes how familiar physical concepts arise from the formal model without being assumed.

5.1 Emergence of Time

Time is not an independent variable. It emerges as the ordered sequence of irreversible updates.

The update index (k) does not represent physical time; it is only a bookkeeping parameter. Physical time corresponds to **experienced change**, defined by the accumulation of non-reversible state transitions under finite memory.

Because updates:

- incur cost,
- overwrite or compress prior state,
- cannot be perfectly reversed,

the system acquires a natural arrow. Ordering becomes meaningful only because earlier states cannot be reconstructed from later ones.

Time = ordered irreversibility.

5.2 Emergence of Space

Space is not predefined geometry. It emerges from persistent relational structure.

Nodes that maintain stable edges with bounded tension form clusters. These clusters behave as neighborhoods. Distance is not metric but relational, defined by:

- number of intervening updates,
- tension propagation delay,
- stability of connectivity.

Spatial continuity is an approximation that holds when graph topology changes slowly relative to update rate.

Space = stable relational graph.

5.3 Emergence of Causality

Causality arises from constrained update dependency.

A state ($s_j(k)$) is said to cause a change in ($s_i(k+1)$) if:

- ($j \in \mathcal{N}(i)$),
- a tension gradient exists,
- the update rule (F_i) depends on ($s_j(k)$).

There is no action at a distance. Apparent non-local effects arise from prior correlations encoded in graph structure and memory.

Causality = dependency under locality and cost.

5.4 Emergence of Particles

Particles correspond to localized, persistent configurations of nodes and edges that satisfy stability conditions.

They are characterized by:

- bounded spatial extent (subgraph),
- sustained internal tension circulation,
- resistance to dispersion under updates.

Particle identity is not fixed substance but maintained pattern. Creation and annihilation correspond to formation or collapse of stable configurations.

Particle = stable tension loop.

5.5 Emergence of Fields

Fields correspond to distributed tension gradients across regions of the graph.

A field is not an entity but a statistical regularity:

- tension varies smoothly across connected nodes,
- updates propagate gradients over many steps,
- local interactions produce coherent global behavior.

Field equations emerge as coarse-grained descriptions of aggregate update dynamics.

Field = large-scale tension gradient.

5.6 Emergence of Probability

Probability is epistemic, not fundamental.

Because:

- nodes have finite memory,
- observers access only local state,
- full system configuration is inaccessible,

outcomes are described probabilistically. Apparent randomness reflects information loss and coarse-graining, not intrinsic indeterminism.

Probability = incomplete local knowledge.

5.7 Emergence of Observation

Observation is a physical interaction that couples two subsystems.

When an observer node interacts with a target configuration:

- tension redistributes,
- both states change,
- prior alternatives collapse due to memory overwrite.

No special measurement postulate is required. Collapse is an update.

Observation = constrained coupling.

This section shows that time, space, causality, particles, fields, probability, and observation are not primitives.

They are emergent regularities of finite-memory, local, tension-governed update systems.

6. Comparisons

This section situates the model relative to existing frameworks. The goal is mapping, not replacement by assertion.

6.1 Quantum Mechanics

Quantum mechanics models systems using a global wave function evolving unitarily, with measurement introduced as an external postulate.

In the tension model:

- There is no global wave function.
- Superposition corresponds to unresolved local tension across multiple possible update paths.
- Collapse corresponds to irreversible update under memory constraint during coupling.

Entanglement arises from shared history encoded in graph structure. Non-local correlations reflect prior tension alignment, not instantaneous influence.

The model reproduces quantum-like behavior without requiring global state or observer-dependent rules.

6.2 Relativity

Relativity treats space-time as a continuous manifold with invariant causal structure.

In the tension model:

- There is no background manifold.
- Causal order emerges from update dependencies.
- Invariance arises statistically from stable relational patterns.

Curvature corresponds to non-uniform tension distributions affecting update propagation. Relativistic effects emerge when relational structure constrains information flow.

6.3 Information Theory

Information theory quantifies entropy, compression, and communication cost but assumes an underlying physical substrate.

Here, information is not layered on physics. It is the substrate.

Entropy corresponds to irreversible state compression under memory limits. Landauer-type bounds are native, not imposed.

6.4 Computation

The model is computational by construction:

- Nodes are finite-state machines.
- Updates are local computations.
- The universe is executable.

Unlike classical cellular automata, topology is dynamic and cost-aware. Unlike Turing machines, there is no global tape.

6.5 Simulation-Based Physics

Traditional physics aims for closed-form solutions.

This framework prioritizes executable rules. Predictions are obtained by running the model under constraints, not solving equations in idealized limits.

Physics becomes a class of simulations constrained by memory and locality.

This model does not contradict existing theories in their domains of validity.

It explains why their effective laws arise and where their assumptions break.

7. Predictions

This section outlines consequences that differ from or extend beyond existing frameworks. These are not metaphysical claims; they are model-level expectations.

7.1 Absence of Perfect Reversibility

Any physical process that appears exactly reversible must rely on hidden memory or external bookkeeping. True microscopic reversibility is impossible in closed systems.

Prediction: there exist fundamental lower bounds on reversibility beyond those predicted by standard thermodynamics, observable in sufficiently isolated, high-precision systems.

7.2 Locality of All Physical Influence

All influence propagates through local graph updates. Apparent non-locality must be explainable via stored correlations.

Prediction: no experiment can exploit entanglement to transmit information without a mediating interaction history, even in principle.

7.3 Memory-Limited Precision

Physical constants and measurable quantities have effective precision limits imposed by memory constraints.

Prediction: at sufficiently small scales or long durations, constants exhibit discretization or drift consistent with bounded state representation.

7.4 Cost of Observation

Observation necessarily perturbs the observed system by redistributing tension.

Prediction: there exist regimes where measurement back-action exceeds standard quantum limits due to memory overwrite effects, not uncertainty relations.

7.5 Breakdown of Continuum Models

Continuum approximations fail when update granularity becomes comparable to system scale.

Prediction: deviations from continuum-based predictions in extreme regimes, even without invoking quantum gravity.

7.6 Simulation Equivalence

Any physical process described by this framework is simulable by a finite, local computational system with matching constraints.

Prediction: there is no physically realizable process that requires non-local or infinite-memory computation.

These predictions are qualitative but falsifiable in principle.

They distinguish the model structurally, not numerically.

8. Simulation Framework

This section outlines how the theory can be instantiated as an executable system.

8.1 Representation

The system is represented as a dynamic graph:

- Nodes: finite-state machines with bounded memory
- Edges: mutable relations carrying tension values
- State: local, discrete, memory-bounded
- Tension: computable locally from state differences

No global controller exists.

8.2 Update Cycle

A single update cycle consists of:

1. **Read**

   Each node reads its own state and adjacent states.
2. **Evaluate**

   Local tension gradients are computed.
3. **Decide**

   A candidate state update is selected under memory and cost constraints.
4. **Apply**

   State is updated, memory overwritten or compressed.
5. **Propagate**

   Tension changes affect neighboring edges.

Update ordering may be synchronous or asynchronous but must remain local.

8.3 Constraints

The simulation must enforce:

- Finite memory per node

- Non-zero cost per update
- No global reads or writes
- Bounded fan-out

Violating these invalidates correspondence with the theory.

8.4 Observables

Observables are coarse-grained patterns:

- Persistent subgraphs
- Stable tension distributions
- Propagation delays
- Update frequencies

Measurement is implemented as coupling between subsystems.

8.5 Scaling

Macroscopic behavior emerges from:

- large node counts,
- slow topology change,
- averaged tension dynamics.

Continuum physics appears as an effective description.

This framework defines the minimum requirements for a faithful simulation of the theory.

All claims must be testable within such an executable model.

9. Implications

This section summarizes consequences that follow directly from the framework, without extending the formalism.

9.1 Physics

Physical law is not a set of equations over continuous variables but a class of stable update behaviors under constraint. Laws persist because they are tension-balanced, not because they are fundamental.

Unification becomes structural: different forces correspond to different regimes of tension propagation and stabilization.

9.2 Computation

Computation is not an abstraction imposed on physics; it is what physics is doing.

Limits of computation (memory, locality, cost) are identical to limits of physical law. There is no hypercomputation in nature.

9.3 Information

Information is physical tension under constraint. Meaning arises only in persistent structures capable of storing and reusing state.

Noise, entropy, and dissipation are unavoidable features of finite memory systems.

9.4 Consciousness

Consciousness is not assumed or explained here, but the framework allows it to be modeled as a high-order persistent structure that:

- maintains internal tension gradients,
- selectively couples to external systems,
- optimizes state under constraint.

No non-physical ingredients are required.

9.5 Systems Design

The same principles apply to engineered systems:

- distributed computation,
- economic systems,
- social structures.

Robust systems are those that manage tension locally and respect memory limits.

These implications follow directly from the postulates and model, without additional assumptions.

10. Open Problems

This section identifies unresolved aspects of the theory and directions for validation.

10.1 Formal Specification of Tension

The theory requires a concrete, computable definition of the tension function (\tau) that:

- is local,
- respects finite memory,
- reproduces known physical limits when coarse-grained.

Multiple candidates may exist. Determining minimal sufficient forms is open.

10.2 Quantitative Mapping

The current framework is structural. Mapping it quantitatively to:

- known constants,
- measured spectra,
- empirical scaling laws

remains open and necessary for experimental contact.

10.3 Emergence Thresholds

Precise conditions under which:

- stable particles form,
- fields become smooth,
- relativistic invariance appears

are not yet derived. These require simulation and phase analysis.

10.4 Observer Modeling

While observation is defined as coupling, modeling observers as internal subsystems with bounded memory and selective access remains incomplete.

This is required to connect predictions with experimental protocols.

10.5 Computational Limits

The exact relationship between:

- memory bounds,
- update rates,

- observable physical limits

is not yet formalized. This includes maximum resolution, minimum time, and maximal causal depth.

10.6 Falsification Strategy

Clear experimental or simulation-based falsifiers must be defined:

- regimes where continuum models provably fail,
- limits on reversibility,
- precision bounds inconsistent with standard theory.

11. Conclusion

This paper presents a minimal, local, finite-memory framework in which **tension** is the fundamental primitive. From constrained state updates, time, space, causality, and form emerge without requiring global structures, continuous manifolds, or special measurement postulates.

The framework shifts physics from equation-first to **process-first**, from idealized infinity to executable constraint. Its validity depends not on elegance but on whether the resulting simulations can reproduce and predict physical behavior under realistic limits.

The theory is incomplete by design. Its purpose is to define a foundation solid enough to build on, test, and potentially break.