

# **Distance, Time, and Gravity as Emergent Constraint Relations: Extensions of Bidirectional Constraint Closure**

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## **Abstract**

Classical physics treats distance, time, and gravity as fundamental features of spacetime. However, growing evidence from quantum gravity, cosmology, and

cognitive science suggests that spacetime itself may be emergent. Building on the Bidirectional Constraint Closure (BCC) framework and the redefinition of Dimension-W as a Reflective Interface, this paper reformulates distance, time, and gravity as relational outcomes of constraint balance rather than primitive quantities. Distance is redefined as relational incompatibility between coherent patterns; time as irreversible constraint renegotiation; and gravity as curvature induced by asymmetric constraint density. These reformulations align with known results from general relativity, holographic duality, thermodynamics, and neural criticality. Finally, speculative but logically constrained implications for alternative propulsion, spacetime navigation, and non-classical travel are explored, remaining consistent with established physical limits.

# 1. Introduction

Modern physics has repeatedly revealed that quantities once thought fundamental are emergent from deeper relational structures. Temperature arises from particle statistics, pressure from momentum exchange, and solidity from electromagnetic constraint. Spacetime itself is increasingly suspected to be emergent rather than primitive, as suggested by quantum gravity approaches and holographic principles (Rovelli, 1997; Maldacena, 1999).

Within the Bidirectional Constraint Closure (BCC) framework, reality is stabilized by two mirrored constraint regimes whose balance produces a Reflective Interface (formerly Dimension-W). If spacetime

emerges from this interface, then distance, time, and gravity must be reformulated accordingly. This paper develops that reformulation.

## **2. Distance as Relational Constraint Separation**

### **2.1 Classical View**

In classical physics, distance is an intrinsic metric property of space. Objects are separated by spatial intervals independent of their internal structure.

### **2.2 BCC Reformulation**

Under BCC, distance is not primitive.

Instead:

Distance is a measure of relational incompatibility between coherent patterns under shared constraints.

Let P1 and P2 be two stable patterns.

Define  $D(P1, P2)$  as:

$$D(P1, P2) = 1 / C(P1, P2)$$

where  $C(P1, P2)$  represents the degree of constraint compatibility at the Reflective Interface.

High compatibility (shared constraints, synchronized phase) yields low effective distance. Low compatibility yields high effective distance.

This formulation explains:

- Quantum nonlocality (high compatibility across spatial separation)
- Psychological and social “distance”
- Rapid reconfiguration of perceptual space

Spatial metrics emerge statistically from averaged constraint compatibilities across many patterns.

## **3. Time as Irreversible Constraint Renegotiation**

### **3.1 Classical View**

Time is typically treated as a fundamental dimension, flowing uniformly and

independently of structure.

## 3.2 BCC Reformulation

In BCC, time emerges from irreversible changes in constraint balance.

Let  $C(t)$  represent the global configuration of constraint relations at the Reflective Interface. Time corresponds to ordered transitions:

$$C(t_1) \rightarrow C(t_2)$$

where the transition is irreversible due to entropy increase and information integration.

Thus:

Time = ordered sequence of constraint renegotiations

This aligns with:

- Thermodynamic arrow of time (entropy increase)
- Psychological time dilation and contraction
- Relativistic time dependence on energy and curvature

Time does not “flow”; rather, coherence is updated.

## **4. Gravity as Constraint Curvature Imbalance**

### **4.1 Classical and Relativistic Views**

In Newtonian physics, gravity is a force. In general relativity, it is spacetime curvature caused by mass-energy.

## 4.2 BCC Reformulation

Under BCC:

Gravity is the macroscopic effect of asymmetric constraint density at the Reflective Interface.

Let  $\rho^+$  and  $\rho^-$  represent densities of integrative and differentiative constraints, respectively. Curvature  $\kappa$  emerges when:

$$\kappa \propto |\rho^+ - \rho^-|$$

Regions with high constraint imbalance cause surrounding patterns to reorganize relationally, producing trajectories analogous to geodesics.

This reproduces general relativistic behavior while grounding curvature in constraint dynamics rather than geometry alone.

## 5. Unified Picture of Spacetime Emergence

Distance, time, and gravity are not independent. All arise from the same underlying mechanism:

- Distance: relational compatibility
- Time: irreversible constraint updates
- Gravity: constraint density gradients

Spacetime is the large-scale statistical geometry of constraint relations.

# 6. Implications for Alternative Travel and Propulsion

## 6.1 Constraint Navigation vs. Spatial Translation

If distance is relational, travel need not involve traversing intervening space. Instead, systems may reduce effective distance by increasing constraint compatibility.

This reframes speculative concepts such as:

- Wormholes (constraint tunnels)
- Alcubierre-type metrics (localized constraint redistribution)

No violation of light-speed limits occurs; rather, relational distance is altered.

## 6.2 Time Manipulation Limits

Because time corresponds to irreversible constraint renegotiation, reversal is forbidden. However, **rate modulation** is possible:

- Time dilation arises from high constraint density
- Time contraction from reduced renegotiation cost

This aligns with relativistic time dilation without permitting paradoxical time travel.

## 6.3 Propulsion via Constraint Gradient Engineering (Speculative)

A hypothetical propulsion system would:

- Increase integrative constraints ahead of a craft
- Increase differentiative constraints behind it

This creates a constraint gradient analogous to gravitational curvature, producing motion without reaction mass.

Such systems remain speculative but do not violate known conservation laws if constraint redistribution carries energetic cost.

## **7. Falsifiability and Experimental Hooks**

The framework is falsified if:

- Distance remains invariant under demonstrable constraint synchronization
- Conscious awareness persists without irreversible constraint updates
- Gravity is shown to be independent of informational or constraint density

Potential tests include:

- Neural synchronization altering perceived distance
- Artificial modulation of criticality affecting time perception
- Information-density experiments in analog gravity systems

## 8. Plain-Language Summary

Space is not a container. Distance is how difficult it is for patterns to relate.

Time is not a river. It is the record of change that cannot be undone.

Gravity is not a pull. It is what happens when balance bends.

All three arise from the same source: how limits negotiate with each other to allow reality to hold together.

## **9. Conclusion**

By reformulating distance, time, and gravity as emergent outcomes of Bidirectional Constraint Closure, this work offers a unified relational ontology

consistent with modern physics and conscious experience. While speculative extensions into propulsion and travel remain theoretical, they follow logically from the same principles that already govern spacetime behavior. The model preserves empirical rigor while opening new conceptual pathways for understanding reality.

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