The Relational Zero State (RZS) Axiom: Pre-Geometric Foundations of Systemic Stability and Gradient Flow Dynamics

Felipe Gianini Romero
Independent Researcher, Brazil
lipegianini88@gmail.com

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Abstract

This paper formalizes the Relational Zero State (RZS) Law as a fundamental, pre-geometric organizational principle governing the stability of complex systems across scales. We propose that systemic stability (σ) is an emergent property defined by the inverse ratio of informational noise (I) and response latency (τ). Within this framework, spacetime is not a background manifold but a derivative of a "Relational Update Rate," where the universal constant c represents the network's maximum refresh frequency. We identify the scaling exponent $\alpha \approx 1.5$ as the universal attractor for relational saturation, consistent with recent JWST observations of high-redshift galaxy populations. The RZS framework is applied to unify cosmological emergence, biological homeostasis, and the critical failure of macro-scale information networks.

Keywords: Pre-geometric Physics, Systemic Stability, Information Theory, RZS Law, Spacetime Emergence, Relational Saturation, Gradient Flow, Romero Axiom.

1 The Romero Axiom of Stability

The integrity of any organized system—from the quantum vacuum to social and biological structures—is governed by the **Law of Relational Stability**:

$$\sigma \propto \frac{B}{I \cdot \tau} \tag{1}$$

Where σ represents stability, B is the processing bandwidth, I is informational noise, and τ is the response latency. Unlike linear cause-and-effect laws, the RZS operates as a **Law of Organization**, determining the threshold where connectivity ceases to generate order and begins to trigger collapse through saturation.

2 Foundations: The Φ_{RZS} Scalar Field and Gradient Flow

We postulate that spacetime geometry is not absolute but emerges from a pre-geometric Relational Potentiality Field[1].

- **Gradient Flow Dynamics:** Cosmic evolution is the result of a flow that seeks to minimize the relational instability of the original vacuum. Existence is a thermodynamic necessity for field relaxation [1].

[1]This addresses the emergence of the metric manifold from non-metric relational precursors, providing the "Ansaetze" for the origin of spacetime points.

- **The Rest Point ($\alpha \approx 1.5$):** Systems reach a "low-latency equilibrium" when their connectivity distribution follows a power law with a critical slope near 1.5. This is the **Zero State**—the configuration of maximum informational efficiency.

3 The Temporal Update Principle (RZS Clock)

In this law, time (t) is redefined as the update rate of relational interactions.

- **Constant c:** The speed of light is not a displacement limit, but the **Maximum Relational Update Rate** of the universal fabric.
- **Relational Saturation (Σ_{sat}):** Systemic collapse occurs when the density of information to be processed exceeds the update cadence ($\tau > c^{-1}$), leading to a loss of causality and the physical disintegration of the structure.

4 Cross-Domain Applications and Validation

The RZS provides a unified metric for diagnosing entropy across multiple scales:

- **Astrophysics:** Explains the "early mass peak" in primordial galaxies as an accelerated convergence toward the $\alpha \approx 1.5$ attractor.
- **Biology and Oncology:** Identifies pathological states as processing failures (High Relational Latency), where mutational noise prevents homeostatic response.
- **Social Systems:** Governance crises and institutional collapses are analyzed as **Narrative Saturation** phenomena, where excessive noise (I) nullifies the social system's ability to update and coordinate.

5 Conclusion: Systemic Responsibility

The RZS demonstrates that the preservation of stability requires the active reduction of noise; in saturated systems, contradictory information is not merely an error—it is an **agent of physical disintegration**. Maintaining the Zero State is, therefore, both an ethical and technical imperative for the continuity of any complex system in the universe.

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References

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