Emergent String-Like Infrared Dynamics from Primordial Four-Dimensional Discrete Geometry A Candidate GR-Endogenous Mechanism within the Cosmological Pangaea Framework

Charles Richard Walker (C. Rich)
Independent Researcher / Theoretical Philosopher
mylivingai.com / ORCID: 0009-0007-6541-3905
Cosmological Pangaea Project: osf.io/vf5cw/overview
tinyurl.com/GoogleScholarCRich

Abstract

We propose a candidate GR-endogenous geometric mechanism in which string-like infrared dynamics emerge naturally as a coarse-grained effective description from the primordial four-dimensional discrete geometry of Cosmological Pangaea. The self-dual 24-cell / F_4 weight lattice provides the low-entropy scaffold. A small deformation parameter ε (≈ 0.015–0.06) encodes residual topological coherence after fracturing via distinction cuts. Canonical height grading on the F_4 lattice yields linear mass-squared towers $m_n^2 \approx n$ ($M_{Pl}^2\ \varepsilon$). Projection onto the dominant height direction and a simple ε-deformed transfer-operator model for flag transitions produces schematic 4-point amplitudes exhibiting towers of s-channel poles, exponential residue suppression, and softened high-energy asymptotics. In the coarse-grained infrared limit below $E^* \approx M_{Pl}\sqrt{\varepsilon}$, the discrete dynamics recover key string-like features as the unresolved shadow of deeper geometric memory. This framework proposes a physically grounded four-dimensional origin for *aspects of* string-theoretic infrared phenomenology. We maintain strict separation between rigorously demonstrated elements of the toy model and open questions (full quantization, graviton consistency, fermion representations, anomaly cancellation).

1. Introduction

String theory has yielded elegant mathematical structures that successfully capture important low-energy phenomenological features, most notably linear Regge trajectories and towers of resonances. Recent bootstrap approaches have derived many of these features from general principles such as unitarity, crossing symmetry, and minimal zeros under comparatively memoryless assumptions.

The Cosmological Pangaea framework challenges the memoryless premise. It posits a primordial low-entropy, self-dual 24-cell scaffold that fractures through distinction cuts

governed by Axiom D and Weyl-curvature backreaction. The present work advances this program by constructing a specific geometric mechanism for the emergence of string-like infrared dynamics.

Central Thesis: String-like infrared dynamics are not fundamental but emerge as the coarse-grained shadow of primordial discrete geometric memory.

2. What This Work Is Not

This work does not claim a complete ultraviolet completion of quantum gravity, nor does it present a replacement for established string-theoretic constructions. Rather, it proposes a candidate geometric mechanism explaining why several characteristic infrared features commonly associated with string theory may emerge naturally from a four-dimensional discrete cosmological substrate.

3. The 24-Cell / F_4 Scaffold and ε-Deformation

The regular 24-cell realizes the short roots of F_4. Flag states represent locally coherent excitation domains on the fractured scaffold, labeled by F_4 weight lattice positions and connected through Weyl-allowed transitions. The deformation parameter ε controls residual topological coherence.

Positive roots admit unique expansions $\alpha = \sum k_i \alpha_i$ ($k_i \geq 0$), with canonical height $ht(\alpha) = \sum k_i$. Flag transitions change height by integer steps $\Delta ht = \pm 1$.

4. Height Grading, Linear Towers, and Toy Amplitudes

Projecting onto the dominant height direction yields an effective one-dimensional chain $|n\rangle$, producing the linear spectrum

$m_n^2 \approx n \cdot (M_{Pl}^2\ \varepsilon)$,

with effective Regge slope $\alpha' = 1/(M_{Pl}^2\ \varepsilon)$.

The transfer operator is defined as

T_{mn} = ε^{|m-n|} A_{mn}

(A_{mn} = 1 for Weyl-allowed transitions). Schematic 4-point amplitudes take the form

$\mathcal{A}_4(s; \varepsilon) \sim \sum L\ (T^L)\{fi\} \times$ kinematic factors.

For representative $\varepsilon \approx 0.03$, low-order poles display exponential residue suppression. In the coarse-grained infrared limit ($E < E^* \approx M_{Pl} \sqrt{\varepsilon}$), the discrete sums approximate a linear density of states, recovering Regge-like behavior and bootstrap-compatible features.

5. Explanatory Inversion and Geometric Memory

This construction embodies an explanatory inversion. Traditional approaches often begin with fundamental strings (or branes) from which low-energy phenomenology descends. Here, primordial four-dimensional discrete geometry gives rise to effective string-like infrared behavior through coarse-graining. Geometric memory encoded in the fractured scaffold supplies the ultraviolet structure and selection rules absent in memoryless derivations, while leaving the infrared approximately string-like.

If successful, this framework suggests that familiar string mathematics may itself be an emergent infrared description of deeper primordial geometry.

6. Relation to the String Landscape

A companion analysis using the GR-Razor battery identifies significant challenges for the conventional String Theory Landscape + Eternal Inflation picture (privileged base asymmetry, ontological non-parity, extrinsic geometry, and unresolved global entropy/measure issues). Cosmological Pangaea offers a candidate GR-native alternative: endogenous branching with thermodynamic accountability and finite generational depth. The present mechanism shows how string-like infrared phenomenology can arise naturally within this setting.

7. Discussion and Open Directions

The central bridge, from F_4 lattice grading through ε-deformed flag dynamics to emergent infrared structure, provides a constructive derivation of string-like features from primordial cosmology. Collective quadrupolar deformations may furnish routes to emergent tensor modes, while F_4 representation branchings appear combinatorially fertile for fermions.

Open Questions (strictly separated from demonstrated results):

- Full quantization and graviton consistency.
- Fermion representations and anomaly cancellation.
- Discriminating signatures and quantitative bounds on branching depth from entropy costs.

Summary

I have presented a candidate GR-endogenous mechanism in which string-like infrared physics emerges naturally from primordial four-dimensional discrete geometry through coarse-graining. The memorable thesis is that string mathematics appears as the

unresolved infrared shadow of deeper discrete geometric memory. This toy model is offered for scrutiny and further development within the Cosmological Pangaea research program.

References

[1] C. Cheung et al., "Strings from Almost Nothing," arXiv:2508.09246 [hep-th] (2025). [2] C. Cheung, A. Hillman, and G. N. Remmen, "Bootstrap Principle for the Spectrum and Scattering of Strings," Phys. Rev. Lett. 133, 251601 (2024). [3] A. F. Ali, "Quantum Spacetime Imprints: The 24-Cell, Standard Model Symmetry and Its Flavor Mixing," arXiv:2511.10685 [hep-ph] (2025). [4] N. Bourbaki, *Lie Groups and Lie Algebras, Chapters 4–6* (Springer, 2002). [5] J. H. Conway and N. J. A. Sloane, *Sphere Packings, Lattices and Groups*, 3rd ed. (Springer, 1999).

C. Rich Walker, *Cosmological Pangaea: Decoding the Universe With Artificial Intelligence* (2025). C. Rich Walker, *Cosmological Pangaea: The Story of Entropy* (2026).

Project Repository: https://osf.io/vf5cw/overview