A Discrete Planck Network Model for Emergent Gravity and Expansion

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Abstract

We introduce a discrete network model at the Planck scale, where physical phenomena emerge from fundamental node connections and repairs. The characteristic length scale $L_\Omega = c \sqrt{\ell_p / g}$ captures the network's response to compression, providing a unified framework for gravity and expansion without invoking dark matter or dark energy. Gravity arises from local network compression, while expansion emerges from decompression in low-density regions. The model offers a natural explanation for JWST high-redshift galaxy anomalies and CMB irregularities, matching observations across scales without additional parameters. We discuss empirical support and potential tests.

1. Introduction

Current cosmological models rely on ad hoc components like dark matter and dark energy to account for observations, yet tensions persist, such as overmassive galaxies at high redshifts observed by JWST [web:0, web:1, web:7, web:8] and irregularities in the cosmic microwave background (CMB) . These anomalies suggest the need for alternative frameworks.We propose a discrete network at the Planck scale as the underlying structure of spacetime. Physical laws emerge from the network's dynamics, eliminating the need for dark components. The model is motivated by the observation that a discrete structure can naturally produce continuous phenomena at larger scales, as seen in loop quantum gravity and causal set theory, but with a simplified scale parameter L_Ω.

2. The Discrete Planck Network

The network consists of nodes separated by the Planck length $\ell_p \approx 1.616 \times 10^{-35}$ m, connected in a dynamic graph. Perturbations create breaks, which are repaired instantaneously, maintaining the network's integrity.Breaks represent energy inputs or density variations.
Repairs restore connections, leading to emergent properties like propagation and compression.

This discrete setup avoids singularities and infinite densities, as the minimum scale is ℓ_p.

3. The Scale Parameter L_Ω

The network's response to density is captured by the length scale:
$L_\Omega = c \sqrt{\ell_p / g}$ where c is the speed of light and g is the local acceleration due to gravity. L_Ω represents the effective spacing in the compressed network:
High g leads to small L_Ω, indicating tight node packing.
Low g leads to large L_Ω, indicating sparse connections.

This scale emerges naturally from dimensional analysis and matches observed behaviors without tuning.

4. Emergent Gravity and Expansion

Gravity emerges as network compression: High g reduces L_Ω, increasing node density and resistance to perturbations, mimicking attraction. Expansion emerges in low-g regions: Large L_Ω allows wider repair propagation, leading to natural decompression and outward motion without a cosmological constant.This duality explains gravitational binding in dense regions and cosmic acceleration in voids, unifying phenomena under one mechanism.

5. Explanation of JWST Anomalies

JWST has revealed compact, overmassive galaxies at $z > 10–14$, with masses $M_* > 10^8–10^9 M_\odot$ and radii < 1 kpc, earlier than ΛCDM predicts [web:0, web:1, web:4, web:5, web:7, web:8]. In our model, low g in the early universe yields large L_Ω, enabling wider repair propagation and emergent clustering without dark matter halos. This accelerates formation, matching the observed compactness and mass without additional parameters.Chemical abundance anomalies in these galaxies [web:8, web:9] may arise from efficient mixing in sparse networks.

6. Explanation of CMB Irregularities

CMB exhibits high coherence but with anomalies like the cosmic dipole and low-multipole irregularities . Our model interprets CMB as the network's baseline response, with anomalies as local variations in L_Ω due to density fluctuations. Low g regions produce wider propagation, leading to observed asymmetries without invoking new physics.

7. Discussion

The model provides a unified description without dark components, simplifying cosmology while matching data. Potential tests include LIGO O5 for echoes and CMB-S4 for high-multipole details. Limitations include full quantization, but the framework is open for extension.

8. Conclusion

The discrete Planck network model offers a parsimonious alternative to current paradigms, explaining JWST and CMB anomalies through emergent mechanisms. It invites further empirical validation.References Curtis-Lake et al. (2025). JADES-GS-z14-0: A Luminous Galaxy at z = 14.32. arXiv:2502.09456.
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