The Non-Local Grid Dimension and the Emergence of Gravity

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Abstract

We propose a discretized model of space-time augmented by a compactified, non-local dimension—the *grid*—as a new framework for reconciling quantum entanglement with relativistic locality. In this construction, quantum correlations persist via topological links embedded within the grid structure, while causal constraints within the familiar space-time lattice remain inviolate. The resulting picture resolves the Einstein-Podolsky-Rosen paradox without invoking superluminal communication and offers a reinterpretation of gravity as an emergent phenomenon arising from the grid's topological curvature. We argue that the grid dimension provides a unified geometric substrate underlying both quantum coherence and classical gravitation, suggesting potential empirical signatures such as gravitational lensing anomalies and deviations from Lorentz invariance at high energies.

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1. Introduction

The tension between quantum nonlocality and relativistic causality remains one of the most profound challenges in theoretical physics. Quantum entanglement—verified experimentally through violations of Bell inequalities—defies any explanation based on local hidden variables, while relativity forbids causal influences propagating faster than light. Despite remarkable progress in quantum information theory and quantum field theory, no universally accepted resolution to this apparent conflict has yet emerged.

In this work, we explore an alternative perspective: that space-time itself is fundamentally discrete, composed of Planck-scale lattice points, and is augmented by a compactified, non-local *grid dimension*. Through this additional topological structure, entangled particles can remain correlated across spacelike separations without violating local causality within the space-time lattice. The proposal thus suggests a way to preserve the causal structure of relativity while accounting for the empirically verified nonlocality of quantum mechanics.

Moreover, we suggest that gravity—rather than arising from the curvature of a Riemannian manifold as in general relativity—emerges from curvature in the grid's

topological structure. In this framework, space-time, entanglement, and gravitation are not separate domains stitched together artificially but facets of a single underlying non-local geometric entity.

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2. The Discrete Space-Time Lattice and the Grid Dimension

We begin by postulating that space-time is fundamentally discrete, characterized by a lattice of Planck-scale nodes. Adjacent nodes are separated by one Planck length, and causal influence is restricted to propagation between neighboring nodes, limited by the Planck time—thus recovering the relativistic limit on the speed of light.

Beyond this lattice, we introduce a compactified non-local dimension: the *grid*. The grid establishes topological connections between non-adjacent points in the space-time lattice, effectively linking distant regions without violating local causal structure. These connections are not embedded within the standard four-dimensional continuum but reside in the higher-dimensional structure of the grid, inaccessible to causal signaling yet capable of sustaining quantum correlations.

Thus, while an observer confined to the space-time lattice perceives locality and causal propagation, the underlying grid maintains nonlocal coherence between distant points. Quantum entanglement arises not from action at a distance, but from the persistent topological links within the grid.

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3. Reconciling Entanglement and Locality

In this framework, the Einstein-Podolsky-Rosen paradox finds a natural resolution. When two particles become entangled, their space-time coordinates are simultaneously connected within the grid structure. Measurements on one particle are not transmitted instantaneously across space, but rather reflect a global adjustment of the topological configuration—a reorganization of the grid's connections—which preserves the observed correlations without causal transmission.

Collapse of the wavefunction, traditionally conceived as an instantaneous and somewhat mysterious process, is reinterpreted as a topological transition within the grid, altering the connectivity of nodes associated with the entangled system. No signal traverses space-time faster than light; instead, the pre-existing grid connections globally constrain the outcomes of measurements.

Because these grid connections are immune to local decoherence processes in space-time, entanglement exhibits its characteristic robustness against environmental noise—a phenomenon often cited as paradoxical within standard interpretations.

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4. Emergent Gravity from Grid Curvature

Extending this model, we propose that gravity itself is a manifestation of curvature in the grid dimension. Where the density of topological connections increases—corresponding to regions of mass-energy concentration—the effective geometry of the space-time lattice is distorted. Observers confined to the lattice experience this distortion as gravitational effects: time dilation, redshift, and the warping of geodesics.

Crucially, this emergent gravity does not arise from curvature within a smooth Riemannian manifold, but from the global, combinatorial structure of the grid's topology. Different inertial observers correspond to different staggered, quantized frames within the grid, linked by the network of connections. Transition between these frames underlies gravitational phenomena, with the invariance of the speed of light arising from the coupling between grid geometry and the lattice frames rather than from Lorentz symmetry alone.

This reinterpretation suggests new pathways for addressing puzzles such as black hole entropy, the emergence of classical space-time from quantum coherence, and the role of the observer in cosmological phenomena.

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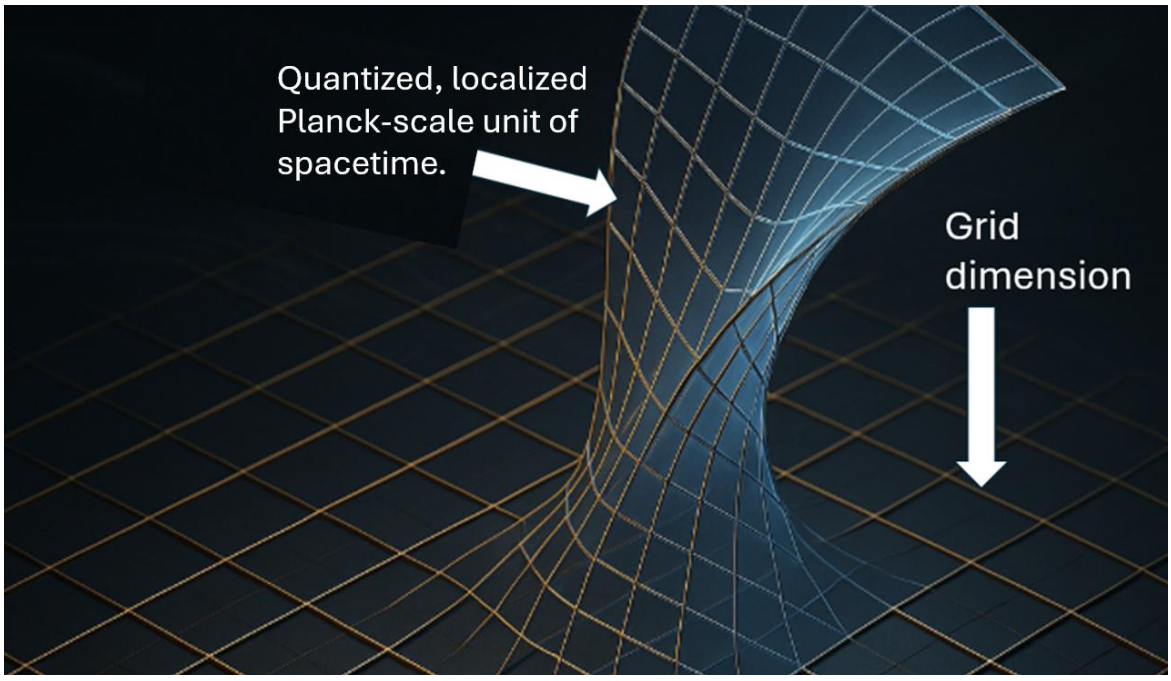
6. Conclusion

By introducing a discrete space-time lattice augmented by a compactified, non-local grid dimension, we offer a unified geometric substrate for understanding quantum entanglement, locality, and gravity. This model reconciles the apparent contradictions between quantum mechanics and relativity without sacrificing either, and suggests that gravity itself is an emergent phenomenon rooted in the topology of a deeper, non-local structure.

The interplay between discreteness, nonlocality, and curvature invites a rethinking of the foundational structures of physics, pointing toward a potentially coherent and testable theory of quantum gravity.



The image depicts golden grid lines forming the non-local grid dimension, serving as a connective framework. The rectangles, arranged on this grid, represent localized, discrete units of Planck scaled quantized spacetime. This contrast highlights how non-local structure underlies and links the otherwise separate, localized spacetime units.

Acknowledgments:
The author thanks Gabriel Sinbar for discussions and insights regarding the topological structure of non-local quantum systems.

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