Kosmodynamic Quantum Mechanics

Historical Geometry, Loss of Geometric Continuation, and the Emergence of Quantum Behavior

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Abstract

We develop a scale-invariant quantum framework on top of the discrete-frame cosmodynamic model previously introduced for emergent gravitation. In this picture, physical reality is generated as a sequence of frames, each at a slightly smaller physical scale than its predecessor, while outer geometric layers are preserved as historical geometry. Macroscopic objects are defined as systems that continuously extend their historical geometric trace across frames; they possess a stable geometric center, effective mass, inertia and gravitation. In contrast, microobjects (elementary quanta) are states for which this geometric continuation is interrupted. They retain a historical origin but no longer propagate their own trace into subsequent frames. As a consequence they are effectively massless, centerless, and non-gravitating.

Within this framework, the quantum wavefunction is reinterpreted as a compatibility functional that encodes the set of possible reattachments of a microobject to existing historical geometry. Probabilities arise from the relative geometric continuation capacity of different attachment options. Measurement is described as a purely geometric recoupling process in which a macroscopic system takes over the continuation of the interrupted trace, producing a sharp and objective "collapse". Interference and entanglement are explained as consequences of frame-wise evaluation of competing attachment structures and shared historical constraints in the global geometry. The boundary between quantum and classical behavior is no longer a postulate but follows from the density and robustness of geometric continuation. We outline the formal structure of this kosmodynamic quantum mechanics and discuss its relation to standard quantum theory.

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1 Introduction

Quantum mechanics (QM) describes the behavior of matter and radiation at microscopic scales with remarkable empirical success. Its standard formulation, however, leaves several fundamental questions unresolved. Among them are:

- the meaning and ontology of the wavefunction,
- the origin and mechanism of wavefunction collapse,
- the nature of quantum probabilities,
- the status of superposition and the emergence of classicality,
- and the physical origin of entanglement and apparent nonlocality.

These questions become even more pressing when quantum theory is considered alongside gravitation. General Relativity (GR) models gravitation as curvature of a smooth spacetime manifold with fixed local scales, while QM operates on a static atomic scale and does not address the global structure or evolution of scale itself. The resulting tension between quantum theory and gravitation has motivated numerous attempts at unification, often at the cost of increasing formal complexity.

In previous work, we introduced *Scale-Invariant Cosmodynamics*, a discrete-frame model in which physical reality emerges through successive frames of slightly smaller physical scale. Each frame updates the geometry only within a newly contracted interior region, while outer regions are preserved as historical layers of geometry. Massive objects imprint their contraction history into these layers, and the resulting asymmetries produce emergent gravitation without a fundamental gravitational force or curvature field.

The purpose of the present paper is to extend this cosmodynamic framework into the quantum domain. We show that quantum phenomena can be understood as a direct consequence of how different physical systems participate in, or fail to participate in, the continuation of historical geometry across frames:

- Macroscopic objects continuously extend their geometric trace and behave classically.
- Microobjects represent states where this continuation is interrupted and become quantum.

In this picture, the quantum wavefunction does not describe a physical wave in space, but rather the structured set of possible reattachments of an interrupted trace to existing historical geometry. Probabilities become measures of geometric continuation capacity, and the collapse of the wavefunction is the objective moment at which a macroscopic system resumes geometric continuation on behalf of the microobject. Entanglement arises when multiple microobjects share a common historical constraint in the global geometry and thus must satisfy a common consistency condition at the frame level.

The kosmodynamic quantum framework proposed here therefore does not modify the empirical content of quantum mechanics. Instead, it provides a geometric mechanism underlying its formal structure, and it places quantum behavior and gravitation within a single scale-invariant, discrete-frame ontology.

2 Geometric and Scale Framework

We briefly recall the core geometric and scale structure of Scale-Invariant Cosmodynamics, focusing only on the elements needed to formulate the quantum framework. The reader is referred to the gravitation paper for a more detailed treatment.

2.1 Discrete Frames and Scale Evolution

Physical reality consists of a sequence of discrete frames

$$F_0, F_1, F_2, \ldots, F_n, \ldots,$$

each representing a complete physical configuration at index n. No intermediate states exist; all evolution is realized as transitions from F_n to F_{n+1}.

Each frame F_n is characterized by a global physical scale S_n:

$$S_{n+1} = S_n - \Delta S_n, \qquad \Delta S_n > 0.$$

All local physical processes (atomic sizes, energy levels, characteristic times, and effective speed of light) scale proportionally with S_n. As a result, observers within a single frame cannot detect absolute scale drift; local physics in F_n appears identical to that in F_{n+1}.

2.2 Historical Geometry

Let $G_n(\boldsymbol{x})$ denote the spatial geometry at point $\boldsymbol{x}$ in frame F_n. When a new frame F_{n+1} is generated:

- geometry is updated only within a contracted interior region,
- the outer region remains unchanged and constitutes a preserved historical layer.

This process leads to a *historical geometry*, a layered structure in which:

- inner layers represent more recent frames at smaller scale,
- outer layers represent older frames at larger scale.

The historical geometry stores a cumulative record of how space has been successively contracted and distorted by matter.

A detailed radial version of this construction was given in the gravitation paper. For the quantum framework, it is sufficient to note that historical geometry provides:

- a persistent archive of the past,
- a global constraint structure shared by all frames,
- and a substrate on which both classical and quantum behavior are defined.

2.3 Macroscopic Objects and Geometric Continuation

A crucial concept in the present work is *geometric continuation.* A macroscopic object is defined as a system that:

- maintains a stable geometric center across frames,
- continuously extends its geometric trace into F_{n+1},
- and thereby imprints its presence into the historical geometry.

Let $\mathcal{H}_n$ denote the geometric contribution of an object to frame F_n. For a macroscopic object we have

$$\mathcal{H}_{n+1} \approx \mathcal{H}_n + \Delta\mathcal{H}_n,$$

with $\Delta\mathcal{H}_n$ small and consistent across frames. This persistence defines:

- an effective mass (as the ability to maintain a center),
- inertia (as resistance to deviation from the established trace),
- and gravitation (as alignment with the displaced historical center).

Macroscopic objects are thus those that remain geometrically present in the historical record with high fidelity.

2.4 Microobjects and Interrupted Continuation

In contrast, we define *microobjects* as states for which geometric continuation is *interrupted.* A microobject:

- has a historical origin in past frames,
- but does not maintain its own geometric center across frames,
- and therefore does not contribute a stable trace to the historical geometry.

Formally, for a microobject we have

$$\mathcal{H}^{\text{micro}}_{n+1} \not\approx \mathcal{H}^{\text{micro}}_n + \Delta\mathcal{H}^{\text{micro}}_n,$$

and instead its trace is replaced by a set of possible future attachments to existing macroscopic structures.

Microobjects are therefore:

- effectively massless, in the sense of having no self-maintaining geometric center,
- non-gravitating as independent sources,
- and fundamentally quantum in their behavior.

The kosmodynamic quantum theory is built precisely on this contrast between continued and interrupted geometric participation.

3 Microobjects and Masslessness from Geometry

We now formalize the geometric status of microobjects and show how their effective masslessness and quantum character arise from interrupted continuation.

3.1 Historical Origin Without Current Center

Every microobject has a *historical origin*: it is produced by a process involving macroscopic systems (sources, detectors, bound states, etc.) that do maintain geometric continuation. Let this origin be encoded in historical geometry as a structure $B(\boldsymbol{x})$ representing the geometric boundary condition associated with the creation event.

However, after creation, the microobject does not sustain its own evolving center:

$$\nabla \mathcal{H}_n^{\text{micro}}(\boldsymbol{x}) \approx 0,$$

in the sense that it does not define a preferred geometric center in subsequent frames. The historical origin remains encoded in $B(\boldsymbol{x})$, but the microobject ceases to contribute a stable update to G_{n+1}.

Thus, a microobject is a state that:

- is *rooted* in historical geometry via $B(\boldsymbol{x})$,
- but is no longer *anchored* by its own ongoing trace.

3.2 Mass as Geometric Continuation Capacity

Within this geometric framework, we may define an effective notion of mass as the capacity of a system to maintain and extend its geometric center across frames. Let C be a measure of geometric continuation such that

$$m \propto C,$$

with C large for macroscopic objects and $C \approx 0$ for microobjects.

Then:

- macroscopic objects have $m > 0$, strong continuation, and gravitate,
- microobjects have $m \approx 0$, no self-continuation, and do not gravitate independently.

This definition of mass is purely geometric and applies equally to inertial and gravitational mass.

The masslessness of elementary quanta (such as photons) in this sense is therefore not an ad hoc assumption but an immediate consequence of their failure to maintain a self-generated geometric trace in the historical geometry.

3.3 Quantum Nonclassicality as Geometric Freedom

Because microobjects do not fix a center in subsequent frames, they are geometrically *free*. Their future relation to the historical geometry is not determined by a pre-existing trace, but by the set of possible attachment configurations to macroscopic structures in future frames.

This geometric freedom is the kosmodynamic origin of:

- lack of definite trajectories,
- superposition of possible outcomes,
- and the probabilistic character of measurement results.

From this point of view, quantum behavior is not mysterious: it is the natural behavior of states that no longer carry their own geometric identity forward in time.

4 Wavefunction as Compatibility Functional

In standard quantum mechanics, the wavefunction $\psi(\boldsymbol{x})$ is a complex-valued function encoding the probabilistic distribution of outcomes for measurements of position (or other observables). Its ontological status is a subject of ongoing debate. Within the kosmodynamic framework, the wavefunction attains a clear geometric interpretation.

4.1 Definition of the Compatibility Functional

Let the historical geometry (including macroscopic objects) in frame F_n be denoted by $\mathcal{G}_n$. For a given microobject with historical boundary condition B, we define a *compatibility functional*

$$\mathcal{C}_n(\boldsymbol{x} \,|\, \mathcal{G}_n, B)$$

that quantifies how well a hypothetical attachment of the microobject at position $\boldsymbol{x}$ in F_{n+1} would extend and remain consistent with the existing historical geometry and boundary condition.

We then define the wavefunction as a rescaled version of this compatibility functional:

$$\psi_n(\boldsymbol{x}) \propto \mathcal{C}_n(\boldsymbol{x} \,|\, \mathcal{G}_n, B),$$

with an appropriate normalization condition

$$\int |\psi_n(\boldsymbol{x})|^2 \, d^3x = 1.$$

4.2 Born Rule from Geometric Continuation

The Born rule, in standard quantum mechanics, assigns probabilities via $P(\boldsymbol{x}) = |\psi(\boldsymbol{x})|^2$. In the kosmodynamic framework, this rule arises naturally if we interpret $|\psi_n(\boldsymbol{x})|^2$ as a measure of the geometric continuation capacity associated with attachment at $\boldsymbol{x}$.

Specifically, let

$$P_n(\boldsymbol{x}) \propto \mathcal{C}_n^2(\boldsymbol{x} \,|\, \mathcal{G}_n, B)$$

be the relative likelihood that the microobject will attach at $\boldsymbol{x}$ in frame F_{n+1}, given the historical geometry and boundary conditions. Normalizing over all possible attachment points yields

$$P_n(\boldsymbol{x}) = |\psi_n(\boldsymbol{x})|^2.$$

We may therefore interpret the Born rule as expressing the relative strength of different geometric continuation pathways for an interrupted trace.

4.3 Superposition and Interference

Consider two alternative macroscopic configurations or paths that define different subsets of possible attachment locations, e.g. the two slits in a double-slit experiment. Each path contributes a partial compatibility functional

$$\mathcal{C}_n^{(1)}(\boldsymbol{x}), \qquad \mathcal{C}_n^{(2)}(\boldsymbol{x}),$$

and the total compatibility is

$$\mathcal{C}_n(\boldsymbol{x}) = \mathcal{C}_n^{(1)}(\boldsymbol{x}) + \mathcal{C}_n^{(2)}(\boldsymbol{x}).$$

The corresponding wavefunction is

$$\psi_n(\boldsymbol{x}) = \psi_n^{(1)}(\boldsymbol{x}) + \psi_n^{(2)}(\boldsymbol{x}),$$

and the probability density is

$$|\psi_n(\boldsymbol{x})|^2 = |\psi_n^{(1)}(\boldsymbol{x})|^2 + |\psi_n^{(2)}(\boldsymbol{x})|^2 + 2\Re\big(\psi_n^{(1)}(\boldsymbol{x})\,\psi_n^{(2)*}(\boldsymbol{x})\big).$$

The interference term arises not because a particle propagates along two paths simultaneously, but because the geometric compatibility structure arising from the two possible attachment routes is evaluated jointly at the frame level.

Superposition is thus the linear superposition of compatible geometric continuation structures; interference reflects how these structures reinforce or suppress each other in the evaluation of $\mathcal{C}_n$ across frames.

5 Measurement and Collapse as Geometric Recoupling

The measurement problem in standard quantum mechanics is often framed as the question of how and when a superposed wavefunction produces a definite outcome. Collapse is typically introduced as an additional, poorly understood process. In the kosmodynamic framework, measurement and collapse are purely geometric events.

5.1 Macroscopic Systems as Continuation Carriers

As defined above, macroscopic systems are characterized by robust geometric continuation. Let $\mathcal{G}_n^{\mathrm{macro}}$ denote the geometry associated with such a system in frame F_n, with

$$\mathcal{G}_{n+1}^{\mathrm{macro}} \approx \mathcal{G}_n^{\mathrm{macro}} + \Delta\mathcal{G}_n^{\mathrm{macro}}.$$

When a microobject interacts with a macroscopic system, the combined system may:

- absorb the microobject into its ongoing geometric continuation,
- thereby converting an interrupted trace into a continued one.

This process is what we identify as *measurement*.

5.2 Formal Description of Measurement

Let the microobject be described by a wavefunction $\psi_n(\boldsymbol{x})$ and the macroscopic system by geometry $\mathcal{G}_n^{\mathrm{macro}}$. The joint compatibility for a specific outcome channel k (e.g. a particular detector element, pointer position, or macroscopic configuration) is

$$\mathcal{C}_n^{(k)} = \int d^3x \; M_k(\boldsymbol{x})\, \mathcal{C}_n(\boldsymbol{x} \,|\, \mathcal{G}_n^{\mathrm{macro}}, B),$$

where $M_k(\boldsymbol{x})$ encodes the geometric coupling between the microobject and the macroscopic configuration corresponding to outcome k.

The probability for outcome k is then

$$P_n(k) \propto |\mathcal{C}_n^{(k)}|^2.$$

Upon realization of outcome k, the microobject no longer exists as an interrupted trace. Instead, the macroscopic geometry is updated to

$$\mathcal{G}_{n+1}^{\mathrm{macro}} \to \mathcal{G}_{n+1}^{(k)},$$

where $\mathcal{G}_{n+1}^{(k)}$ incorporates the microobject into the continuing trace of the macroscopic system.

This update is the geometric counterpart of wavefunction collapse: a single outcome channel is selected, and the corresponding macroscopic geometry becomes the new continuation carrier.

5.3 Collapse as Loss of Necessity for the Wavefunction

In this framework, collapse is not a mysterious physical process. It is simply the moment when the geometric continuation is no longer underdetermined:

- Before measurement, the microobject has multiple possible attachment options, encoded in $\psi_n(\boldsymbol{x})$.
- After measurement, the microobject is absorbed into a specific macroscopic continuation, and the set of options collapses to a single realized pathway.

The wavefunction ceases to be needed as a descriptor; the continuation of the macroscopic geometry fully determines the future behavior. Collapse is therefore:

- objective (it corresponds to a real change in geometric status),
- frame-based (it occurs within the discrete sequence of frames),
- and non-mystical (no additional postulate beyond geometric recoupling is required).

6 Dynamics of Free Microobjects

Standard quantum mechanics describes the evolution of the wavefunction between measurements by the Schrödinger equation (or its relativistic counterparts). In the kosmodynamic framework, the evolution of $\psi_n(\boldsymbol{x})$ arises from the frame-wise reassessment of geometric compatibility.

6.1 Frame-to-Frame Update

Between measurement events, the microobject does not attach to macroscopic geometry. Instead, its wavefunction evolves according to changes in the historical geometry $\mathcal{G}_n$ caused by ongoing scale contraction and macroscopic continuation.

We may abstractly write the frame-to-frame update as

$$\psi_{n+1}(\boldsymbol{x}) = \mathcal{U}_{n\to n+1}[\psi_n](\boldsymbol{x}),$$

where $\mathcal{U}_{n\to n+1}$ is a linear operator encoding:

- the effect of scale contraction,
- the effect of changes in macroscopic geometry,
- the preservation of overall compatibility structure.

In suitable continuous limits, this update can be expected to reproduce Schrödinger-type evolution equations. The detailed derivation of such continuum equations is beyond the scope of the present paper, but the essential point is that:

- free quantum evolution corresponds to the propagation of the compatibility functional through the evolving historical geometry,
- without any need for a literal path or particle trajectory.

6.2 Absence of Classical Trajectories

Because microobjects do not maintain a geometric center, they do not follow classical trajectories. Instead:

- the expectation value of position,
- and other observables,

follow smooth curves determined by the evolution of $\psi_n(\boldsymbol{x})$ and the underlying geometry.

Trajectories appear only when macroscopic objects are involved, since only they possess geometric continuation capable of defining a consistent path across frames. Quantum behavior thus naturally lacks sharply defined paths, consistent with standard quantum mechanics.

7 Entanglement as Shared Historical Constraint

Quantum entanglement is one of the most puzzling phenomena in standard quantum mechanics, often associated with nonlocal correlations and apparent superluminal effects. The kosmodynamic framework offers a simple geometric explanation.

7.1 Common Historical Boundary

Consider two microobjects created in a joint process, such as a decay or interaction of macroscopic systems. Their creation event imprints a shared boundary condition B_{12} into the historical geometry:

$$B_{12} = B_1 = B_2.$$

This boundary condition constrains the possible attachments of both microobjects in all subsequent frames. The compatibility functionals for the two microobjects,

$$\mathcal{C}_n^{(1)}(\boldsymbol{x}_1 \,|\, \mathcal{G}_n, B_{12}), \qquad \mathcal{C}_n^{(2)}(\boldsymbol{x}_2 \,|\, \mathcal{G}_n, B_{12}),$$

are not independent but jointly restricted by B_{12} and the same historical geometry $\mathcal{G}_n$.

7.2 Global Consistency in a Single Frame

When one of the microobjects attaches to macroscopic geometry (measurement), the resulting outcome must be consistent with the shared boundary condition B_{12}. The geometric recoupling that realizes this outcome also constrains the allowed attachments for the other microobject in the same frame.

Thus, correlation between outcomes arises not from any signal propagating between the microobjects, but from:

- the fact that both attachments are evaluated within the same frame F_n,
- under the same global historical constraint B_{12}.

The apparent instantaneous correlation is a reflection of global consistency, not of dynamical influence.

7.3 Violation of Bell-Type Inequalities

Bell-type inequalities are violated in quantum experiments, suggesting that no local hidden-variable model can reproduce quantum predictions. The kosmodynamic framework is neither a hidden-variable theory nor a purely local model in the conventional sense:

- the historical geometry is globally defined and acts as a shared constraint,
- but no signals or influences propagate superluminally between the microobjects.

Nonlocal correlations arise because:

- the same historical boundary condition and geometry constrain both outcomes,
- and geometric consistency is enforced at the level of the frame, not along a path in spacetime.

Entanglement is therefore a manifestation of global geometric constraint rather than a mysterious instantaneous influence.

8 Classical Limit and Emergence of Macroscopic Behavior

A central question in any interpretation of quantum mechanics is how classical behavior emerges from quantum rules. In the kosmodynamic framework, the answer is direct: classical behavior arises where geometric continuation is dense and robust.

8.1 Geometric Density and Classicality

Let an object consist of N microscopic constituents, each with geometric contribution $\mathcal{H}_n^{(i)}$. The total geometric trace of the object is

$$\mathcal{H}_n^{\mathrm{tot}} = \sum_{i=1}^{N} \mathcal{H}_n^{(i)}.$$

If N is large and the contributions are tightly bound, the combined trace is:

- dense,
- coherent,
- and stable across frames.

This defines a macroscopic object with strong geometric continuation and thus classical behavior.

When N is small, or the constituents are weakly bound, the trace is fragile. The system may lose its ability to continue its own geometric center and enter a quantum regime where interrupted continuation dominates. The classical limit is therefore not a sharp boundary but a transition governed by geometric density.

8.2 Suppression of Superposition at Macroscopic Scales

Superposition requires that a state have multiple viable attachments to future geometry. For macroscopic systems with strong continuation, the existing trace already fixes a unique continuation path:

- large geometric density,
- strong inertial alignment with historical center,
- suppression of alternative attachment options.

Thus, superposition becomes effectively impossible for robust macroscopic objects. They follow a single classical path, not because quantum rules change, but because their geometric continuation leaves no room for alternative configurations that would be stable across frames.

This eliminates the need for ad hoc decoherence mechanisms to explain the absence of macroscopic superpositions; decoherence effects may still occur, but the primary reason for classicality is geometric.

9 Relation to Standard Quantum Mechanics

The kosmodynamic quantum framework is intended to reproduce the empirical predictions of standard quantum mechanics while offering a different underlying mechanism. We briefly comment on key points of contact.

9.1 Wavefunction and Hilbert Space

In standard quantum mechanics, the wavefunction is an element of a Hilbert space, and observables correspond to operators on this space. In the kosmodynamic view:

- the wavefunction is a functional of geometric compatibility,
- the Hilbert space structure reflects the linearity of superposition of compatibility contributions,
- and observables correspond to different geometric coupling structures (such as $M_k(\boldsymbol{x})$ in measurement).

The formal machinery of Hilbert space emerges as a convenient representation of how geometric compatibility structures combine and transform across frames.

9.2 Unitary Evolution and Schrödinger Equation

Between measurements, standard quantum mechanics postulates unitary evolution governed by the Schrödinger equation. In the kosmodynamic framework, the frame-to-frame update operator $\mathcal{U}_{n\to n+1}$ plays an analogous role:

- it propagates the compatibility structure through the evolving historical geometry,
- it is linear in $\psi_n(\boldsymbol{x})$,
- and it preserves overall normalization.

In a suitable continuous limit, it is plausible that $\mathcal{U}_{n\to n+1}$ reduces to a unitary operator generated by an effective Hamiltonian. The detailed derivation of this limit is left for future work.

9.3 Measurement Problem and Interpretations

Standard quantum mechanics requires an additional postulate to handle measurement, often leading to multiple interpretations (Copenhagen, Many-Worlds, GRW, etc.). In the kosmodynamic picture:

- measurement is a geometric recoupling in which macroscopic continuation absorbs an interrupted trace,
- collapse is the loss of necessity for the wavefunction once a specific continuation path has been realized,
- and no branching of worlds or modification of dynamics is required.

The measurement problem is thus replaced by a geometric mechanism rooted in the difference between macroscopic and microscopic participation in historical geometry.

10 Conclusions and Outlook

We have presented a kosmodynamic quantum framework built on the discrete-frame, scale-invariant geometry introduced in Scale-Invariant Cosmodynamics. The central idea is that:

- macroscopic objects continuously extend their historical geometric trace across frames, thereby defining classical behavior, while
- microobjects are states in which this continuation is interrupted, giving rise to quantum behavior.

Within this picture:

- mass is reinterpreted as geometric continuation capacity,
- the wavefunction becomes a compatibility functional encoding possible reattachments to historical geometry,
- probabilities arise from relative continuation strengths,
- measurement is a geometric recoupling process,
- collapse is the objective resolution of multiple potential attachments into a single realized continuation,
- interference reflects the joint evaluation of competing geometric structures across frames,
- and entanglement arises from shared historical boundary conditions in the global geometry.

Quantum mechanics and gravitation are thereby unified at the level of mechanism:

- gravitation emerges from asymmetric contraction of historical geometry induced by macroscopic continuation,
- quantum phenomena emerge from interrupted continuation and the resulting space of geometric attachments.

Several avenues for future work are apparent:

- derivation of explicit evolution equations for $\psi_n(\boldsymbol{x})$ in the continuous limit,
- quantitative modeling of specific experiments (double-slit, Stern–Gerlach, Bell tests),
- analysis of the transition region between quantum and classical behavior in terms of geometric density,
- exploration of connections to quantum field theory and relativistic extensions,
- and formulation of experimental tests sensitive to the geometric nature of measurement and entanglement within this framework.

The kosmodynamic quantum theory proposed here does not aim to replace the formal machinery of standard quantum mechanics. Instead, it seeks to provide a simple, coherent, and scale-invariant geometric mechanism behind it, aligning quantum behavior with emergent gravitation in a unified picture of historical geometry and framewise scale dynamics.

References

[1] Sandro Schäfer. Scale-invariant cosmodynamics: A discrete-frame approach to historical geometry and emergent gravitation. Zenodo, 2025. Independent private research.

[2] Sandro Schäfer. Kosmodynamic quantum mechanics: Historical geometry, loss of geometric continuation, and the emergence of quantum behavior. Preprint, 2025. Independent private research.

[3] Albert Einstein. Die grundlage der allgemeinen relativitätstheorie. *Annalen der Physik*, 354(7):769–822, 1916.

[4] John von Neumann. *Mathematische Grundlagen der Quantenmechanik*. Springer, Berlin, 1932.

[5] J. S. Bell. On the Einstein-Podolsky-Rosen paradox. *Physics*, 1:195–200, 1964.

[6] J. J. Sakurai and J. Napolitano. *Modern Quantum Mechanics*. Cambridge University Press, Cambridge, 3 edition, 2017.

[7] Charles W. Misner, Kip S. Thorne, and John Archibald Wheeler. *Gravitation*. W. H. Freeman, San Francisco, 1973.