

A New Entry into Quantum Mechanics and Relativity Opened by NNRT

A Turn toward Universal Physical Spacetime and the Repositioning of Hilbert Space and Observational Spacetime—Clarifying the Common Origin of Quantum and Relativistic Paradoxes

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Abstract

Conventional relativity places four-dimensional spacetime connected by Lorentz transformations, and four-dimensional spacetime curved by gravity, at the foundation of physical spacetime, whereas quantum mechanics places Hilbert space at the foundation of state description. As long as these two structures are simultaneously treated as fundamental realities, relativistic quantum theory and quantum gravity must begin with the problem of how a dynamically curved spacetime is to be quantized and made consistent with Hilbert-space states. Nakaza New Relativity Theory (NNRT) changes this very point of departure. NNRT takes universal time and universal three-dimensional space as physical spacetime and connects the real motions of all inertial systems by the Galilean Transformation (GT), while relocating the Lorentz transformation, time dilation, length contraction, and the gravitational metric to the observational and measurement layer obtained through electromagnetic phase. The successful mathematics and experimental values of conventional relativity are therefore retained, but the ontology in which curved and deformable four-dimensional spacetime is the unique physical spacetime is not retained. This paper uses NNRT as a new entry into quantum mechanics and repositions Hilbert space not as physical space, but as a mathematical representation space that preserves states, phases, probabilities, and correlations. Using the atomic clock as a concrete example, the paper further presents a continuous observational chain in which quantum levels generate a frequency scale and the resulting phase signal is compared between systems through relative motion and gravitational fields. Accordingly, the conventional entry point—how to quantize a physically real curved four-dimensional spacetime and incorporate it into Hilbert space—loses its premise within NNRT, and quantum theory and relativity are reconstructed as distinct representational and observational structures arising from a common universal physical spacetime. Schrödinger's cat, EPR/Bell correlations, time dilation, length contraction, the twin problem, and the reification of the gravitational metric can then be organized as manifestations of a common ontological operation: identifying a mathematical representation with physical reality itself. The significance of this paper is therefore not to add another interpretation alongside conventional relativity, but to absorb its successful mathematics into the observational layer of NNRT and, by turning the ontological point of departure, to provide a new formulation of foundational problems that includes quantum mechanics.

Keywords: NNRT, universal spacetime, Galilean Transformation, Hilbert space, observational spacetime, phase invariance, observation map, quantum mechanics, relativity, quantum paradoxes, relativistic paradoxes, atomic clocks

1. Introduction

The problem of unifying quantum mechanics and relativity has conventionally been formulated as the problem of how to make two highly successful theories mathematically compatible. Quantum mechanics places states in Hilbert space [1], whereas special and general relativity place Lorentz transformations and curved spacetime geometry at the center of their formulations [2,3]. As long as this starting point is retained, quantum theory must be constructed on relativistic spacetime and, once gravity is included, the quantization of curved and dynamical spacetime itself becomes unavoidable.

NNRT does not modify this conventional problem setting from within; it changes the point of entry itself. NNRT takes universal time and universal three-dimensional space as the unique physical spacetime and connects the real motions of all inertial systems by GT. Physical laws need only be defined in one inertial system, and the Lorentz transformation need not be extended to all inertial systems as a transformation of physical spacetime itself. The Lorentz transformation is instead repositioned as an observation map relating the phase, frequency, and wave number of electromagnetic signals exchanged between systems. Likewise,

the curved metric of gravitation is retained not as the shape of physical spacetime, but as an observational metric constructed under gravity. [4–7]

Accordingly, this paper does not treat conventional relativity and NNRT as two coexisting images of spacetime. The equations, observational formulae, and numerical agreements established by special and general relativity are retained within the observational layer of NNRT, but the conventional ontology that Lorentzian and curved four-dimensional spacetime is the unique physical spacetime is not adopted. In this sense, the NNRT principle of “same mathematics, same experiments, transformed interpretation” is not an additional interpretation that preserves the old theory unchanged, but a theoretical turn that relocates successful mathematics within a new ontology. [4–7]

This turn also changes the entry into quantum mechanics. In the conventional approach, the problem is how to unify quantum states described in Hilbert space with curved four-dimensional spacetime regarded as physically real. In NNRT, physical spacetime already exists universally behind quantum states, while Hilbert space and relativistic observational spacetime are both moved to distinct representational layers established on that common basis. The ontological conflict expressed as “quantize physically real curved spacetime and incorporate it into Hilbert space” therefore ceases to be the first problem to solve. The remaining physical question is how the quantum states of matter and fields in physical spacetime generate observables through phase, frequency, and wave number, and how those observables are compared between systems under motion and gravity.

As a historical analogy, this turn resembles the transition from a geocentric to a heliocentric arrangement without discarding the numerical values of observed planetary motions. The point is not that the two historical situations are identical, but that the basis of real motion is changed while the successful observations are retained. The significance of NNRT lies precisely in this foundational turn, which makes it possible to reconsider not only problems internal to relativity but also long-standing problems of quantum mechanics from a different point of entry.

The central questions are the following four:

- (1) How should the measured values obtained through physical standards and comparison procedures be theoretically separated from the physical spacetime posited as the object of measurement?
- (2) To what extent can the individual mathematical structures constituting Hilbert space be related to physical processes in physical spacetime?
- (3) How can quantum mechanics and relativity be connected within a common observational chain through phase θ , frequency ω , and wave number $\mathbf{k}$?
- (4) Can representative paradoxes of quantum theory and relativity be reorganized within a common structure by separating reality, mathematical representation, and observed values?

2. Spacetime Itself Is Not Directly Measured—Physical Standards and Measured Spacetime

Time and space are recognized as the basis on which physical phenomena are described, but an experimenter cannot directly extract “spacetime itself,” grasp it with an apparatus, and measure it. What an experimental apparatus directly provides is a reading obtained with physically defined standards and comparison procedures. In an atomic clock, measurement is constructed from the frequency originating in a quantum-level difference and from repeated phase counting; in length measurement, it is constructed from repeated comparison using a ruler, a wavelength, a light-propagation time, or a related standard. The experimentally constructed time and length therefore constitute measured spacetime mediated by the standards and comparison procedures employed.

This fact means that an observed difference in time or length cannot immediately be identified with expansion, contraction, or deformation of physical spacetime itself. If relative motion or gravity affects the measurement standard itself, or the phase, frequency, and propagation relations used to compare standards, then that influence alone can change the measured value. Hence an additional logical identification is required between the experimental fact that “the measured value changes relativistically” and the ontological statement that “physical spacetime itself is deformed.”

NNRT does not infer universal spacetime merely from the fact that spacetime itself cannot be measured directly. NNRT places universal time and universal three-dimensional space as the physical basis [4–7], relocates the Lorentz transformation, clock comparisons, gravitational metrics, and related structures that have been successfully used in conventional relativity to the observational and measurement layer, and adopts a theoretical structure that reproduces the same experimental values. The relevant question is

therefore not whether universal spacetime has itself been directly measured, but whether the observations uniquely require expansion, contraction, or curvature of physical spacetime.

This measurement-theoretical distinction is taken as a premise throughout the remainder of this paper. In quantum theory, a state in Hilbert space is not identified with physical reality itself; in relativity, observational spacetime constructed from measurement standards and signal comparisons is not identified with physical spacetime itself. The three-layer separation of reality, representation, and observation is therefore not an optional philosophical addition, but a methodology for clarifying what is directly given by experiment and what constitutes an ontology subsequently placed upon those observations.

3. Basic Three-Layer Structure

In this paper, physical theory is separated into the following three layers.

3.1 Reality Layer

As the basis of physical reality, we set

$$M_{\text{real}} = \mathbb{R}_t \times \mathbb{R}^3. \quad (1)$$

where t denotes universal physical time and $\mathbf{x}$ denotes the coordinates of universal three-dimensional physical space. The state of a physical system is written generally as s_{phys} . For a composite system, the state may include not only the states of the individual subsystems but also, when necessary, a relational state R_{AB} ,

$$s_{\text{phys}}^{AB} = (X_A, X_B, R_{AB}, \dots) \quad (2)$$

which we write as above.

In NNRT, this universal spacetime is not one “interpretive option” existing alongside conventional relativity; it is the unique physical basis. All inertial systems are connected by GT, and the physical laws governing real motion need only be defined in one inertial system. The Lorentz transformation is not the fundamental transformation of real motion, but appears at a later stage as a map connecting electromagnetic observables. The separation between physical spacetime and measured spacetime is therefore not an auxiliary explanation in NNRT, but a fundamental principle that makes the subsequent reconstruction of quantum theory possible.

Here, R_{AB} does not mean “an object existing in another higher-dimensional space.” As discussed below, entanglement cannot in general be reduced to a simple local hidden variable because of Bell constraints; the state of a composite system must therefore be allowed to contain relational structure that cannot be factorized into the individual attributes of its constituents.

3.2 Representation Layer

The mathematical structures used to describe physical states are called the representation layer. In quantum theory, these include

$$|\Psi\rangle \in \mathcal{H}, \quad \rho, \quad \mathcal{A} \quad (3)$$

Here, $\mathcal{H}$ denotes Hilbert space, ρ a density operator, and $\mathcal{A}$ the algebra of observables.

For relativistic observations, the representation layer includes

$$\theta, \quad K_\mu = \partial_\mu \theta, \quad g_{\mu\nu}^{\text{obs}} \quad (4)$$

In this paper, $g_{\mu\nu}^{\text{obs}}$ is interpreted as a metric describing measurement and observation.

Likewise, NNRT does not retain the successful gravitational metric of general relativity as a second physical spacetime existing in parallel. The metric mathematics reproducing gravitational redshift, light bending, Shapiro delay, and related effects is retained as an observational metric, whereas the interpretation of curved four-dimensional spacetime itself as the physical basis is rejected within NNRT. When conventional relativity is referenced in this paper, its mathematics is used as a comparison or as a description of the observational layer, not as a second independent theory of reality preserved alongside NNRT.

The basic principle of this paper is therefore

$$\text{representation} \neq \text{physical reality} \quad (5)$$

as stated above.

3.3 Observation Layer

Let the actual observational record be O_{obs} . In quantum measurement this may be a detected position, a spin readout, photon count, current, voltage, or pixel record; in relativistic observation it may be a frequency ratio, phase difference, clock reading, radar distance, or redshift.

The general observation map is written as

$$\Phi_M: s_{\text{phys}} \rightarrow P(O_{\text{obs}} | M, s_{\text{phys}}) \quad (6)$$

where M denotes the measuring apparatus and measurement context. Quantum-measurement outcomes are generally probabilistic, and there is no need to embed in the real state, before measurement, a determinate value bearing the same name as the eventual observed value.

The three layers can therefore be summarized as

$$\text{Reality} \rightarrow \text{Representation} \rightarrow \text{Observation.} \quad (7)$$

as shown above.

4. Physical Status of Hilbert Space

Hilbert space is a mathematical space in which linear combinations of states, inner products, orthogonality, unitary transformations, tensor products, and related structures can be treated consistently. Its structure, however, differs from that of ordinary three-dimensional physical space $\mathbb{R}^3$. Therefore, [1]

$$\mathcal{H} \neq M_{\text{real}}. \quad (8)$$

This distinction does not imply that Hilbert space is unnecessary. On the contrary, Hilbert space is an extremely efficient representational device for preserving relations among physical states, observables, probabilities, and transformations.

This understanding is also consistent with algebraic quantum theory. If one first specifies an observable algebra $\mathcal{A}$ and a state ω_s , then the Gelfand–Naimark–Segal (GNS) construction yields [8]

$$(\mathcal{A}, \omega_s) \xrightarrow{\text{GNS}} (\mathcal{H}_s, \pi_s, |\Omega_s\rangle) \quad (9)$$

a Hilbert-space representation afterward. Hilbert space is therefore a powerful mathematical realization of quantum theory, but it need not be placed ontologically at the starting point as physical space itself.

5. Physical Decomposition of Hilbert-Space Structure

5.1 Complex Numbers and Phase

Write the wave function as

$$\psi(\mathbf{x}, t) = A(\mathbf{x}, t)e^{i\theta(\mathbf{x}, t)} \quad (10)$$

where $A = |\psi|$ is the amplitude and θ is the phase. Complex representation itself is not unique to quantum theory; it is widely used in linear wave theory, including classical electromagnetic waves.

From the phase, one can define

$$\omega = -\frac{\partial \theta}{\partial t}, \quad \mathbf{k} = \nabla \theta \quad (11)$$

Thus, at least in the wave sector, the introduction of complex numbers can be understood as a mathematical method for representing amplitude and phase relations in a unified form.

5.2 Inner Product and Orthogonality

The inner product of two states,

$$\langle \phi | \psi \rangle \quad (12)$$

represents their overlap. For wave modes $u_m(x), u_n(x)$ in physical space, the same structure also appears as

$$\int u_m^*(x) u_n(x) dx \quad (13)$$

Thus the same structure is obtained. For distinct eigenmodes,

$$\langle m | n \rangle = 0 \quad (m \neq n) \quad (14)$$

the resulting orthogonality may be regarded as the Hilbert-space representation of mode independence in physical space.

5.3 Eigenstates and Superposition

Eigenvalues and eigenfunctions arise from linear differential equations and boundary conditions, and a complete set permits the expansion

$$|\Psi\rangle = \sum_n c_n |n\rangle \quad (15)$$

Linear superposition itself also occurs in classical waves. Equation (15) therefore does not by itself justify the conclusion that a physical object has split into multiple material entities in physical space. In this paper, we distinguish

superposition in $\mathcal{H} \neq$ material duplication in M_{real} (16)
as stated above.

6. Fourier Duality, Noncommutativity, and Uncertainty

In the position representation, let

$$\hat{x} = x, \quad \hat{k} = -i \frac{\partial}{\partial x} \quad (17)$$

Acting on an arbitrary wave function $\psi(x)$ gives

$$[\hat{x}, \hat{k}] \psi = i \psi, \quad [\hat{x}, \hat{k}] = i. \quad (18)$$

Using, in addition, the de Broglie relation

$$p = \hbar k \quad (19)$$

we obtain

$$[\hat{x}, \hat{p}] = i \hbar. \quad (20)$$

as required.

This structure does not directly imply that physical space itself is noncommutative. It can instead be read as an operator relation arising from the Fourier-dual position and wave-number representations of the same wave state.

Similarly, Fourier analysis gives

$$\Delta x \Delta k \geq \frac{1}{2} \quad (21)$$

and, from Eq. (19),

$$\Delta x \Delta p \geq \frac{\hbar}{2}. \quad (22)$$

Thus the mathematical core of the position–momentum uncertainty relation can be traced to the relation between localization width and wave-number bandwidth. This is distinct from the separate issue of disturbance caused by the measuring apparatus.

7. Decomposition of the Born Rule

From the Schrödinger equation

$$i \hbar \frac{\partial \psi}{\partial t} = \hat{H} \psi \quad (23)$$

one obtains

$$\rho = \bar{\psi} \psi = |\psi|^2 \quad (24)$$

for

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \mathbf{J} = 0 \quad (25)$$

For a nonrelativistic particle,

$$\mathbf{J} = \frac{\hbar}{m} \text{Im}(\bar{\psi} \nabla \psi). \quad (26)$$

and substituting Eq. (10) gives

$$\mathbf{J} = \frac{\hbar}{m} A^2 \nabla \theta. \quad (27)$$

Thus $|\psi|^2$ is a special density that is nonnegative, invariant under a global phase transformation, normalizable, and locally conserved. [9]

However,

$$|\psi|^2 \rightarrow \text{single-event probability} \quad (28)$$

the final physical identification expressed above cannot be derived completely from the continuity equation alone. The Born rule is retained as the empirical and axiomatic content of standard quantum

mechanics, while the question of why its squared-amplitude structure becomes the probability of a discrete single detection is explicitly left open in this paper. [10]

For a general measurement, using a POVM element E_m , one may write

$$P(m) = \langle \Psi | E_m | \Psi \rangle \quad (29)$$

Accordingly, this paper interprets the Born rule not as a “probability existing in Hilbert space,” but as a statistical observation map connecting a state representation with a concrete measurement context.

Gleason’s theorem provides an important constraint on the structure of consistent probability measures over projections in Hilbert space. [11]

8. Composite Systems, Tensor Products, and Entanglement

For two systems A, B , the state space is

$$\mathcal{H}_{AB} = \mathcal{H}_A \otimes \mathcal{H}_B \quad (30)$$

A state that cannot be factorized into the product state

$$|\Psi_{AB}\rangle = |\psi_A\rangle \otimes |\psi_B\rangle \quad (31)$$

is called an entangled state.

For example, the singlet state is

$$|\Psi^-\rangle = \frac{1}{\sqrt{2}}(|\uparrow\rangle_A \otimes |\downarrow\rangle_B - |\downarrow\rangle_A \otimes |\uparrow\rangle_B). \quad (32)$$

In this case the total system has a pure state, whereas the subsystem states cannot individually be reduced to pure states. In the reality layer, this paper writes

$$s_{\text{phys}}^{AB} = (X_A, X_B, R_{AB}) \quad (33)$$

and introduces R_{AB} as a nonseparable relational state belonging to the composite system.

Here, R_{AB} must not be regarded as a set of classical pre-existing values carried by each particle. As Bell’s theorem shows, a locally causal factorization of the form [12]

$$P(A, B; a, b, \lambda) = P(A; a, \lambda)P(B; b, \lambda) \quad (34)$$

cannot, in general, reproduce all quantum correlations.

The realism adopted here is therefore not the classical realism according to which every observable possesses, before measurement, a context-independent pre-existing value. [13] What is required is

$$\text{reality} = \text{local states} + \text{relational states} + \text{measurement context}. \quad (35)$$

as stated above.

9. Unified Representation–Observation Principle

On the basis of the preceding discussion, we propose the following principle.

Unified Representation–Observation Principle

Physical reality is distinguished from the state space or measurement space used to describe it. In quantum mechanics, Hilbert space is a mathematical representation preserving observable relations among physical states; in relativity, observational spacetime and the observational metric represent inter-system measurement relations constructed with phase signals. Neither is the common physical basis itself. Both are intermediate structures through which observed values are constructed from real physical processes.

In symbolic form,

$$M_{\text{real}} \rightarrow s_{\text{phys}} \rightarrow \begin{cases} \mathcal{H} \rightarrow O_{\text{QM}}, \\ (\theta, K_{\mu}, g_{\mu\nu}^{\text{obs}}) \rightarrow O_{\text{rel}} \end{cases}. \quad (36)$$

The important point is not to identify $\mathcal{H}$ and $g_{\mu\nu}^{\text{obs}}$. Their common feature is their ontological status: both belong to the representation layer rather than being physical reality itself.

10. Phase, Frequency, and Wave Number as the Bridge between Quantum Mechanics and Relativity

In quantum theory,

$$E = \hbar\omega, \quad \mathbf{p} = \hbar\mathbf{k}. \quad (37)$$

In relativistic measurement, meanwhile, phase, frequency, and wave number are used to construct time, distance, and frequency shifts.

Therefore,

$$(E, \mathbf{p}) \xleftarrow{\hbar} (\omega, \mathbf{k}, \theta) \xrightarrow{\Phi_{\text{rel}}} (t_{\text{obs}}, \mathbf{x}_{\text{obs}}). \quad (38)$$

Equation (38) is the central relation connecting quantum mechanics and relativity in this paper.

Not every quantum state, however, can be described by a single scalar phase θ . Spin, internal symmetries, entanglement, and related structures require a richer state description. Accordingly, $\theta, \omega, \mathbf{k}$ is not proposed as a variable reducing all quantum theory to one quantity; it is the principal bridge in the wave and propagation sector directly shared by quantum theory and relativity.

11. Atomic Clocks: From Quantum States to a Time Scale

Consider a two-level atom

$$|g\rangle, \quad |e\rangle \quad (39)$$

with energy difference

$$\Delta E = E_e - E_g. \quad (40)$$

For the quantum state

$$|\psi(t)\rangle = c_g e^{-iE_g t/\hbar} |g\rangle + c_e e^{-iE_e t/\hbar} |e\rangle \quad (41)$$

the relative phase is

$$\Delta\phi(t) = \frac{\Delta E}{\hbar} t + \Delta\phi_0. \quad (42)$$

Thus the internal reference frequency of the atom is

$$\omega_0 = \frac{\Delta E}{\hbar}. \quad (43)$$

In an actual atomic clock, an electromagnetic local oscillator is locked to this transition, and the local-oscillator phase θ_{LO} is extracted as a macroscopic clock signal. Ideally,

$$\frac{d\theta_{\text{LO}}}{dt} \simeq \omega_0. \quad (44)$$

If the number of cycles is $N = \Delta\theta_{\text{LO}}/(2\pi)$, then

$$t_{\text{obs}} = \frac{N}{\nu_0} = \frac{\Delta\theta_{\text{LO}}}{\omega_0}. \quad (45)$$

The clock reading is therefore constructed from a frequency standard generated by a quantum-level difference and from phase counting.

In this sense, quantum mechanics does not generate “time itself”; it provides the physical standard used to measure time.

12. Two Clocks in Relative Motion and the Electromagnetic Observation Map

For real motion, NNRT uses the Galilean Transformation (GT). In one dimension, let clock A be $x_A = 0$, and clock B be [4–7]

$$x_B(t) = x_{B0} + vt, \quad t' = t \quad (46)$$

as defined above.

Let the phase signal emitted from clock A be

$$\theta = kx - \omega t \quad (47)$$

The simple phase-encounter rate along the real trajectory of B is then

$$\omega_{\text{enc}} = \omega - vk_x. \quad (48)$$

For electromagnetic observation, however, phase invariance and the vacuum dispersion relation

$$\omega^2 - c^2|\mathbf{k}|^2 = 0 \quad (49)$$

are preserved under the observation map. This requirement gives

$$\omega' = \gamma(\omega - vk_x), \quad k_x' = \gamma\left(k_x - \frac{v\omega}{c^2}\right) \quad (50)$$

where

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}. \quad (51)$$

NNRT interprets Eq. (50), not as a transformation of physical spacetime itself, but as

$$\Phi_v: (\omega, \mathbf{k}) \mapsto (\omega', \mathbf{k}') \quad (52)$$

a map of electromagnetic observables.

For light propagating in the receding direction, $k_x = \omega/c$, so that

$$\omega' = \omega \sqrt{\frac{1 - v/c}{1 + v/c}}. \quad (53)$$

This gives the same numerical value as the relativistic longitudinal Doppler shift, but NNRT does not interpret it as a slowing of the real time of the local atomic clock. What changes is the observed rate of the phase signal exchanged between systems.

The one-way Doppler factor in Eq. (53) must not be identified directly with the usual $1/\gamma$ -type clock-comparison factor. Propagation Doppler effects, synchronization conventions, and two-way comparisons must be treated separately.

13. Gravitational Redshift and Phase Transport

Let the weak observational-metric perturbation be [3,7]

$$g_{\mu\nu}^{\text{obs}} = \eta_{\mu\nu} + h_{\mu\nu} \quad (54)$$

In the geometrical-optics limit, phase transport is

$$\frac{dK_\mu}{d\lambda} = -\frac{1}{2}\partial_\mu h_{\alpha\beta} K^\alpha K^\beta. \quad (55)$$

For a static gravitational field, $\partial_t h_{\alpha\beta} = 0$, and therefore

$$\frac{dK_0}{d\lambda} = 0. \quad (56)$$

If the four-velocity of a local observer is u^μ , the observed frequency is

$$\omega_{\text{obs}} = -u^\mu K_\mu. \quad (57)$$

For a Schwarzschild-type observational metric,

$$F(r) = 1 - \frac{2GM}{rc^2} \quad (58)$$

two stationary points A, B give

$$\frac{\omega_B}{\omega_A} = \sqrt{\frac{F(r_A)}{F(r_B)}}. \quad (59)$$

In the weak-field limit,

$$\frac{\Delta\omega}{\omega} \simeq -\frac{\Delta\Phi}{c^2}. \quad (60)$$

Substituting the atomic-clock relation $\omega_0 = \Delta E/\hbar$ gives

$$\omega_{A \rightarrow B}^{\text{rec}} \simeq \frac{\Delta E}{\hbar} \left(1 - \frac{\Delta\Phi}{c^2}\right). \quad (61)$$

Therefore,

$$\Delta E \rightarrow \omega_0 \rightarrow K_\mu \rightarrow \Phi_g \rightarrow \omega_{\text{rec}} \rightarrow \Delta t_{\text{obs}}. \quad (62)$$

which yields a consistent observational chain linking quantum mechanics, gravity, and relativity.

NNRT retains universal physical time,

$$dt_A^{\text{real}} = dt_B^{\text{real}} = dt \quad (63)$$

while allowing, for observed time constructed from phase and frequency comparisons,

$$dt_A^{\text{obs}} \neq dt_B^{\text{obs}} \quad (64)$$

Thus the conventional expression that “a higher clock runs faster” is repositioned not as a change in physical time itself, but as an observed difference in clock signals constructed in a gravitational field.

14. Five Representative Phenomena in a Common Form

The three-layer structure of this paper can be applied commonly to representative phenomena in quantum theory and relativity.

Table 1. Correspondence among the Reality, Representation, and Observation Layers for Five Representative Phenomena

Phenomenon	Reality Layer	Representation Layer	Observation Map	Observed Record
Double slit	Physical system and two-path condition	$\psi_1 + \psi_2$	Φ_{screen}	$P(x)$, detection position
Schrödinger's cat	Quantum system + entangled macroscopic apparatus	superposition	Φ_{cat}	Alive/dead record
EPR/Bell	X_A, X_B, R_{AB}	$\mathcal{H}_A \otimes \mathcal{H}_B$	$\Phi_{a,b}$	Joint correlation
Atomic clock	Internal atomic state	$\Delta E, \omega_0, \theta$	Φ_{clock}	t_{obs}
Gravitational redshift	Clock + gravitational source	$K_\mu, g_{\mu\nu}^{\text{obs}}$	Φ_g	$\Delta\nu/\nu, \Delta t_{\text{obs}}$

The common structure in every row of the table is
 physical reality $\neq$ mathematical representation $\neq$ observed value. (65)
 as shown above.

15. Minimal Principle System and Mathematical Propositions

The theoretical construction of this paper can be reduced to the following four principles.

Principle I (Physical Basis)

$$M_{\text{real}} = \mathbb{R}_t \times \mathbb{R}^3. \quad (66)$$

Principle II (Non-identity of Representation and Reality)

$$\text{representation} \neq \text{reality}. \quad (67)$$

Principle III (Quantum-State Representation)

A physical state may be represented by Hilbert space or by an algebra of observables, but that representation is not identified with physical space itself.

Principle IV (Observation Map)

$$\text{physical state} \rightarrow \Phi_M \rightarrow O_{\text{obs}}. \quad (68)$$

On these principles, the mathematical propositions of established quantum mechanics and relativity—Fourier duality, canonical commutation relations, Schrödinger evolution, Born statistics, tensor products, Bell correlations, phase transport, Doppler shifts, and gravitational redshift—are retained.

It is important to distinguish mathematically derived propositions from the ontological principles of NNRT. Equations (20), (22), (25), (55), and (59), for example, are mathematical propositions. Equations (8), (63), and related statements, by contrast, are ontological premises of NNRT or consequences of those premises and are not mathematical theorems in the same sense.

16. The New Entry into Quantum Mechanics Opened by NNRT

The central significance of this paper is not to list familiar individual results—Hilbert space, Fourier duality, Bell correlations, and so forth—as new discoveries. What matters is that the very starting point for thinking about quantum mechanics changes once NNRT rejects the ontology of conventional relativity. As long as conventional relativity is used as the entry point, quantum states are placed on a physically real Lorentzian and curved four-dimensional spacetime, and the fundamental problem ultimately becomes how to quantize that spacetime geometry or make it consistent with Hilbert-space states.

NNRT does not attempt to solve this problem from the same entry point. It takes universal time and universal three-dimensional space as the physical basis and describes real inertial motion by GT, while moving the Lorentz transformation and gravitational metric to the observational layer. The fundamental reality to be incorporated into quantum mechanics is therefore not a curved and deformable four-dimensional spacetime, but a common invariant physical spacetime. Hilbert space becomes the mathematical space representing state relations on that physical spacetime, while the observational metric becomes the measured image obtained on the same physical basis.

As a result of this repositioning, the ontological problem “how to quantize physically real curved four-dimensional spacetime itself and accommodate it within Hilbert space” loses its premise in NNRT. This does not mean that the full dynamics of quantum fields and gravity have already been calculated. It means, however, that the conflict between two putative realities—Hilbert-space states and dynamical spacetime geometry—that preceded the conventional quantum-gravity problem is removed. The next question becomes how quantum states, fields, and gravitational sources in universal physical spacetime generate measured quantities through the observation map.

This paper therefore does not preserve conventional relativity and merely add an NNRT interpretation beside it. The successful equations and experimental values of special and general relativity are absorbed into NNRT, while their ontological foundation is replaced. Within NNRT, conventional relativity does not remain as an independent theory of reality; rather, its successful observational mathematics is repositioned within a new reality—observation structure.

In this sense, the NNRT turn is historically analogous to the transition from a geocentric to a heliocentric arrangement. The significance of heliocentrism was not merely that it described existing observations in different words, but that it changed the basis of the real motions producing those observations. Likewise, NNRT does not discard relativistic numerical results; it changes the physical basis that produces them to universal physical spacetime and the observation map. This foundational turn provides quantum mechanics with an entry point unavailable in the conventional lineage.

Table 2. Comparison between the Conventional-Relativity Entry Point and the NNRT Entry Point

Issue	Conventional Relativity as the Entry Point	NNRT as the Entry Point
Physical spacetime	Lorentzian, curved four-dimensional spacetime is placed at the foundation of physical spacetime	Universal time and universal three-dimensional space are placed as the unique physical basis
Inertial systems	The Lorentz transformation is used as a spacetime transformation	GT connects real motion, while the Lorentz transformation is repositioned as an electromagnetic observation map
Gravity	Metric curvature is read as curvature of physical spacetime	Successful metric mathematics is retained as an observational metric
Connection to quantum theory	The starting problem is to unify and quantize dynamical spacetime geometry and Hilbert-space states	Hilbert space and observational spacetime are placed in the representation layer over a common physical basis
Paradoxes	Quantum and relativistic paradoxes are treated as separate problems	They are reorganized from the common cause of identifying representation with reality

17. Why This Argument Is Difficult to Reach within the Conventional Theoretical Lineage

Within the conventional relativistic lineage, Lorentzian four-dimensional spacetime, or four-dimensional spacetime curved by gravity, is placed as physical spacetime itself. As long as this premise is retained, quantum mechanics must be constructed “on” that spacetime, and the problem of introducing gravity into quantum theory necessarily takes the form of incorporating dynamical spacetime geometry into quantum states. A formulation in which spacetime geometry itself is lowered to the status of observational representation while a separate universal physical spacetime is introduced is therefore difficult to obtain from within the conventional theory itself.

For the same reason, it has been difficult to compare Hilbert space and the relativistic spacetime metric at the same ontological level. In the conventional framework, one is regarded as the mathematical space of quantum states and the other as physical spacetime itself; their incompatibility therefore appears only as a problem of how to unify the two. By separating observational spacetime from physical spacetime, NNRT makes it possible to place both Hilbert space and the observational metric in the representation layer and to place a common physical basis behind them.

This difference is not merely terminological. In quantum mechanics, the issue is how far the nonclassical structure of state space should be transferred to the mode of existence of the real world; in relativity, the

issue is how far measured time, length, and metric should be transferred to physical spacetime itself. These questions have conventionally been discussed separately. With NNRT as the entry point, however, they are unified into a single question: may the mathematics of observation and representation be identified with reality itself?

The first problem addressed concretely in this paper is the ontological conflict created by the requirement to unify Hilbert space and curved spacetime as two fundamental realities. The second is the previously unclear physical point of contact between quantum mechanics and relativity, which is made concrete by the observational chain from a quantum level in an atomic clock to a frequency standard, electromagnetic phase, and inter-system comparison. The third is the separation by which quantum paradoxes and relativistic paradoxes have been treated as distinct classes of difficulty; they are reorganized by the common principle that representation and reality are not identical. The fourth concerns the entry into quantum gravity: once quantization of physical spacetime itself need not be the first task, the problem can be moved to the dynamics of matter, fields, gravitational sources, and the observation map.

The present argument is therefore not an auxiliary interpretation obtained as an extension of conventional theory. It becomes possible only because NNRT restores physical spacetime and relocates the Lorentz transformation and gravitational metric to the observational layer. In this sense, the quantum-theoretical argument developed here is a consequence of NNRT and cannot be derived in the same form from a lineage that leaves the ontology of conventional relativity unchanged.

18. Common Origin and Resolution of Quantum and Relativistic Paradoxes

One of the most important consequences of extending NNRT to quantum theory is that representative quantum and relativistic paradoxes, although mathematically different phenomena, can be seen to arise ontologically from the same type of misidentification. Their common origin is the elevation of a mathematical representation to physical reality itself on the grounds that the representation reproduces experiments accurately.

In quantum theory, if a superposition in Hilbert space is identified with the material double existence of a real object, the paradox of macroscopic double existence typified by Schrödinger's cat appears. If an entangled state is decomposed into pre-existing attributes carried independently by two local objects, EPR/Bell correlations are drawn toward pictures of action at a distance or instantaneous physical change. In this paper, superposition is treated as a state representation and entanglement as a nonseparable relational structure of a composite system; relations in Hilbert space are not identified with the material existence of objects in three-dimensional physical space.

The same structural pattern appears in relativity. If the transformed time and length values given by the Lorentz transformation are identified with a slowing of physical time itself and a contraction of physical length itself, reciprocal time dilation and the twin problem appear as paradoxes concerning the rate of physical time. Likewise, if the gravitational metric is identified with curvature of physical spacetime itself because it accurately reproduces redshift, light bending, Shapiro delay, and related effects, the distinction between measured geometry and the physical basis prior to measurement is lost. NNRT returns these quantities to the electromagnetic observation map and observational metric while retaining universal time and universal space as the physical basis.

The NNRT resolution therefore does not deny experimental facts such as quantum correlations, Lorentz-type observed values, or gravitational redshift. Rather, it retains their numerical agreement fully while separating the observables directly demonstrated by experiment from the ontology additionally imposed on those observables. By returning Hilbert space in quantum theory and observational spacetime in relativity from the reality layer to the representation layer, the paradoxes of both fields can be organized by the same principle.

This common resolution principle does not claim that quantum theory and relativity possess the same mathematics. Their mathematics is different. What they share is the structural fact that paradoxes arise when mathematical representation is connected directly to reality, whereas ontological contradictions can be removed without losing successful mathematics when the three layers—reality, representation, and observation—are separated. The importance of NNRT lies in making this common structure visible.

Table 3. Identification of Representation with Reality in Quantum Theory and Relativity, and Its Repositioning in NNRT

Field	Successful Mathematical Representation	Problem Caused by Identification with Reality	Repositioning / Resolution in NNRT
Quantum theory	Hilbert-space superposition	Macroscopic double existence in Schrödinger's cat	Treat superposition as state representation and distinguish it from material double existence
Quantum theory	Entangled state	Reification of action at a distance or instantaneous collapse	Treat it as a nonseparable relational structure of the composite system and as a joint observational correlation
Special relativity	Lorentz transformation	Slowing of physical time, contraction of physical length, twin problem	Use GT for real motion and reposition the Lorentz transformation as an electromagnetic observation map
Gravitation	Relativistic metric	Identification of observed geometry with physical spacetime	Retain the successful metric mathematics as an observational metric and separate it from universal physical spacetime

19. Foundational Problems Resolved by NNRT and the Remaining Dynamical Tasks

The foundational problems resolved in this paper are, first, the ontological conflict that arises from having to unify Hilbert space and curved four-dimensional spacetime as two heterogeneous fundamental realities. In NNRT, only universal spacetime is the physical basis, while Hilbert space and observational spacetime are placed in distinct representation layers; the conflict itself therefore disappears. Second, the problem of “how to quantize physically real curved spacetime” is not the first task in NNRT, because its physical reality is not assumed. Third, the point of contact between quantum theory and relativity is made explicit as a concrete observational chain in which a quantum state generates a frequency standard and its phase signal is compared between systems by the relativistic observation map. Fourth, the paradoxes of both theories are organized under the common cause of identifying representation with reality. [4–7]

These are not mere substitutions of words. They change the order of the research questions themselves: what should be quantized as a fundamental variable, what should be treated as an observable, and to which mathematical objects ontological status should be assigned. NNRT frees quantum mechanics from the conventional entry point of “quantizing curved spacetime” and permits direct investigation of matter, fields, phase, and measurement interactions in universal physical spacetime.

At the same time, the next dynamical tasks can be clearly separated. These include the mechanism by which a conserved positive density becomes the probability of each discrete single detection, the concrete dynamics of the nonseparable relational state corresponding to entanglement, extension to quantum field theory including spinors, gauge symmetry, and particle creation and annihilation, and a unified dynamics describing interactions between gravitational sources and quantum fields.

The fact that these problems remain is distinct from the validity of the foundational turn developed here. Conventionally, an ontological obstacle—how to unify “two systems of reality”—was placed before the dynamical problem. NNRT removes that obstacle and clarifies what must next be constructed dynamically. In this sense, this paper does not present a completed quantum-gravity equation; it provides a new theoretical entry point by changing the premises on which that equation would be sought.

20. Discussion—The Physical Turn Introduced by NNRT

The starting intuition of this paper was to regard quantum mechanics as “a theory that tells us the state inside a measuring device” and relativity as “a theory that measures between systems using signals obtained from that state.” The analysis has refined this intuition into a division of roles: quantum mechanics supplies internal states, levels, phases, and probabilities, while relativistic observation compares the frequency, wave number, and phase signals generated from them between systems. The atomic clock shows that these two stages are connected within a single physical device. [4–7]

The larger significance of this paper, however, does not lie in this connection alone. NNRT is not a coexisting interpretation added to Einsteinian relativity. It removes from the physical basis the Lorentzian and curved four-dimensional spacetime that conventional relativity placed as the unique physical spacetime and restores universal time and universal three-dimensional space. The Lorentz formulas, gravitational metric, redshift, light bending, and other successful structures of the conventional theory are then repositioned in the observational layer. The physical meaning of NNRT therefore lies not in changing the numerical values, but in changing the foundation of the world-picture from which those numerical values arise.

If one uses the historical analogy of the transition from a geocentric to a heliocentric arrangement, the important point is not the rejection of existing observations, but the change in the arrangement of real motion by which those observations are understood. NNRT likewise accepts the experimental agreement of special and general relativity while declining to read that agreement as evidence for the expansion, contraction, or curvature of physical spacetime itself; it reads it instead as the construction of observational spacetime through electromagnetic phase. This turn releases quantum mechanics from the conventional entry point of “how to quantize curved physical spacetime.”

The status of Hilbert space changes accordingly. Hilbert space is not a second physical space existing alongside curved four-dimensional spacetime; it becomes the mathematical state space representing states, phases, probabilities, and correlations arising in universal physical spacetime. Observational spacetime is likewise not the physical basis. The unification of quantum theory and relativity therefore ceases to be a problem of forcibly merging two heterogeneous realities and becomes the problem of how two distinct representational and observational structures arise from a single physical basis.

The fact that quantum and relativistic paradoxes can be organized under the same cause further shows that this turn is not merely an interpretive change internal to relativity. Schrödinger’s cat, EPR, collapse, time dilation, length contraction, the twin problem, and the reification of spacetime curvature are different in their phenomena and mathematics, yet share a common structure: they arise when a representation is transferred to reality itself. By removing this common cause, NNRT provides a simultaneous physical perspective across multiple fields.

This paper therefore presents only one part of the results of NNRT, but even this part shows that NNRT opens a new entry into foundational physics, including quantum mechanics. The next task is not to return to the ontology of conventional relativity, but to determine how far quantum states, matter fields, gravitational sources, phase transport, and the observation map can be developed into concrete dynamics on the basis of universal physical spacetime.

21. Conclusion

This paper has reconstructed the relation between quantum mechanics and relativity starting from the universal physical spacetime restored by NNRT. The most important point is that conventional relativity has not been left to run in parallel with NNRT as an independent theory of reality. The equations and experimental values established by special and general relativity are retained, but the ontology in which Lorentzian and curved four-dimensional spacetime is the unique physical spacetime is not adopted in NNRT; the successful mathematics is repositioned in the observational layer.

First, by taking universal time and universal three-dimensional space as the physical basis and connecting the real motions of all inertial systems by GT, the physical basis on which quantum mechanics rests becomes invariant physical spacetime. The Lorentz transformation is positioned as an electromagnetic observation map and the gravitational metric as an observational metric, both being distinguished from expansion, contraction, or curvature of physical spacetime itself.

Second, this turn clarifies the ontological status of Hilbert space. Hilbert space is not physical space itself, but a mathematical state space representing states, phases, orthogonality, probabilities, transformations, and composite-system correlations in universal physical spacetime. The conventional ontological conflict that requires the unification of two heterogeneous realities—Hilbert space and curved four-dimensional spacetime—therefore does not arise.

Third, the conventional entry into quantum gravity—“how to quantize physically real curved four-dimensional spacetime and place it within Hilbert space”—loses its premise in NNRT. This does not mean that the complete dynamics of quantum fields and gravity have been completed; it means that the formulation of what should be quantized is fundamentally changed. The next question is how matter, fields,

and gravitational sources in universal physical spacetime generate quantum and relativistic observables through phase and the observation map.

Fourth, quantum mechanics and relativity are directly connected through the atomic clock. A quantum-level difference generates a frequency standard, that frequency is converted into an electromagnetic phase signal, and the signal is compared in another system through relative motion or a gravitational field. Quantum mechanics therefore provides the physical origin of the measurement standard, while NNRT relativity describes the inter-system transport and comparison of that standard.

Fifth, Schrödinger's cat, EPR/Bell correlations, time dilation, length contraction, the twin problem, and the reification of the gravitational metric can all be organized as consequences of the common ontological operation of identifying a mathematical representation with physical reality itself. By separating the Hilbert representation and relativistic observational spacetime from the reality layer, NNRT repositions quantum and relativistic paradoxes simultaneously under a single principle.

Sixth, this result is not an added interpretation that leaves the conventional relativistic lineage intact. It becomes possible only because NNRT restores universal physical spacetime. In historical analogy, NNRT has the character of a turn from a geocentric to a heliocentric arrangement in the sense that the basis of real motion is changed while observational values are retained. The significance of NNRT lies not only in reproducing relativistic numerical values, but in opening, through this turn, a new entry into difficult problems in other fields, including quantum mechanics.

The final conclusion of this paper is therefore that reality and observational representation must first be separated correctly before quantum mechanics and relativity are unified. With the emergence of NNRT, quantum mechanics no longer needs to begin from the conventional question of "how to quantize a curved and deformable four-dimensional physical spacetime." Universal physical spacetime is taken as the common basis, while Hilbert space and relativistic observational spacetime are constructed upon it as distinct representational and observational structures. This new point of entry is the central result obtained in the present analysis through NNRT.

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