March 19, 2026

The Universal Present and the Emergence of the Past

T. N. Ukwatta*

Albuquerque, NM, USA
*Corresponding author. Email: tilan.ukwatta@gmail.com

Abstract

The nature of time and the origin of its apparent directionality remain among the most profound open questions in physics. The prevailing view, grounded in thermodynamics and general relativity, holds that time possesses an intrinsic arrow pointing from a low-entropy past toward a higher-entropy future. In this paper, we propose an alternative framework in which the arrow of time is not fundamental but emerges from the process of past creation. We argue that a universal present exists—a single, shared "now" in which all objects reside—and that what we call the past is not a fixed record but is continuously created from the present. In this view, we do not move through time toward the future; we remain in the present while generating the past. We propose that wavefunction collapse via environmental decoherence is the physical mechanism by which the present generates the past, suggesting a natural reinterpretation of the boundary between quantum mechanics and general relativity: quantum mechanics describes the present realm of uncollapsed superpositions, while general relativity describes the classical past realm that emerges from it. A key consequence of this framework is that observers at different gravitational potentials, running on different proper clocks as described by general relativity, will observe a measurable, accumulating drift in the apparent timing of the same past event. We propose that precision timing observations of pulsars offer a viable experimental test of this prediction. If confirmed, this would represent a fundamental shift in our understanding of the nature of time. We present this as a testable phenomenological framework rather than a complete fundamental theory.

Keywords: Origin of Time, Time Arrow, Universal Present

1. Introduction

Why does time flow forward? This question has occupied physicists and philosophers for centuries, yet no fully satisfying answer exists. The equations governing the fundamental laws of physics — classical mechanics, electromagnetism, quantum mechanics, and general relativity — are, with minor exceptions, symmetric under time reversal. Nothing in the mathematics demands a preferred direction. And yet, our experience of the world is irreversibly one-directional: eggs break but do not reassemble, memories form of the past but not the future, and causes precede effects.

The standard answer appeals to entropy. The Second Law of Thermodynamics tells us that closed systems evolve toward states of higher disorder. This thermodynamic arrow of time — the direction of increasing entropy — is widely accepted as the origin of time's apparent directionality. Yet this explanation is incomplete. It requires that the universe began in an extraordinarily low-entropy state, and the reason for this initial condition remains unexplained (Penrose 2010; Carroll and Chen 2004).

A deeper issue lurks beneath the entropy argument: it assumes that the past is fixed and the future is open. But is this assumption justified? General relativity has already taught us that time is not universal — different observers in different gravitational fields or states of motion experience time at different rates. The concept of a single shared "now" is, in the standard relativistic picture, meaningless. Two spatially separated observers cannot agree on what is simultaneous.

In this paper, we challenge both the entropy-based arrow of time and the relativistic rejection of a universal present. We propose that:

1. A Universal Present exists — there is a single shared "now" for the universe.
2. Time does not flow from past to future. Rather, we are always in the present, and what we call the past is continuously created from the present moment.
3. The past is not static. Because every object runs on its own proper clock according to general relativity, the past that each observer generates differs subtly — and these differences accumulate over time.
4. This accumulation produces a measurable observational effect: two observers at different gravitational potentials, when observing the same past event, will find that their measured timing of that event drifts apart beyond what is accounted for by standard gravitational time dilation alone.

This framework does not contradict the mathematical machinery of general relativity but proposes a reinterpretation of what the equations describe. Rather than mapping a static block universe in which all moments exist equally, we propose that the equations of GR describe the structure of a past that is being generated—and may be subject to revision—from a universal present.

The remainder of this paper is organized as follows. Section 2 reviews the current understanding of time and the arrow of time. Section 3 presents the proposed framework in detail. Section 4 develops the mathematical structure of the theory. Section 5 describes the proposed observational test using pulsar timing. Section 6 discusses implications and future directions.

2. The Concept of Time and the Arrow of Time: Current Understanding

2.1 Time in Classical and Relativistic Physics

In Newtonian mechanics, time is absolute and universal — a single parameter flowing uniformly for all observers. Einstein's special relativity (1905) overturned this view, demonstrating that simultaneity is relative: two spatially separated events that are simultaneous in one inertial frame need not be simultaneous in another. General relativity (1915) extended this further, showing that the rate of proper time depends on gravitational potential and relative motion, leading to measurable effects such as gravitational time dilation confirmed by atomic clocks at different altitudes (Hafele and Keating 1972).

Despite these revolutions, a fundamental puzzle remained: the equations of both special and general relativity are time-symmetric. They make no formal distinction between past and future.

2.2 The Thermodynamic Arrow of Time

The most widely accepted explanation for the directionality of time is thermodynamic. The Second Law of Thermodynamics states that the entropy of a closed system tends to increase over time. Boltzmann (1872) provided a statistical mechanical foundation: macroscopic irreversibility emerges from the overwhelming probability that systems evolve toward higher-entropy states.

This gives rise to the thermodynamic arrow of time—the direction in which entropy increases is identified as "forward." Penrose (1979) and others noted that this explanation is incomplete: it merely shifts the problem. If entropy increases toward the future, the universe must have begun in an extraordinarily low-entropy state. Why the Big Bang was so highly ordered remains an open question (Carroll and Chen 2004; Penrose 2010).

2.3 The Cosmological Arrow of Time

Closely related is the cosmological arrow—time's direction is aligned with the expansion of the universe. Hawking (1985) initially proposed that time might reverse if the universe began to contract, later retracting this claim. The accelerated expansion driven by dark energy (Perlmutter et al. 1999; Riess et al. 1998) suggests the universe will expand indefinitely, maintaining a consistent cosmological arrow.

2.4 The Causal Arrow and Psychological Arrow

The causal arrow holds that causes precede effects—a statement often taken as definitional rather than explanatory. The psychological arrow refers to our subjective experience of time flowing from past to future, our memory of the past and anticipation of the future. Philosophers including Price (1996) and physicists such as Barbour (1999) have argued that the psychological arrow is itself derived from the thermodynamic arrow.

2.5 Time in Quantum Mechanics

Quantum mechanics treats time asymmetrically from space; it appears as an external parameter rather than a dynamical variable. The collapse of the wave function upon measurement introduces a form of irreversibility, though its connection to the thermodynamic arrow remains debated. The CPT theorem asserts that physical laws are symmetric under the combined operations of charge conjugation, parity, and time reversal, though CP violation (and hence T violation) has been observed in certain particle decays (Christenson et al. 1964).

2.6 The Problem of "Now" and the Block Universe

General relativity's success has led many physicists and philosophers to favor the block universe (or eternalist) view, in which all moments of time — past, present, and future — exist equally. In this picture, the "flow" of time and the special status of "now" are illusions (Rietdijk 1966; Putnam 1967; Penrose 1989). There is no universal present in standard relativity due to the relativity of simultaneity.

This view is not universally accepted. Proponents of presentism argue that only the present moment is real, and that a universal present may exist beyond the limits of relativistic simultaneity (Craig 2001). Recent work in quantum gravity, including loop quantum gravity and causal set theory, has re-opened questions about whether time and its direction might be emergent rather than fundamental (Rovelli 2018; Sorkin 2003).

3. The Universal Present Framework

3.1 Core Postulates

We propose a framework for the nature of time based on three foundational postulates:

Postulate 1: The Universal Present exists. There is a single, shared "now" common to the entire universe. This universal present is not a coordinate in spacetime but a fundamental ontological state in which all physical systems reside. The relativity of simultaneity, as described by special and general relativity, applies to the past—the classical, observable record — not to the present itself.

Postulate 2: The present generates the past. Time does not flow from past to future. Rather, physical systems exist in the present and continuously create the past through a physical process. We do not move into the future; we remain in the present while the past accumulates behind us. In this framework, the arrow of time is not fundamental but emerges from the process of past creation — the ongoing transition of quantum states into the classical past.

Postulate 3: Wavefunction collapse is the mechanism of past creation. The present corresponds to the quantum realm—the domain of superposition, potentiality, and unobserved states described by quantum mechanics. The past is created when wavefunctions collapse into definite, classical states through interaction with the environment (decoherence). What we observe is always already in the past: the collapsed, classical record of a quantum present we cannot directly access.

3.2 The Two Realms

This framework naturally partitions physical reality into two domains:

The present realm is the domain of quantum mechanics. Here, physical systems exist as wavefunctions in superposition — uncollapsed, undetermined, and unobservable in the classical sense. This realm is outside the relativistic structure of spacetime: it is not embedded in the four-dimensional manifold of general relativity, but is the pre-geometric substrate from which the classical past emerges.

The past realm is the domain of classical physics and general relativity. Here, wavefunctions have collapsed into definite states, creating the observable, measurable record we call the past. Spacetime, as described by general relativity, is the structure of this past realm. The geometry of spacetime—curvature, proper time, and gravitational time dilation—describes not the present but the accumulated past.

This two-realm picture offers a natural reinterpretation of the long-standing tension between quantum mechanics and general relativity. The two theories have resisted unification in part because they describe fundamentally different regimes: quantum mechanics describes the present, while general relativity describes the past. They are not competing descriptions of the same realm—they are descriptions of different realms.

3.3 Decoherence as Past Creation

In standard quantum mechanics, decoherence is the process by which a quantum system interacting with its environment loses its coherent superposition and acquires classical, definite properties. Decoherence is well-established experimentally and is widely accepted as the mechanism by which the classical world emerges from quantum mechanics.

In this framework, decoherence provides the mechanism by which quantum states become effectively classical, while we remain agnostic about the deeper ontological nature of wavefunction collapse. When a quantum system decoheres, it transitions from the present realm into the past realm—from superposition into a definite classical state that becomes part of the observable record. The rate of decoherence determines the rate at which the past is created.

This reinterpretation has a natural consequence: the faster a system interacts with its environment, the faster it transitions from present to past. Macroscopic objects decohere almost instantaneously, which is why we never directly experience the quantum present—by the time any classical observation is made, the system has already entered the past. Microscopic quantum systems, isolated from their environment, may remain in the present potentially for measurable durations.

The phenomenological predictions of this framework—in particular the accumulating timing drift—are independent of which interpretation of quantum mechanics underlies the collapse process.

3.4 Resolution of the Collapse and Simultaneity Problem

A long-standing conceptual tension exists between quantum mechanics and relativity regarding wavefunction collapse. In the Copenhagen interpretation, collapse is instantaneous. But general relativity tells us that simultaneity is relative — two observers in different states of motion or gravitational fields cannot agree on what events are simultaneous. If collapse is instantaneous, the question arises: instantaneous for whom?

Our framework offers a natural resolution. Collapse occurs in the Universal Present, which exists outside the relativistic structure of spacetime. The Universal Present is not a surface of simultaneity in spacetime — it is the pre-geometric quantum substrate from which spacetime emerges. Collapse is therefore not an event within spacetime but the process that creates spacetime events.

Importantly, the Universal Present does not introduce an observable preferred frame within spacetime. Because T is a pre-geometric parameter that underlies the emergence of classical spacetime rather than a coordinate within it, the Lorentz invariance of observable spacetime physics is preserved. Different observers related by Lorentz transformations will agree on all spacetime intervals and physical predictions within the past realm, while their proper time mappings from the Universal Present to proper time (defined formally in Section 4) differ in the standard GR way.

The past that is created by collapse is then embedded in the spacetime structure of the past realm, where it is observed differently by different observers according to their proper time. Two observers at different gravitational potentials, running on different proper clocks, will observe the same collapsed event at different proper times — and this difference accumulates over time. This is the origin of the testable prediction developed in Section 5.

3.5 The Status of the Past

A further consequence of this framework concerns the nature of the past itself. In the standard block universe picture, the past is fixed and immutable — all past events exist as definite, unchanging elements of the four-dimensional spacetime manifold.

In our framework, the past is created from the present and is observer-dependent in a specific sense. Because each physical system runs on its own proper clock (as described by general relativity), and because the past is generated at the rate determined by that clock, different observers accumulate past records at different rates. The content of the past — the events that occurred — is shared, but the temporal structure of the past, as experienced from the present, differs between observers and changes over time.

This does not mean the past is arbitrary or that events can be "undone." Once a wavefunction has collapsed and a classical event has been created, that event is part of the permanent past record. What changes is the observer's relationship to that record — specifically, the measured time elapsed since the event — and this change is accumulating and in principle measurable.

4. Mathematical Framework

4.1 The Universal Present Parameter

We introduce a global scalar parameter T, which we call the Universal Present. Unlike coordinate time t or proper time τ, the parameter T is not embedded in the spacetime manifold. It is a pre-geometric parameter that indexes the progression of the present moment across the universe.

For each worldline γ_i in spacetime (corresponding to a physical observer or system i), we define a mapping:

$$\phi_i : T \to \tau_i \tag{1}$$

where τ_i is the proper time accumulated along γ_i as a function of the Universal Present T. In general relativity, the proper time along a worldline is defined by the spacetime line element:

$$d\tau^2 = -g_{\mu\nu}\, dx^\mu\, dx^\nu$$

where $g_{\mu\nu}$ is the spacetime metric evaluated along the worldline. Taking the square root:

$$d\tau = \sqrt{-g_{\mu\nu}\, dx^\mu\, dx^\nu}$$

Now, a worldline can be parametrized by any smooth parameter — proper time itself, coordinate time, or in our case the Universal Present parameter T. Dividing both sides by dT:

$$\frac{d\tau}{dT} = \sqrt{-g_{\mu\nu} \cdot \frac{dx^\mu}{dT}\frac{dx^\nu}{dT}}$$

Thus, the rate of this mapping is given by:

$$\frac{d\tau_i}{dT} = \sqrt{-g_{\mu\nu}(x_i) \cdot \frac{dx_i^\mu}{dT}\frac{dx_i^\nu}{dT}} \tag{2}$$

Integrating along the worldline from an initial Universal Present moment T_0 to T, the total proper time accumulated by observer i is:

$$\tau_i(T) = \int_{T_0}^{T} \sqrt{-g_{\mu\nu}(x_i) \cdot \frac{dx_i^\mu}{dT'}\frac{dx_i^\nu}{dT'}}\, dT' \tag{3}$$

This is the elapsed proper time for observer i as a function of the Universal Present T, and forms the basis for the past record functional defined in Section 4.2. In the absence of any additional effects, this recovers standard general relativistic proper time. The Universal Present T thus provides a global parameterization, while each observer's proper clock runs at a rate determined by the local metric.

4.2 The Past Record Functional

For an observer i, we define the past record $P_i(T)$ as the set of all classical events—collapsed quantum states—that observer i has accumulated up to Universal Present time T. Formally:

$$P_i(T) = \{E : \tau_i(T_\mathrm{E}) \leq \tau_i(T)\} \tag{4}$$

where T_E is the Universal Present moment at which event E was created (i.e., when the relevant wavefunction collapsed).

For a given past event E, observer i measures the elapsed proper time since E as:

$$\Delta\tau_i(T) = \tau_i(T) - \tau_i(T_E) \tag{5}$$

This quantity depends on both the metric along γ_i and the Universal Present moment T_E at which E was created. Crucially, T_E is a universal quantity—the same for all observers—while $\Delta\tau_i(T)$ is observer-dependent.

4.3 The Accumulating Drift

Consider two observers A and B at different fixed gravitational potentials Φ_A and Φ_B, with $\Delta\Phi = \Phi_A - \Phi_B$. Both observe the same past event E, created at Universal Present time T_E.

The exact general relativity result for the proper time ratio between two static observers at different gravitational potentials is:

$$\frac{d\tau_A}{d\tau_B} = \sqrt{\frac{1 + 2\Phi_A/c^2}{1 + 2\Phi_B/c^2}} \tag{6}$$

In the weak field limit, where $|\Phi|/c^2 \ll 1$, this simplifies via a Taylor expansion to:

$$\frac{d\tau_A}{d\tau_B} \approx 1 + \frac{\Delta\Phi}{c^2} \tag{7}$$

This approximation is valid for Earth-based and near-Earth observers, where $|\Phi|/c^2 \sim 10^{-9}$, and is the regime relevant to the proposed pulsar timing test in Section 5.

To derive the accumulated drift, we rearrange Equation 7 as a differential relation between proper time increments:

$$d\tau_A \approx \left(1 + \frac{\Delta\Phi}{c^2}\right) d\tau_B.$$

Integrating both sides from T_E to T gives the total elapsed proper times:

$$\Delta\tau_A \approx \left(1 + \frac{\Delta\Phi}{c^2}\right) \Delta\tau_B.$$

The difference in elapsed proper time between the two observers is therefore:

$$\delta \equiv \Delta\tau_A - \Delta\tau_B = \frac{\Delta\Phi}{c^2}\,\Delta\tau_B.$$

Since the weak-field correction is negligible at second order, $\Delta\tau_B \approx (T - T_E)$ to leading order, and the accumulated drift becomes:

$$\delta(T) = \Delta\tau_A(T) - \Delta\tau_B(T) = \frac{\Delta\Phi}{c^2} \cdot (T - T_E) \tag{8}$$

The factor $\Delta\Phi/c^2$ is the standard gravitational time dilation, well established experimentally (Hafele and Keating 1972). When T is identified with coordinate time in an appropriate reference frame, Equation 8 is numerically equivalent to the standard GR result — the Universal Present parameter therefore represents a reinterpretation of GR rather than a numerical departure from it. The novel, testable departure from standard GR arises solely from the quantum correction term introduced in Section 4.4.

4.4 The Quantum Correction Term

Decoherence is the process by which a quantum system loses phase coherence through interaction with its environment. As environmental degrees of freedom become entangled with the quantum system, the interference terms between superposed states are suppressed, and the system acquires effectively classical properties. The decoherence rate Γ_i quantifies how rapidly this process occurs for system i, and depends on the local temperature, particle density, and electromagnetic environment. In the present framework, Γ_i characterizes the rate at which system i transitions from the present realm into the past realm — a higher decoherence rate corresponds to faster past creation. Two observers in different gravitational environments will in general have different decoherence rates, leading to a difference in their rates of past creation and hence an accumulating timing drift.

Standard general relativity treats the metric as classical and deterministic. However, in our framework, the creation of the past is fundamentally a quantum process—wavefunction collapse via decoherence. We propose that this quantum process introduces an additional correction to the proper time mapping.

We model the decoherence-induced past creation rate for system i as:

$$\frac{d\tau_i}{dT} = \sqrt{-g_{\mu\nu}(x_i) \cdot \frac{dx_i^\mu}{dT} \frac{dx_i^\nu}{dT}} \cdot \left(1 + \alpha \cdot \frac{\hbar \Gamma_i}{mc^2}\right) \tag{9}$$

where:

- Γ_i is the local decoherence rate of the system (in s^{-1})
- $\hbar$ is the reduced Planck constant
- m represents the characteristic mass scale of the quantum degrees of freedom mediating the measurement process (e.g., electrons or atoms), rather than the bulk detector mass
- α is a dimensionless coupling constant (to be determined experimentally)

Notably, gravitational fields are expected to directly influence the local decoherence rate. Gravitational time dilation affects the rate of all local physical processes, including environmental interactions that drive decoherence. Additionally, the equivalence principle implies that observers at different gravitational potentials experience different effective thermal environments, further modifying their local decoherence rates (Unruh 1976). This provides a natural physical mechanism by which $\Gamma_A \neq \Gamma_B$ for observers at different gravitational potentials, directly motivating the quantum correction term in Equation 9.

The correction term $\alpha \cdot \frac{\hbar\Gamma_i}{mc^2}$ represents the influence of the quantum past-creation process on the effective rate of proper time accumulation. In the classical limit ($\Gamma_i \to 0$), this reduces exactly to standard GR.

The total drift between observers A and B now becomes:

$$\delta_{\text{total}}(T) = \delta_{\text{GR}}(T) + \delta_{\text{quantum}}(T) \tag{10}$$

where

$$\delta_{\text{quantum}}(T) = \alpha \cdot \frac{\hbar}{mc^2} \cdot (\Gamma_A - \Gamma_B) \cdot (T - T_E) \tag{11}$$

This additional term predicts a drift proportional to the difference in decoherence rates between the two observers. Observers in different gravitational environments will have different decoherence rates due to differences in local temperature, particle density, and electromagnetic environment — making this in principle separable from the pure GR contribution.

This form is phenomenological and represents the lowest-order dimensionless correction consistent with dependence on decoherence rate and fundamental constants.

4.5 Dimensional Analysis and Scale

For macroscopic objects, the quantum correction is extremely small. As an order-of-magnitude estimate, consider:

- $\hbar \approx 10^{-34}\ \text{J} \cdot \text{s}$
- $m \approx 1$ kg (macroscopic object)
- $c^2 \approx 10^{17}\ \text{m}^2\text{s}^{-2}$
- $\Gamma \approx 10^{30}\ \text{s}^{-1}$ (estimated decoherence rate for a macroscopic object at room temperature)

This gives:

$$\frac{\hbar\Gamma}{mc^2} \approx \frac{10^{-34} \times 10^{30}}{1 \times 10^{17}} \approx 10^{-21} \tag{12}$$

This is an extraordinarily small correction for everyday macroscopic systems, consistent with why we do not observe it in daily life.

However, for pulsars—the most precise natural clocks in the universe, with timing precision reaching 10^{-15} s over decades—and for observations conducted over long baselines with large $\Delta\Phi$, accumulated drifts may reach detectable levels if α is of order unity. Section 5 develops this estimate in detail.

5. Proposed Observational Test: Pulsar Timing

5.1 Why Pulsars

Pulsars are rapidly rotating neutron stars that emit highly regular beams of electromagnetic radiation. The most stable pulsars—millisecond pulsars (MSPs)—rival atomic clocks in precision, with timing residuals reaching 10^{-15} seconds over observation baselines of years to decades. This extraordinary precision makes them ideal natural laboratories for probing subtle effects in the nature of time.

Pulsar timing has already been used to confirm predictions of general relativity to high precision, including gravitational wave detection (Hulse and Taylor 1975), tests of gravitational time dilation, and constraints on alternative theories of gravity. We propose that the same precision timing infrastructure can be used to search for the accumulating drift predicted by the Universal Present framework.

5.2 The Experimental Setup

We propose the following observational configuration:

- A target pulsar serving as the past event generator — a precise, repeating clock whose signals constitute a well-defined sequence of past events
- Two or more ground-based observers (radio telescopes) at significantly different gravitational potentials and/or velocities, simultaneously receiving and timing pulsar signals over a baseline of months to years

Suitable existing facilities include:

- The Parkes Pulsar Timing Array (PPTA) in Australia
- The North American Nanohertz Observatory for Gravitational Waves (NANOGrav)
- The European Pulsar Timing Array (EPTA)
- The Five-hundred-meter Aperture Spherical Telescope (FAST) in China

Ideally, one receiver would be at a significantly higher altitude or in orbit (e.g., a space-based receiver) to maximize the gravitational potential difference $\Delta\Phi$ and thus the magnitude of the predicted drift.

5.3 The Predicted Signal

From the framework developed in Section 4, the total timing drift between two observers A and B accumulates as follows:

$$\delta_{\text{total}}(T) = \frac{\Delta\Phi}{c^2} \cdot (T - T_E) + \alpha \cdot \frac{\hbar}{mc^2} \cdot (\Gamma_A - \Gamma_B) \cdot (T - T_E) \tag{13}$$

The first term is the standard GR gravitational time dilation—already known and correctable. The second term is the novel prediction of our framework: an additional drift proportional to the difference in local decoherence rates between the two observing stations.

Key observational signature: After subtracting all known GR effects (gravitational time dilation, Doppler shifts, dispersion measure variations, proper motion), a residual accumulated timing drift should remain between the two observers. This residual should:

1. Grow linearly with time — accumulating over the observation baseline
2. Correlate with gravitational potential difference—larger $\Delta\Phi$ between observers produces larger signal
3. Correlate with environmental decoherence rate difference—observers in different thermal, electromagnetic, or particle-density environments should show different residuals
4. Be independent of the pulsar itself — the same drift should be observed across multiple pulsars, confirming it is an observer-side effect

5.4 Distinguishing the Signal from Known Effects

Standard pulsar timing already accounts for numerous systematic effects: interstellar dispersion, proper motion, binary orbital dynamics, solar wind, and instrumental noise. The residual we predict must be distinguished from these.

The key discriminators are:

- **Universality across pulsars**: The predicted drift depends on the observers' gravitational potentials and decoherence environments, not on the properties of the individual pulsar. A signal present in one pulsar but not others would not be our effect. The signal should appear consistently across all pulsars observed simultaneously by the two stations.
- **Linear accumulation**: Known noise sources in pulsar timing are generally white (uncorrelated) or follow a red noise power spectrum. A linearly accumulating deterministic drift is a distinct signature.
- **Environmental dependence**: If the decoherence term is significant, the residual should vary systematically with the local environment of each observatory—temperature, altitude, local electromagnetic conditions. This provides an additional handle for isolating the effect.

5.5 Estimated Signal Magnitude

For two ground-based observers at altitude difference $\Delta h \approx 1000$ m:

$$\frac{\Delta\Phi}{c^2} \approx \frac{g\Delta h}{c^2} \approx \frac{10 \times 10^3}{10^{17}} \approx 10^{-13} \tag{14}$$

Over an observation baseline of $T = 10$ years $\approx 3 \times 10^8$ s:

$$\delta_{\text{GR}} \approx 10^{-13} \times 3 \times 10^8 \text{ s} \approx 30\ \mu\text{s} \tag{15}$$

This GR term is well within the sensitivity of current pulsar timing arrays and is already routinely corrected for. The residual after GR correction would be the quantum term δ_{quantum}, whose magnitude depends on α and $\Delta\Gamma$.

For an upper bound estimate, if $\alpha \approx 1$ and $\Delta\Gamma \approx 10^6\ \text{s}^{-1}$ (modest environmental decoherence rate difference between stations):

$$\delta_{\text{quantum}} \approx \frac{10^{-34}}{1\ \text{kg} \times 10^{17}} \times 10^6 \times (3 \times 10^8) \approx 10^{-36}\ \text{s} \tag{16}$$

This is far below current sensitivity for macroscopic detectors. However, the relevant mass scale may not be the detector mass but the characteristic mass of the quantum systems mediating the measurement — electrons or atoms in the detector electronics, where $m \approx 10^{-30}$ kg, giving:

$$\delta_{\text{quantum}} \approx \frac{10^{-34}}{10^{-30}\ \text{kg} \times 10^{17}} \times 10^6 \times (3 \times 10^8) \approx 1\ \text{ns} \tag{17}$$

This is at the edge of current pulsar timing sensitivity and motivates a careful observational search. A detailed analysis of noise sources and systematics is required to determine whether this signal can be robustly extracted.

5.6 A Space-Based Enhancement

The sensitivity of the proposed test scales directly with $\Delta\Phi$ between observers. A space-based receiver—for example aboard the International Space Station (ISS, $\Delta h \approx 400$ km) or a dedicated satellite—would increase $\Delta\Phi$ by a factor of $\sim$400 compared to a 1 km altitude difference on the ground, correspondingly amplifying the predicted signal.

We propose that a joint ground-space pulsar timing campaign, using existing facilities supplemented by a space-based receiver, represents the most promising near-term path to testing the predictions of this framework.

6. Discussion and Implications

6.1 Summary of the Framework

We have proposed a fundamental reinterpretation of the nature of time. Rather than a dimension through which physical systems move, or an emergent property of entropy increase, time in this framework is the process by which the present generates the past. The Universal Present is real and universal — a pre-geometric substrate from which the classical spacetime of general relativity emerges through wavefunction collapse. The arrow of time is not a fundamental feature of reality but emerges from the process of past creation — the irreversible transition of quantum states into the classical past via decoherence.

The three central claims of this framework are:

1. A Universal Present exists, shared by all physical systems, outside the relativistic structure of spacetime
2. Wavefunction collapse—via environmental decoherence—is the physical mechanism by which the present creates the past
3. Observers at different gravitational potentials accumulate past records at different rates, producing a measurable timing drift beyond the predictions of standard general relativity

6.2 Relationship to Existing Theories

General Relativity: The framework does not contradict the mathematical predictions of GR. The spacetime metric, geodesic motion, and gravitational time dilation are all preserved as descriptions of the past realm. What changes is the interpretation: GR describes not a static block universe but the accumulated structure of the past being continuously created from the present. The Universal Present parameter T provides a global parameterization that is consistent with — but extends beyond — the local proper time of GR.

Quantum Mechanics: Standard quantum mechanics is preserved as the description of the present realm. The measurement problem — what causes collapse and when — is reinterpreted rather than solved: collapse is the process of past creation, and its occurrence is what defines the transition from present to past. The framework is agnostic about the precise trigger of collapse, but is most naturally aligned with environment-induced decoherence rather than consciousness-based or many-worlds interpretations.

The Block Universe: Our framework is directly opposed to the block universe (eternalist) view (Rietdijk 1966; Putnam 1967), in which all moments of time exist equally and the flow of time is an illusion. In our framework, the past exists as a created record, the present is the only ontologically active moment, and the future does not exist at all—it has not yet been created. This aligns more closely with presentism (Craig 2001), though the Universal Present extends beyond standard presentist accounts by providing a physical mechanism for past creation.

Thermodynamic Arrow of Time: The entropy-based arrow of time is reinterpreted in this framework as a consequence of past creation rather than its cause. Entropy increases in the past record because decoherence — the mechanism of past creation — is an irreversible process. The Second Law is preserved, but it describes a property of the past being created, not a fundamental direction of time itself.

6.3 The QM-GR Boundary

One of the deepest unsolved problems in physics is the incompatibility between quantum mechanics and general relativity. Numerous approaches—string theory, loop quantum gravity (Rovelli 2018), causal set theory (Sorkin 2003)—have attempted to unify them within a single mathematical framework.

Our proposal suggests a different perspective: quantum mechanics and general relativity are not competing descriptions of the same domain that require unification. They are accurate descriptions of different domains—the present and the past respectively. The boundary between them is wavefunction collapse via decoherence.

This does not resolve all technical incompatibilities—in particular, quantum field theory in curved spacetime and the behavior of spacetime at the Planck scale remain open questions. However, it offers a conceptual reframing that may guide future theoretical development. If the present is fundamentally quantum and the past is fundamentally classical and geometric, then the search for a theory of quantum gravity may benefit from focusing on the collapse process itself—specifically, how decoherence gives rise to classical spacetime structure.

6.4 The Nature of the Past

A striking consequence of this framework is that the past, while permanent in the sense that collapsed events cannot be undone, is not fully static. Different observers generate different past records at different rates, and the temporal structure of the past — the measured intervals between events — is observer-dependent and accumulating. This is consistent with but extends beyond the standard GR picture of observer-dependent proper time.

This has a subtle but important implication: the past we reconstruct from observation is always a projection of the Universal Present onto the observer's proper time. Historical records — whether human memory, geological strata, or the cosmic microwave background — are not a fixed, objective history but a particular observer's accumulated past record. Different observers, in principle, construct slightly different histories of the same events. The content of those histories is shared, but their temporal structure is not.

6.5 Implications for Cosmology

If the Universal Present is real and pre-geometric, it raises the question of what happened at the Big Bang. In standard cosmology, the Big Bang is the origin of spacetime itself — time begins there. In our framework, the Big Bang would be better described as the moment at which the past-creation process began — the first decoherence events that generated the initial classical spacetime structure from a purely quantum substrate.

This reframing may offer new perspectives on several cosmological puzzles:

- The low-entropy initial condition: Why did the universe begin in such a highly ordered state? In our framework, the initial quantum present had no past — it was pure superposition. The first decoherence events created the first past, necessarily simple and ordered. Entropy increase in the past record is then a natural consequence of the expanding, increasingly complex process of past creation.
- The cosmological arrow: The expansion of the universe may be a consequence of the ongoing creation of past rather than its cause. As the past record grows, the spacetime manifold expands—the two may be equivalent descriptions of the same process.
- Dark energy: The accelerated expansion of the universe, attributed to dark energy (Perlmutter et al. 1999; Riess et al. 1998), remains unexplained. If expansion is related to the rate of past creation, dark energy may reflect a property of the decoherence process at cosmological scales.

These connections are speculative and require significant further development. We note them here as directions for future work.

6.6 Limitations and Open Questions

We acknowledge several significant open questions that this framework does not yet resolve:

1. The derivation of the quantum correction term in Section 4 is phenomenological. A rigorous derivation from first principles — connecting the decoherence rate Γ to the proper time mapping—remains to be developed.
2. The value of the coupling constant α is unconstrained by the current theory. It must be determined experimentally. If α is much less than unity, the quantum correction may be undetectable with near-term technology.
3. The nature of the Universal Present parameter T requires further clarification. What physical quantity does T correspond to? Is it related to a global quantum state of the universe, and if so, what determines its rate?
4. The many-worlds interpretation of quantum mechanics has no collapse — in that framework, our mechanism of past creation does not operate. Our framework implicitly assumes that collapse is a real physical process, aligning with objective collapse theories (e.g., GRW, Penrose's gravitational collapse proposal (Penrose 1989)) or decoherence-based approaches.
5. Quantum field theory is not addressed in this framework. Extending the Universal Present picture to relativistic quantum fields is a necessary step for a complete theory.

6.7 Conclusions

We have proposed a new framework for the nature of time in which the Universal Present is real, wavefunction collapse is the mechanism of past creation, and the past is continuously generated from a quantum present that cannot be directly observed. This framework naturally reinterprets the relationship between quantum mechanics and general relativity, offers a new perspective on the thermodynamic arrow of time, and makes a concrete, falsifiable prediction: an accumulating timing drift between observers at different gravitational potentials, detectable in principle with pulsar timing arrays.

The theory is in an early stage of development. The mathematical framework presented here is a first approximation, and significant theoretical work remains. However, the core conceptual picture is coherent, internally consistent, and grounded in established physics. We invite critical engagement from the community and hope that the proposed observational test will provide an empirical anchor for this line of inquiry.

The universe does not flow through time. It creates the past—one collapsed wavefunction at a time.

References

Barbour, Julian. 1999. *The end of time: the next revolution in physics.* New York: Oxford University Press.

Boltzmann, Ludwig. 1872. Weitere studien über das wärmegleichgewicht unter gasmolekülen. *Wiener Berichte* 66:275–370.

Carroll, Sean M., and Jennifer Chen. 2004. Spontaneous inflation and the origin of the arrow of time. *arXiv preprint* hep-th/0410270. https://arxiv.org/abs/hep-th/0410270.

Christenson, J. H., J. W. Cronin, V. L. Fitch, and R. Turlay. 1964. Evidence for the 2π decay of the K_2^0 meson. *Physical Review Letters* 13 (4): 138–140. https://doi.org/10.1103/PhysRevLett.13.138.

Craig, William Lane. 2001. *Time and the metaphysics of relativity.* Dordrecht: Kluwer Academic Publishers.

Hafele, J. C., and Richard E. Keating. 1972. Around-the-world atomic clocks: predicted relativistic time gains. *Science* 177 (4044): 166–168. https://doi.org/10.1126/science.177.4044.166.

Hawking, Stephen W. 1985. Arrow of time in cosmology. *Physical Review D* 32 (10): 2489–2495. https://doi.org/10.1103/PhysRevD.32.2489.

Hulse, R. A., and J. H. Taylor. 1975. Discovery of a pulsar in a binary system. *The Astrophysical Journal Letters* 195:L51–L53. https://doi.org/10.1086/181708.

Penrose, Roger. 1979. Singularities and time-asymmetry. In *General relativity: an einstein centenary survey,* edited by Stephen W. Hawking and Werner Israel, 581–638. Cambridge: Cambridge University Press.

———. 1989. *The emperor's new mind: concerning computers, minds, and the laws of physics.* Oxford: Oxford University Press.

———. 2010. *Cycles of time: an extraordinary new view of the universe.* London: Bodley Head.

Perlmutter, S., et al. 1999. Measurements of Ω and Λ from 42 high-redshift supernovae. *The Astrophysical Journal* 517 (2): 565–586. https://doi.org/10.1086/307221.

Price, Huw. 1996. *Time's arrow and archimedes' point: new directions for the physics of time.* New York: Oxford University Press.

Putnam, Hilary. 1967. Time and physical geometry. *The Journal of Philosophy* 64 (8): 240–247. https://doi.org/10.2307/2024493.

Riess, Adam G., et al. 1998. Observational evidence from supernovae for an accelerating universe and a cosmological constant. *The Astronomical Journal* 116 (3): 1009–1038. https://doi.org/10.1086/300499.

Rietdijk, C. W. 1966. A rigorous proof of determinism derived from the special theory of relativity. *Philosophy of Science* 33 (4): 341–344. https://doi.org/10.1086/288104.

Rovelli, Carlo. 2018. *The order of time.* New York: Riverhead Books.

Sorkin, Rafael D. 2003. Causal sets: discrete gravity. *arXiv preprint* gr-qc/0309009. https://arxiv.org/abs/gr-qc/0309009.

Unruh, William G. 1976. Notes on black-hole evaporation. *Physical Review D* 14 (4): 870–892. https://doi.org/10.1103/PhysRevD.14.870.