

Time Is Not a Dimension: A Paradigm Innovation of Spacetime Based on Local Temporal Degrees of Freedom

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Abstract

As a framework built upon four- dimensional spacetime geometry, special and general relativity have successfully described how gravitational fields and relative motion modulate proper time, laying the cornerstone of modern physics. Serving as a highly efficient tool for correlating and computing macroscopic phenomena, this framework features strong logical self- consistency and high computational precision. Nevertheless, it is essentially a mathematical formalization of observational phenomena. It neither proves that the passage of time is uniquely determined by spacetime geometry, nor rules out alternative physical mechanisms governing time modulation. While the four- dimensional spacetime model achieves unparalleled success at macroscopic scales, it has never attained universal compatibility with core principles of quantum mechanics, including nonlocality, quantum entanglement and wave function collapse. Meanwhile, its unified explanatory power exhibits clear limitations when confronted with anomalous signals in high- precision atomic clock experiments, and it fails to incorporate the physical logic underlying subjective temporal experience into a unified theoretical system. Subjective time perception has long been studied within psychology and neuroscience, while its underlying universal physical foundation remains insufficiently explored and integrated into mainstream physics. Centered on the unification of quantum mechanics and relativity, and taking atomic clock anomalies as an empirical entry point, this paper proposes the hypothesis of Local Temporal Degrees of Freedom while fully preserving all experimentally verified conclusions of relativity. We argue that space is an objective three- dimensional reality, and time is not an independent spatial dimension but a local dynamical property of evolution determined jointly by the coupling strength between a material system and the cosmic background, as well as its internal recursive phase- locking degree. Free from high- dimensional assumptions and untestable ad- hoc postulates, this framework complies with Occam's Razor. It provides a unified account for macroscopic relativistic effects, quantum nonlocality, atomic clock anomalies and subjective time perception. Adhering to theoretical self- consistency, inclusiveness and falsifiability, this work offers a simpler, more

unified and mechanism- clear new pathway for fundamental physics, with full respect for all frontier research endeavors.

1. Introduction: Core Motivation and Scientific Positioning of This Work

I state the most essential and honest motivation of this research at the very beginning: my construction of the local temporal theory is initially driven by the irreconcilable fundamental conflict between quantum mechanics and relativity.

The spacetime framework serving as the core foundation of modern physics fails to accommodate the most fundamental and repeatedly verified phenomena in the quantum domain, whereas quantum theory, despite its exceptional precision, cannot be coherently integrated into the causal structure of four- dimensional spacetime. This is not a minor inconsistency but a fundamental fracture at the bedrock of fundamental physics. A deeper motivation lies in one of the central challenges of theoretical physics: bridging the incompatible rules governing the macroscopic and microscopic realms. A universal theoretical framework ought to pursue such unification rather than compartmentalizing the natural world into disjoint domains.

Systematic frequency drifts repeatedly observed in high- precision atomic clock experiments, which cannot be eliminated by relativistic corrections, provide a standardized, quantifiable and mainstream- recognized empirical entry for this study. These anomalies are not random noise but critical indicators revealing the application boundaries of existing spacetime theories.

Every researcher exploring fundamental theories possesses unique theoretical inclinations, physical intuitions and aesthetic preferences. Some scholars conceal their stances to pursue formal objectivity, yet I maintain that researchers need not abandon their inclinations so long as their theories are logically consistent, empirically compatible and open to falsification. Scientific progress has never been achieved through neutrality without bias, but through rigorous, rational and inclusive dialogue among diverse theoretical standpoints.

2. Towards Relativity: Full Respect, Complete Inheritance and Rational Extension

My stance toward relativity and the four- dimensional spacetime framework is clear, moderate and academically well- defined:

First, relativity never proves that time can only be modulated by velocity and gravity.

It rigorously demonstrates that within its framework, the passage of time is significantly modulated by motion and gravitational potential. However, it does not logically exclude alternative modulation mechanisms, nor does it confirm that spacetime geometry constitutes the sole origin of temporal flow.

Second, the modulation of time by gravity and relative motion constitutes experimentally verified observational phenomena, yet multiple physical

interpretations exist for the underlying mechanisms behind these phenomena.

Four- dimensional spacetime is an extraordinarily successful, logically consistent and practically indispensable tool for correlating and calculating physical phenomena. Its precision and reliability at macroscopic scales and in strong- coupling regimes are beyond dispute, and its capacity to describe and predict known physical phenomena represents a landmark achievement in modern physics. Nonetheless, the exceptional practical efficacy of a theoretical tool does not equate it with the unique account of spacetime nature, nor does it grant it unlimited universal explanatory power.

Third, this theory does not refute relativity but offers a compatible, inherited and testable extension.

There is no need to negate the instrumental value of established mature theories. Instead, we seek a broader and more compatible framework that retains all verified experimental successes while resolving unsolved physical problems within the conventional paradigm.

3. Application Boundaries and Explanatory Limitations of the Four- Dimensional Spacetime Framework

While irreplaceable for macroscopic physical calculations, the four- dimensional spacetime framework exhibits clear application boundaries and explanatory limitations when pursued as a universal unifying physical program:

The framework enables precise correlation and computation of macroscopic phenomena yet suffers an inherent deficiency in physical mechanism interpretation. It fails to provide a clear mechanism for the physical connection between the temporal dimension and the three spatial dimensions, nor can it deliver a self- consistent unified account of core microscopic phenomena such as quantum nonlocality. This lack of mechanistic clarity prevents the framework from forming a complete explanatory loop for cross- scale physical problems.

For over a century, physicists have conducted extensive precise calculations and theoretical deductions under the four- dimensional spacetime framework, yet a consistent and intuitive universal physical picture has never been established. This is not a limitation of human cognition but an inherent boundary of the framework itself. Quantum physics is not lacking in physical imagery; instead, theoretical incompleteness has given rise to excessive competing interpretations. In contrast, the four- dimensional spacetime framework struggles to form a coherent physical picture compatible with both macroscopic and microscopic phenomena from a universal perspective — this represents its core limitation as a unifying theoretical tool.

In accordance with Occam's Razor, the core mission of physical research is to resolve practical problems and unify natural laws. We should not equate the

instrumental effectiveness of a framework with the sole valid interpretation of nature. Instead, we prioritize frameworks that offer simpler and more consistent explanations covering all verified physical phenomena — the core objective of this research.

4. Time Perception: From Psychological Illusion Back to Objective Physical Phenomenon

Human stable and repeatable experience of time passage constitutes a genuine macroscopic physical phenomenon. Its current exclusion from mainstream physics arises primarily from the lack of theoretical tools to seamlessly integrate it into a unified physical picture. Common experiences such as accelerated time flow during focused work and decelerated time flow in life-threatening situations have long been dismissed as neural or psychological effects, isolated from objective physical laws.

Nevertheless, a fundamental and irrefutable intuition holds true:

our subjective experience of altered temporal flow likely reflects objective changes in the proper time evolution of the material systems hosting consciousness; our perception of altered internal order likely corresponds to real changes in physical evolutionary sequences.

This theory proposes that such perceptual differences originate from variations in the spacetime coupling strength and recursive phase-locking degree of neural systems, directly manifesting as deviations in local proper time. Perception is not an illusion but a direct reflection of physical reality. This does not negate neural correlates of consciousness but provides a more fundamental physical causal explanation for them.

5. Theoretical Objectives: Constructing a Simpler, Unified and Testable Spacetime Framework

The consistent objective of this work is not to subvert modern physics but to identify a more inclusive theoretical pathway that fulfills the following criteria:

- It fully complies with all experimentally verified laws of relativity;
- It naturally accommodates all well-established core phenomena of quantum mechanics;
- It resolves the century-old fundamental incompatibility between quantum mechanics and relativity;
- It accounts for atomic clock anomalies unexplained by conventional theories;
- It reintegrates human time perception into objective physical laws;
- It avoids untestable high-dimensional postulates and maintains theoretical parsimony;
- It delivers a clear, consistent and intuitive causal physical picture.

Following this objective, we develop a system of three- dimensional objective space plus Local Temporal Degrees of Freedom. This does not represent a regression to Newtonian absolute spacetime but a fundamental advancement that reinterprets time from an abstract geometric dimension into a quantifiable dynamical evolutionary property intrinsic to material systems.

This conceptualization of time as a system- specific dynamical property rather than an independent dimension echoes several strands in philosophy of physics, including the relational time proposed by J. Barbour and the time paradigm in C. Rovelli's loop quantum gravity. The key advancement of this work lies in the construction of a physically well- defined, quantitatively computable and experimentally testable model grounded in this philosophical stance, thereby elevating it from abstract speculation to empirical physics via two core parameters α and β .

6. Local Temporal Degrees of Freedom: A Third Falsifiable Mechanism for Time Modulation

Relativity identifies velocity and gravitational potential as two modulators of time passage. Building upon this, we propose that temporal flow is jointly governed by two components:

1. The relativistic spacetime geometric term (fully preserved with strict covariance);
2. The local temporal scale term $\xi(\alpha, \beta)$, determined by the spacetime coupling strength α and the recursive phase- locking degree β .

In the strong- coupling regime where the system is tightly coupled to the cosmic background ($\alpha \approx 1$), local scale effects vanish and the theory naturally reduces to relativity, ensuring consistency with all known experimental results. Novel physical effects emerge only under extreme precision conditions, weak coupling and highly stable recursive motion. The definitive falsifiable prediction of this framework states that systematic variations in temporal flow can be observed by manipulating the spacetime coupling strength α experimentally, even with constant velocity and gravitational field. A gradient shielding experiment is designed specifically to test this prediction.

Persistent drifts in high- precision atomic clocks are not instrumental noise but genuine observable signatures of local temporal degrees of freedom. Meanwhile, variations in human time perception can be explained by the same unified physical mechanism.

7. Discriminative Advantages of This Framework: Why It Cannot Be Replaced by Conventional New- Field Hypotheses

Even if stable frequency drifts in atomic clocks are observed in future experiments, a single phenomenon alone cannot uniquely distinguish between the local temporal degrees of freedom framework and hypothetical new fields or interactions within the

conventional four- dimensional spacetime paradigm — a necessary caution in scientific reasoning. However, the true strength and discriminative power of this framework do not rest on post- hoc explanations for isolated anomalies but its ability to simultaneously satisfy three stringent criteria, which form a theoretical filter that conventional new- field hypotheses can scarcely pass.

Criterion 1: Maximal Parsimony — No New Entities or Free Parameters

To explain atomic clock anomalies, any conventional new- field hypothesis (e.g., scalar or vector fields coupled to nuclei or electrons) inevitably introduces new particles, new forms of interactions and additional free parameters such as coupling constants and field masses. This significantly increases theoretical complexity and ad- hoc assumptions, violating Occam's Razor. In contrast, our framework introduces no new fundamental fields or particles. By reinterpreting the physical meaning of time itself, we only adopt two well- defined and independently measurable state parameters — the spacetime coupling strength α and the recursive phase- locking degree β — to unify all phenomena. α and β describe the relationship between a system and its background as well as its internal state, rather than introducing new fundamental entities.

Criterion 2: Maximal Unification — Cross- Domain Explanation Instead of Isolated Ad- Hoc Repairs

Conventional new- field hypotheses are typically tailored to address single anomalies such as atomic clock drifts. They cannot naturally extend to resolve other fundamental puzzles, including the conflict between quantum nonlocality and classical local causal spacetime, macroscopic- microscopic temporal inconsistencies, and universal physical laws governing human time perception — problems treated as mutually independent under conventional paradigms. Our framework, however, provides a unified underlying mechanism: modulation of local temporal flow. The identical mechanism manifests as atomic clock frequency shifts, quantum nonlocal correlations and subjective temporal experience across different scales and physical conditions. This cross- domain explanatory power is unattainable by isolated new- field hypotheses.

Criterion 3: Testable Joint Behavioral Patterns — Fingerprint- Like Structural Predictions

This represents the most decisive advantage. Rather than single isolated predictions, our theory delivers a set of structurally consistent and jointly testable predictions that constitute its unique theoretical fingerprint:

- **Dependency:** Frequency shifts depend monotonically on the shielding level (which reduces α) and the intrinsic stability of the system (β), following a specific functional form $\xi(\alpha, \beta)$.
- **Independence:** The effect is independent of classical gravitational potential, relative velocity and electromagnetic environment. Modulation of conventional physical variables produces no impact on the α - dominated temporal shifts.
- **Universality and Differentiation:** Systems with distinct intrinsic stability (β),

such as atomic clocks based on different elements, exhibit varying magnitudes of frequency drift while maintaining consistent trends.

Any conventional field- based mechanism would couple to field intensity, distance and potential, and cannot reproduce this unique behavioral pattern governed solely by shielding and stability conditions, independent of classical kinematic quantities. Therefore, experimental confirmation of this pattern would rule out conventional unknown- field explanations with high confidence and strongly support the paradigm that time possesses independent degrees of freedom beyond spacetime geometry.

In conclusion, the Local Temporal Degrees of Freedom framework is not merely one among many competing hypotheses. Under current physical knowledge, it stands as the unique theoretical scheme that simultaneously satisfies maximal parsimony (no new entities), maximal unification (cross- domain explanation) and discriminative structural predictions. Experimental validation of its predictions will not only confirm a novel physical effect but also establish the fundamental necessity of a new paradigm where time possesses degrees of freedom transcending geometric spacetime.

8. Respect for Researchers in Four- Dimensional and Higher- Dimensional Theories

I sincerely and explicitly state:

I do not deny the instrumental value and academic contributions of the four- dimensional spacetime framework. Scientists dedicated to four- dimensional, higher- dimensional, string theory, loop quantum gravity and other frontier directions have advanced human understanding of spacetime nature through rigorous research, perseverance and intellectual courage. Their achievements constitute invaluable assets to physics, to which I hold the highest respect. I merely pursue a more parsimonious, experimentally tractable and mechanism- focused pathway to address the unified explanatory gaps of conventional frameworks, which does not diminish the academic value of alternative research directions. Scientific progress is never a single- path race but a collective evolution driven by diverse theoretical perspectives.

9. Conclusion

Four- dimensional spacetime represents one of humanity's greatest tools for correlating and computing physical phenomena, achieving irreplaceable academic and empirical success in macroscopic physics. Nevertheless, it is not a universal framework capable of full explanatory power across all physical domains. Time is not a fourth spatial dimension but a local dynamical degree of freedom governing the evolution of material systems.

The proposed framework of three- dimensional objective space plus Local Temporal Degrees of Freedom forms a logically consistent theory that inherits established physics while generating novel testable predictions. It achieves three core unifications:

1. It unifies macroscopic relativistic effects and microscopic atomic clock anomalies, expanding the boundary of verifiable physical phenomena;
2. It resolves the ontological conflict between quantum nonlocality and classical spacetime, bridging fundamental theoretical fractures;
3. It reintegrates subjective time perception into objective physical laws, realizing cognitive unification.

Free from extra dimensions and ad- hoc assumptions, this framework achieves maximal explanatory power with minimal theoretical modification, complying with Occam's Razor. It provides a concise new pathway addressing deep- rooted challenges in fundamental physics, distinguished by superior universal compatibility and unified explanatory capacity. Its ultimate validity shall be adjudicated by experiments proposed herein and future empirical tests inspired by this work.