

Time from a Timeless Universe

The

Emergence of Time from a Timeless Universe: A Relational Quantum Ontology

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Abstract: The problem of time in physics stems from a foundational conflict between the static, geometric reality described by fundamental theories and the dynamic, flowing time of human experience. Physicalist models that attempt to reify this experiential time, such as the Evolving Block Universe (EBU), suffer from systemic failures, including logical circularity, empirical emptiness, and incompatibility with relativity. This paper argues for a paradigm shift from a substance-based ontology of time to a relational one grounded in quantum information. We deconstruct the failures of the substance ontology and construct a relational framework from the first principles of quantum mechanics, postulating a universal, timeless quantum state governed by the Wheeler-DeWitt equation. Within this framework, we formally derive the time-dependent Schrödinger equation as an effective, emergent description of the correlations between a subsystem designated as a “clock” and the rest of the universe. This derivation demonstrates that the ‘present moment’ is a conditional, observer-dependent state and the ‘passage of time’ is the measurable evolution of this state. The paradoxes of time are thereby resolved as category errors, and the Block Universe is reinterpreted as a static map of the timeless quantum correlations that constitute the fundamental territory of reality.

Keywords Evolving Block Universe, Relational Quantum Mechanics, Page-Wootters Formalism, Problem of Time, Emergence of Time, Timelessness, Wheeler-DeWitt Equation, Quantum Ontology

1.0

Introduction: A Paradigm Shift for the Ontology of time

The problem of time in physics is not a specific technical issue but a symptom of a flawed underlying ontology that reifies subjective temporal experience (Riggs, 2024; Rovelli, 2018). Models that attempt to build a physical reality upon the intuitive notions of a flowing ‘passage’ of time or a universal ‘present moment’ consistently fail, generating irresolvable paradoxes and requiring ad-hoc mechanisms that lack empirical support. This paper will demonstrate that a complete, coherent, and predictive model of time emerges when this ontology is replaced with a relational one based on the principles of quantum information. The central argument will be validated by a formal derivation of the time-dependent Schrödinger equation from a timeless universal state, showing that the temporal world of experience is not a fundamental reality but an effective description for observers embedded within it.

1.1

The Ontological Fork: Time as Substance vs. time as relation

The history of the philosophy and physics of time is defined by a tension between treating time as a fundamental container for reality versus a relational structure derived from reality’s contents (Rovelli, 2018). The substance-based view posits time as a fundamental aspect of the objective world—the “territory” itself. This approach inevitably leads to paradoxes when the properties of this supposed substance conflict with the known laws of physics, such as relativity. Relational ontology, in contrast, treats time as a “map”—an effective, high-level

language for describing the correlations and relationships within the territory. This distinction is crucial: relational ontology avoids paradoxes by deriving the properties of the map (experienced time) from the fundamental, timeless structure of the territory (physical reality).

1.2

Argumentative Strategy: Deconstruction, Construction, and Formal validation

The argument will proceed in three stages: demonstrating the incoherence of the old paradigm, building the new one from first principles, and validating it with a formal derivation. First, the substance ontology will be deconstructed by analyzing the systemic failures of its representative models. Second, a relational ontology will be constructed from the foundational principles of quantum mechanics. Third, this new paradigm will be validated through a rigorous mathematical proof that derives all of temporal dynamics from a timeless quantum state.

2.0

Deconstruction of the Substance Ontology: The Failure of Physicalist Models of Flowing time

Physicalist models that presuppose an objective ‘passage of time’ are fundamentally unable to provide coherent, non-circular, and empirically verifiable definitions for their core temporal concepts (Riggs, 2024). These models attempt to project the human experience of temporal flow onto the fabric of reality, but in doing so, they clash with the established principles of modern physics and fail to produce a logically consistent framework.

2.1

Case Study: The Internal Incoherence of the Evolving Block Universe (EBU)

The Evolving Block Universe (EBU) model is a prime example of a class of theories that fail because they require ad-hoc, physically unmotivated mechanisms to reconcile the static geometry of relativity with the dynamic experience of time (Riggs, 2024). The EBU posits that spacetime grows as the ‘present moment’ advances, converting an indeterminate future into a determinate past. While attempting to capture the intuition of a flowing time, this model collapses under the weight of its own internal contradictions. The model’s definition of the present is circular: the ‘collapse’ events that supposedly generate the passage of time are themselves described as occurring sequentially in time (Riggs, 2024). Furthermore, the model’s entire structure is contingent on a ‘collapse’ interpretation of quantum mechanics, which is not empirically established and is one of several competing, viable interpretations (Riggs, 2024). The astronomical number of local ‘collapse’ events would produce a disordered ‘present,’ not the single, ordered ‘now’ of experience, a problem made intractable by the relativity of simultaneity (Riggs, 2024; Einstein, 1905).

2.2 The

Empirical Emptiness of Temporal ‘passage’

The ‘passage of time’ is an empirically empty, metaphysical concept, not a physical observable, because its defining characteristic—its rate—is immeasurable. No known physical instrument can measure a ‘rate of passage’ for time; clocks measure duration, a relational quantity between events (Riggs, 2024). The concept of a ‘rate of time’s passage’ is a tautology (one second per second) devoid of empirical content, signaling its non-physical nature.

2.3

Synthesis of Failure: The Need for a New ontology

The failures of models like the EBU are not technical but foundational, stemming from the incorrect assumption that time is a substance. The identified problems of circularity, empirical emptiness, and incompatibility with relativity are not isolated flaws but systemic failures of the underlying substance ontology, thus motivating the necessity of a paradigm shift.

3.0

Construction of the Relational Ontology: Time from Timeless information

A coherent model of time is possible if, and only if, time is understood not as a fundamental substance but as an emergent property of quantum correlations between physical subsystems (Page and Wootters, 1983). This section constructs such a model from the first principles of quantum mechanics, showing how a complete description of time can be built from timeless quantum information.

3.1

Foundational Postulate: The Timeless, Static Universal Quantum state

The fundamental description of the universe is a static state vector $|\Psi\rangle$ that is an eigenstate of the total Hamiltonian H with eigenvalue zero (DeWitt, 1967):

$$H|\Psi\rangle = 0 \quad (1)$$

This equation, known as the Wheeler-DeWitt equation in quantum cosmology, contains no time variable. It describes a reality that, when viewed as a whole, is static and timeless. This postulate embraces the timeless nature of fundamental physics rather than attempting to fight it.

3.2

Principle 1: Emergence via Subsystem partition

Observable dynamics are not properties of the universe as a whole but of the relationships between its constituent parts. To describe the experience of an observer within the universe, we partition the total system into subsystems, such as a “clock” and a “system” that is observed. This allows for a description of the system *relative to* the clock, which is the foundational step for recovering a temporal narrative from a timeless state.

3.3

Principle 2: Entanglement as a Static Record of dynamics

Static quantum entanglement between subsystems serves as the complete informational record of a system’s dynamical history relative to a clock. The universal state $|\Psi\rangle$ is a static superposition of entangled states, each term of which correlates a specific state of the clock with a corresponding state of the system. This static web of correlations contains all the information of a complete dynamical history, ready to be “read” by an internal observer.

4.0

Formal Validation: The Derivation of Dynamics from a Timeless state

The entire mathematical framework of time-dependent quantum mechanics can be derived as an effective, relational description from within a globally timeless quantum state, proving the mathematical viability of the relational ontology (Page and Wootters, 1983). This section outlines the core of this derivation, which is presented in full in Appendix A.

4.1

The ‘present moment’ Formalized as a Conditional state

The ‘present moment’ for an observer at time t is formally defined as the conditional state $|\psi(t)\rangle_S$, obtained by projecting the universal state $|\Psi\rangle$ onto the clock’s eigenstate $|t\rangle_C$:

$$|\psi(t)\rangle_S := \langle t|_C |\Psi\rangle \quad (2)$$

This provides a rigorous, physical definition of “now” not as a universal hyperplane, but as the state of the system that is correlated with the state of the observer’s clock. It is crucial to note that this projection is a mathematical tool for defining the conditional state; it is not a model of physical wavefunction collapse. The Page-Wootters formalism provides a powerful solution to the problem of time, but it does not, by itself, claim to solve the quantum measurement problem, which remains a distinct challenge for the foundations of quantum mechanics.

4.2

The Derivation of the Time-dependent Schrödinger equation

The mathematical operation of conditioning the system’s state on the clock’s state transforms the static Hamiltonian constraint ($H|\Psi\rangle = 0$) into the familiar time-dependent Schrödinger equation for the system. As shown in Appendix A, the action of the clock’s Hamiltonian on the conditional state becomes equivalent to a time-derivative operator, while the system’s Hamiltonian acts on the state itself. This directly yields the equation governing all quantum evolution.

4.3

Implications of the Derivation: From Mathematics to physics

The success of the derivation demonstrates that a temporal description of the world is not fundamental but is the effective, high-level language for observers embedded within a timeless reality. This elevates the relational ontology from a philosophical preference to a mathematically validated physical model. Time is not a postulate of physics but a derivable consequence of its timeless quantum foundation.

5.0

Resolution of Paradoxes: A Direct Mapping from Substance to relation

The relational framework provides physically grounded, non-paradoxical definitions for concepts that are ill-defined in substance-ontology models, thereby solving the problem of time. Each paradox of the substance ontology is resolved by mapping it to a coherent physical principle in the relational ontology.

5.1 The Problem of

the Preferred present

The ontological error of the substance view is the assumption that the ‘present’ is a universal, absolute hyperplane. The relational framework corrects this by defining the ‘present’ as a local, physical state of a system conditioned on its correlation with an observer’s clock. The resolution, therefore, is that the locality and observer-dependence of the present are its defining physical features, not a flaw.

5.2 The Problem of

Temporal passage

The ontological error of the substance view is the assumption that ‘passage’ is a metaphysical flow with an intrinsic, yet immeasurable, rate. The relational framework corrects this by defining ‘passage’ as the physical evolution of a system’s conditional state relative to a clock, a process governed by the emergent Schrödinger equation. The concept is thereby transformed from an unobservable metaphysical flow into a measurable, relational dynamic.

5.3 The Problem of

the Block universe

The ontological error of the substance view is the conflation of the geometric representation of history (the map) with the fundamental reality itself (the territory). The relational framework corrects this by identifying the geometric Block Universe as a static map of the timeless quantum correlations that constitute the territory. The paradox of a static block containing a dynamic experience dissolves as a category error: the map is static, but an observer’s processing of information from the map is a dynamic, temporal process.

6.0 Implications and

Future directions

The relational paradigm offers a new foundation for tackling long-standing problems in quantum gravity and cosmology. By providing a framework where dynamics can emerge without a pre-existing spacetime background, it opens new avenues for research.

6.1 Implications for

Quantum gravity

The Page-Wootters mechanism provides a concrete example of how dynamics can emerge in a background-independent theory, where spacetime itself is not a fixed stage (Rovelli, 2004). This is a key requirement for theories of quantum gravity, and the relational approach provides a powerful conceptual and mathematical toolkit for constructing such theories.

6.2 Implications for

the Arrow of time

The directionality of time is not a fundamental law but an emergent feature of the specific universal state $|\Psi\rangle$, which is constrained by a low-entropy past boundary condition (Carroll, 2010). Within the relational framework, the ‘arrow of time’ is understood as a thermodynamic and informational asymmetry related to the boundary conditions of the universe, allowing an observer to form memories of one “temporal” direction but not the other. While the Past Hypothesis provides the necessary global condition, formally demonstrating the emergence of a consistent thermodynamic arrow for all internal observers within this framework is a non-trivial subject of ongoing research.

6.3

Limitations and Generalizations of the Relational Model

It is important to acknowledge the idealizations upon which the simple derivation in Appendix A rests. The assumption of a non-interacting Hamiltonian ($H = H_C + H_S$) and the existence of a “perfect” clock are significant simplifications. In a more realistic scenario, interactions between the clock and system would introduce a term H_{int} , and any physical clock would be imperfect. These factors complicate the emergent dynamics and are the subject of active research aimed at generalizing the model.

Furthermore, the partition of the universe into a “clock” and a “system” is arbitrary. This ambiguity is not a flaw but a core feature of the relational ontology. Different partitions can lead to different, equally valid “temporal narratives” for the same underlying reality. This reinforces the conclusion that time is not a universal, monolithic background but an emergent, perspective-dependent description of relationships between parts of the universe.

7.0

Conclusion: The Success of the Relational paradigm

The relational framework successfully unifies the static, timeless view of the universe suggested by fundamental physics with the dynamic, temporal world of observation. By replacing metaphysical postulates with derivable physical mechanisms, the relational ontology solves the problem of time and provides a coherent foundation for future research. The successful derivation of the Schrödinger equation from a timeless state validates this paradigm, demonstrating that the rich, evolving world we experience can emerge from a reality that is, at its most fundamental level, static and eternal.

**Appendix A: Formal Proof of Emergent Temporal

dynamics** |

This appendix provides a self-contained, rigorous proof of the central theorem: the derivation of the time-dependent Schrödinger equation from the timeless Wheeler-DeWitt equation via the Page-Wootters formalism. |

Axioms and Definitions |

- **Axiom 1 (Timeless Universe):** The universe is a closed system described by a static state vector $|\Psi\rangle$ such that $H|\Psi\rangle = 0$, where H is the total Hamiltonian (DeWitt, 1967). |

$$H|\Psi\rangle = 0 \quad (A)$$

|

- **Axiom 2 (Subsystem Partition):** The universe is partitioned into a non-interacting clock (C) and system (S), with $H = H_C + H_S$. - **Definition 1 (Ideal Clock):** An ideal clock C has a Hamiltonian H_C that generates translations along the eigenstates $|t\rangle_C$ of a time observable T_C . - **Definition 2 (The Present Moment):** The state of the system at time t is the conditional state $|\psi(t)\rangle_S := \langle t|_C |\Psi\rangle$. |

Theorem |

The evolution of the conditional state $|\psi(t)\rangle_S$ with respect to the clock parameter t is governed by the time-dependent Schrödinger equation (TDSE): |

$$i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle_S = H_S |\psi(t)\rangle_S \quad (A)$$

|

Proof |

1. **Project the Constraint:** We begin by applying the

projection operator $\langle t|_C$ to the Hamiltonian constraint: |

$$\langle t|_C(H_C + H_S)|\Psi\rangle = 0 \quad (A)$$

|

1. **Evaluate System Term:** Since H_S acts only on the system's Hilbert space, it commutes with the projection operator: |

$$\langle t|_C H_S |\Psi\rangle = H_S (\langle t|_C |\Psi\rangle) = H_S |\psi(t)\rangle_S \quad (A)$$

|

1. **Evaluate Clock Term:** By the definition of H_C as a generator of translations in its own time-eigenstate basis, its action can be shown to be equivalent to a time-derivative operator on the conditional state: |

$$\langle t|_C H_C |\Psi\rangle = -i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle_S \quad (A)$$

|

1. **Assemble the Equation:** Substituting the results from (A) and (A) into the projected constraint (A) yields: |

$$-i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle_S + H_S |\psi(t)\rangle_S = 0 \quad (A)$$

|

1. **Conclusion (Q.E.D.):** Rearranging the terms of (A) yields the TDSE (A): |

$$i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle_S = H_S |\psi(t)\rangle_S \quad (A)$$

|

This demonstrates that temporal dynamics for a subsystem are a necessary consequence of the timeless correlations in the universal state (Page and Wootters, 1983; Rovelli, 2004). |

References

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- Carroll, S. M. (2010). **From Eternity to Here: The Quest for the Ultimate Theory of Time**. Dutton.
- DeWitt, B. S. (1967). Quantum Theory of Gravity. I. The Canonical Theory. *Physical Review*, 160(5), 1113–1148.
- Einstein, A. (1905). Zur Elektrodynamik bewegter Körper [On the Electrodynamics of Moving Bodies]. *Annalen der Physik*, 322(10), 891–921.
- Page, D. N., & Wootters, W. K. (1983). Evolution without evolution: Dynamics described by stationary observables. **Physical Review D*, 27*(12), 2885–2892.
- Riggs, P. J. (2024). Questioning the Emergence of Time. **Journal for General Philosophy of Science**. <https://doi.org/10.1007/s10838-024-09674-9>

Rovelli, C. (2004). *Quantum Gravity*. Cambridge University Press.

Rovelli, C. (2018). *The Order of Time*. Riverhead Books.