

The NOW Hypothesis: A Timeless Framework for Information Creation and Growth in the Universe

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Abstract

This paper introduces the NOW Hypothesis, a speculative theoretical framework that integrates principles from information theory, quantum mechanics, relativity, and cosmology to describe the indestructibility, growth, and creation of information in the universe. Central to the hypothesis is the concept of "NOW" as a perpetual, non-time-bound boundary where quantum superpositions of future states coalesce into immutable past realities through decoherence, thereby "creating" new classical information. The past is recoverable in principle, the future exists as an infinite, timeless superposition, and information grows monotonically with the universe's expansion. Refinements address quantum uncertainty, the universality of decoherence across sectors (including dark energy and dark matter), and the timeless nature of "NOW." Mathematical formalizations draw from quantum information theory and canonical quantum gravity, with derivational steps provided from first principles or established formulations. Implications span physics (e.g., resolutions to entropy paradoxes), philosophy (e.g., eternalism with dynamic emergence), and technology (e.g., quantum computing paradigms). While speculative, the hypothesis offers testable predictions via decoherence experiments and cosmological observations.

1 Introduction

Information theory, pioneered by Claude Shannon in his seminal work on communication [1], provides a quantitative framework for understanding uncertainty and data transmission. Extending this to physics, John Wheeler's "it from bit" proposal suggests that the physical world emerges from informational foundations [2]. In quantum mechanics, decoherence explains the emergence of classical reality from quantum superpositions, as articulated in Wojciech Zurek's Quantum Darwinism [3]. Cosmologically, the Wheeler-DeWitt equation in quantum gravity posits a timeless universe where time is emergent [4].

The NOW Hypothesis builds on these ideas, positing that information is indestructible yet grows through a universal "NOW" mechanism. This addresses paradoxes like black hole information loss via the holographic principle [7] and entropy increase in an expanding universe [8]. The hypothesis reconciles conservation with growth by distinguishing quantum potential (pre-decoherence) from classical information (post-decoherence).

2 Core Hypothesis

2.1 Information Indestructibility and Growth

Information cannot be destroyed under unitary quantum evolution, aligning with no-cloning and no-deleting theorems. However, the universe's information content grows with each Planck time due to entropy increase, driven by expansion and decoherence [8].

2.2 Past Recoverability and Immutability

Given perfect knowledge of the present state at T_0 , the past (T_0 to T_{-N}) is recoverable via time-reversal symmetry, as past states are encoded in current correlations.

2.3 Future as Infinite Superposition

Pre-decoherence, the future is a timeless, coherent superposition of all possibilities, rendering "information" meaningless until fixed.

2.4 NOW as the Creation Boundary

"NOW" is the perpetual locus of quantum coalescence, where wave functions "collapse" into classical realities, creating new information at a maximum rate bounded by Planck scales.

3 Refinements

3.1 Quantum Uncertainty and Non-Conservation

Uncertainty implies that pre-decoherence information is infinite potential, not conserved classically; decoherence creates discrete bits.

3.2 Timeless, Universal NOW

"NOW" occurs universally and eternally, unbound by time, as a relational boundary in the timeless wave function [4]. It is not simultaneous but always present in every causal patch.

3.3 Decoalesing Factor

A universal mechanism (environmental entanglement or observation) triggers coalescence, operating relativistically.

4 Mathematical Formalization

4.1 Pre- and Post-Decohere States

To illustrate information creation via decoherence, consider a single qubit system, which serves as a simple model for quantum-to-classical transitions [10].

Start with the density operator formalism in quantum mechanics. For a quantum state described by a wave function $|\psi\rangle$, the density matrix is defined as $\rho = |\psi\rangle\langle\psi|$ for pure states [9]. For a balanced superposition state representing the "timeless future":

$$|\psi\rangle = \frac{1}{\sqrt{2}}(|0\rangle + |1\rangle), \quad (1)$$

the density matrix is:

$$\rho_{\text{pure}} = |\psi\rangle\langle\psi| = \frac{1}{2} \begin{pmatrix} 1 & 1 \\ 1 & 1 \end{pmatrix}. \quad (2)$$

The von Neumann entropy $S(\rho)$, which measures the quantum information or uncertainty in the state, is defined as [9]:

$$S(\rho) = -(\rho \log_2 \rho), \quad (3)$$

where the trace is over the Hilbert space, and \log_2 is used for bits (base-2 logarithm). This extends Shannon's classical entropy $H(p) = -\sum p_i \log_2 p_i$ to quantum systems by replacing probabilities with eigenvalues of ρ [1, 9].

To compute $S(\rho_{\text{pure}})$, diagonalize ρ_{pure} . The eigenvalues are found from the characteristic equation $\det(\rho - \lambda I) = 0$, yielding $\lambda_1 = 1$ and $\lambda_2 = 0$. Thus:

$$S(\rho_{\text{pure}}) = -(1 \log_2 1 + 0 \log_2 0) = 0, \quad (4)$$

where $0 \log_2 0 \equiv 0$ by continuity. This reflects no uncertainty in a pure state [9].

Post-decoherence, environmental interactions diagonalize the density matrix in the pointer basis, resulting in a mixed state [3]:

$$\rho_{\text{mixed}} = \frac{1}{2} \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}. \quad (5)$$

Eigenvalues are $\lambda_1 = \lambda_2 = 1/2$, so:

$$S(\rho_{\text{mixed}}) = -\left(\frac{1}{2} \log_2 \frac{1}{2} + \frac{1}{2} \log_2 \frac{1}{2}\right) = 1 \text{ bit}. \quad (6)$$

The entropy increase $\Delta S = S(\rho_{\text{mixed}}) - S(\rho_{\text{pure}}) = 1$ bit quantifies the "creation" of classical information through decoherence [3].

4.2 Timeless Framework

In canonical quantum gravity, time emerges from relational dynamics, leading to a timeless description [4]. Start with general relativity's Einstein-Hilbert action:

$$S = \int d^4x \sqrt{-g} (R - 2\Lambda), \quad (7)$$

where R is the Ricci scalar and Λ the cosmological constant. In the ADM formalism, decompose spacetime into spatial slices with metric h_{ij} and lapse/shift functions [11]. The Hamiltonian constraint arises from varying the action with respect to the lapse, yielding $H = 0$ classically.

Quantization promotes h_{ij} to operators and imposes the constraint as the Wheeler-DeWitt equation [4]:

$$\hat{H}\Psi[h_{ij}, \phi] = 0, \quad (8)$$

where Ψ is the wave function of the universe, \hat{H} the super-Hamiltonian (including kinetic, potential, and matter terms ϕ), and no explicit time parameter appears, reflecting reparametrization invariance. Emergent time τ arises semiclassically from clock variables in subsystems, e.g., via conditional probabilities $\Psi \approx e^{iS/\hbar}$ in WKB approximation, recovering Schrödinger-like evolution $i\partial_\tau\psi = H\psi$ for subsystems [4, 12].

4.3 Decoherence Dynamics

For open quantum systems, the evolution is described by the Lindblad master equation, derived under Markovian approximations [13, 14]. Start with the total Hamiltonian for system S and environment E : $H = H_S + H_E + H_{int}$, where $H_{int} = \sum_k g_k A_k \otimes B_k$ (interaction terms).

In the interaction picture, the reduced density matrix $\rho_S =_E (\rho_{SE})$ evolves via the von Neumann equation $d\rho_{SE}/dt = -i[H_{int}, \rho_{SE}]$. Assuming weak coupling (g_k small) and Markovianity (environment correlations decay fast), expand to second order and trace over E [15]:

$$\frac{d\rho_S}{dt} = - \int_0^\infty dt'_E [H_{int}(t), [H_{int}(t-t'), \rho_S(t) \otimes \rho_E]], \quad (9)$$

where $H_{int}(t)$ is time-evolved. Assuming thermal ρ_E and correlation functions $\langle B_k(t)B_l(0) \rangle = \delta_{kl}e^{-\gamma t}$, this yields the Lindblad form [13]:

$$\frac{d\rho}{dt} = -i[H, \rho] + \sum_k \gamma_k \left(L_k \rho L_k^\dagger - \frac{1}{2} \{L_k^\dagger L_k, \rho\} \right), \quad (10)$$

with jump operators L_k (e.g., σ_z for dephasing) and rates γ_k . This describes irreversible decoherence while preserving trace and positivity [14].

5 Extensions to Dark Energy and Dark Matter

Dark energy (DE) and dark matter (DM) reside within the universal NOW, encapsulating growing information sets via self-consistent past states [5]. Weak interactions with baryonic reality do not imply slow decoherence; self-interactions enable rates comparable to baryonic systems [6]. Decoherence is substrate-independent, appearing baryonic only through observational bias.

For DE as an info field, extend the super-Hamiltonian with a term incorporating relative entropy S_{rel} from vacuum mismatches [5]:

$$\hat{H}_{DE/info} \sim \Lambda + S_{rel}, \quad (11)$$

where Λ is the cosmological constant, and S_{rel} derives from quantum field mismatches in de Sitter space, leading to volume-law entropy growth [5].

For DM gravitational decoherence, consider superposed states with separation Δx . The rate follows from general relativistic metric fluctuations inducing phase loss [6]:

$$\gamma_{DM} \sim \frac{Gm^2\Delta x^2}{\hbar c}, \quad (12)$$

derived by integrating geodesic deviations over spacetime curvature, assuming Newtonian limit for galactic scales [6].

This integration explains cosmological coincidences and entropy growth [5].

6 Implications and Testability

6.1 Physical Implications

Resolves information paradoxes via holography [7] and predicts decoherence signatures in DM experiments [6]. Entropy bounds align with expanding horizons.

6.2 Philosophical Implications

Supports eternalism with emergent time; challenges determinism by local "NOW" choices.

6.3 Technological Implications

Informs quantum error correction and DM detection via decoherence probes.

6.4 Testability

Probe via interferometry for DM decoherence rates [6] or CMB entropy patterns for DE info fields [8].

7 Conclusion

The NOW Hypothesis offers a unified view of information dynamics, bridging quantum and cosmic scales. Future work could simulate full models or test via observations.

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