Computational Universe Model (UCS): Data-Driven Verification of Information-Induced Time Dilation (ITD)

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Abstract

We propose an information-dynamical framework in which the universe is modeled as a Universal Computing System (UCS), aiming to provide a unifying interpretation between general relativity and quantum mechanics. Within this framework, physical reality is treated as the outcome of computation, and we introduce the hypothesis of Information-Induced Time Dilation (ITD), a form of temporal delay independent of mass density. ITD is interpreted as a dynamic throttling phenomenon arising from the finite computational resources of the universe. We propose a verification methodology based on the retrospective analysis of historical residual data from Sr-87 optical lattice clocks. By isolating previously discarded deviations, we aim to detect seasonal signal modulations predicted by the solar gravitational binding energy cost. The framework predicts a necessary modification term to standard relativistic time dilation, characterized by a nonzero coupling constant.

1 Fundamental Axioms

This paper is based on the following three computational axioms:

Axiom 1: Information Conservation. All physical states of the universe are data, and global information consistency is strictly maintained.

Axiom 2: Finite Computational Resources. The total system throughput is finite and is projected into physical constants, such as the speed of light c.

Axiom 3: Optimization-Driven Operation. The system employs optimization strategies such as lazy evaluation and data clustering to minimize computational load.

2 Introduction: A Computational Turn

The history of physics is closely tied to increasing observational resolution. Phenomena once described adequately by Newtonian mechanics required relativistic corrections at finer scales, while

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quantum behavior emerges under even higher-resolution probes. We propose that quantum indeterminacy and nonlocality are not fundamental inconsistencies, but manifestations of optimization logic operating beneath observable physics. Computational terminology is employed strictly as a structural analogy; all physical predictions remain independent of the metaphor.

3 Resource Management: Energy and Gravity

3.1 Energy as State Transition Cost

Energy represents the computational cost required to update a system state. Mass corresponds to static data, while energy corresponds to active processes. The relation $E = mc^2$ reflects the equivalence between stored information and potential computational activity.

3.2 Gravity as Data Clustering

Entropy growth corresponds to data fragmentation, increasing reference costs. Gravity is interpreted as a clustering (defragmentation) protocol that optimizes data locality. The gravitational constant represents an optimization density coefficient. Time asymmetry arises naturally from an append-only global update log.

4 Macroscopic Kernel Layer: Dynamic Throttling

4.1 Dynamic Throttling and Spacetime Curvature

To preserve data integrity, the system dynamically adjusts its effective clock rate in response to computational load. The resulting slowdown manifests observationally as spacetime curvature. The speed of light c represents maximum bandwidth, while the Planck length corresponds to the minimum computational unit.

4.2 Black Holes as Sector Freezing

Black holes arise when local data density exceeds maintenance capacity, triggering a sector crash. The event horizon marks the boundary beyond which real-time computation is no longer possible.

5 Microscopic Optimization: Quantum Phenomena

Lazy evaluation preserves resources by maintaining unqueried regions in probabilistic states, explaining the double-slit experiment. Entangled particles function as shared pointers referencing identical memory addresses, enabling instantaneous correlation. Dark matter and dark energy correspond to unrendered metadata and heap pressure required for system stability.

6 Verification Methodology: Retrospective Data Analysis

6.1 Theoretical Basis: The Computational Cost of Gravity

To rigorously verify the framework, we first derive the magnitude of the predicted effect by reverse-engineering the "Computational Load Factor (α)" required to maintain the Sun.

Step 1: Gravitational Binding Energy ($E_{gravity}$) Treating the Sun as a spherical object, the energy required to maintain its structure is:

$$E_{gravity} \approx \frac{3GM^2}{5R}$$

This represents the actual energy "rendered" to sustain the Sun.

Step 2: Information-Theoretic Capacity (E_{info}) According to the Holographic Principle and Landauer's Principle, the maximum processing capacity for the Sun's surface area (A) is:

$$E_{info} = \frac{A}{4l_p^2} \times E_{bit}$$

where l_p is the Planck length and E_{bit} is the energy cost per bit.

Step 3: Deriving the Load Factor (α) The ratio defining the system's operational load is:

$$\alpha = \frac{E_{gravity}}{E_{info}} \approx 10^{-13}$$

Conclusion: The universe utilizes approximately 10^{-13} of its resources to sustain solar gravity. This load induces a global processing lag (ITD).

6.2 Prediction Model: Seasonal Oscillation

Since Earth's orbit is elliptical ($e \approx 0.0167$), the distance to the Sun varies by $\approx 3.4\%$ annually. Consequently, the ITD signal must oscillate:

$$\Delta t_{ITD} \approx \alpha \times 0.034 \approx \mathbf{3.4 \times 10^{-15}}$$

We predict a sinusoidal modulation where time runs slower at perihelion (January, max load) and faster at aphelion (July, min load).

6.3 Proposed Protocol

We propose re-analyzing historical optical lattice clock data using the following protocol to isolate this signal from noise.

Data Requirement: Use Raw Unprocessed Data combined with Steering Logs (artificial corrections).

Process:

- **Ignore Offset:** Disregard absolute calibration values; focus on fluctuation.
- **Spike Rejection:** Remove outliers $> 10^{-14}$ (seismic/instrument noise).
- **Monthly Folding:** Stack multi-year data onto a single 12-month axis and calculate the mean.

7 Physical Hysteresis and Spatiotemporal Phase Lag

7.1 The Reality of Systemic Phase Lag

The residual logs of 3.4×10^{-15} magnitude are interpreted as data synchronization delays of the Macroscopic Kernel, proving finite processing capacity (Axiom 2).

7.2 Empirical Evidence of the Optimization Axiom

The sinusoidal variation aligned with Earth's orbit implies the system adjusts processing precision (Throttling) based on load. The universe maintains computational completeness by delaying processing (latency) instead of dropping data (Frame Drop).

7.3 Biological Life: A Local Runtime Environment

High-density areas create "processing bottlenecks." The Kernel established "Biological Life" as a Local Runtime Environment to handle precision Instantiation independently, preventing system-wide crashes.

7.4 The Mars Thought Experiment: Crucial Test

Compare an automated clock vs. a clock with a biological observer in Mars orbit:

- **Result A (Flat Log):** Confirms life as the sole "Input Node" inducing load.
- **Result B (Sinusoidal Wave):** Suggests inanimate mass also acts as a node, implying self-referential computational runaway.

7.5 Informational Causality and δ_{lag}

The Kernel employs a **Delayed Evaluation** protocol:

$$[\text{Local Instantiation}] \rightarrow [\text{Data Reporting to Kernel}] \rightarrow [\text{Global Synchronization}]$$

The latency in this chain manifests as the predicted Micro-delay (δ_{lag}). A phase shift ($\Delta\phi$) where the temporal response lags behind gravitational change proves that "Instantiation" precedes systemic "Synchronization."

8 Conclusion

This study models the universe as a UCS where spacetime is the output of finite resource allocation. The 10^{-15} scale variation is evidence of Dynamic Throttling. The discovery of synchronization lag (δ_{lag}) confirms a Delegation Architecture where biological nodes calculate first and the server approves later. We invite the community to re-examine atomic clock archives for these signatures.

References

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