Entropic Emergence of Causality and Anthropic Necessity in the Relative State Formulation: A Five-Dimensional Block Model

José Andrés Castillo Crespo
Guatemala City, Guatemala
January 2020

Abstract

Conventional statistical physics and quantum mechanics typically evaluate the probability of macroscopic configurations from an external, third-person perspective, dismissing the extreme improbability of the chain of events leading to a specific observer as a retrospective probability fallacy. This paper demonstrates that such an approach constitutes a methodological and physical fallacy by omitting a primary empirical parameter: the existence and first-person conscious experience of the observer (the reader) against an overwhelming set of inert timelines ("dead timelines"). By calculating the cumulative probability of the discrete set of configuration events from the Last Universal Common Ancestor (LUCA, approximately 4,000 million years ago) down to the exact line of events terminating in the reader, we obtain probabilities on the order of $P \approx 10^{-575,000,000}$ (51,458.46 σ) over the last 205 million years, and $P \approx 10^{-23,740,000,000}$ (330,645.93 σ) since LUCA. Postulating a single universe governed by stochastic wave-function collapse requires accepting an irrational statistical anomaly. As a solution of maximum axiomatic parsimony, a physical and informational model is developed based exclusively on spacetime relativity, Dirac's relativistic quantum mechanics, and Everett's relative state formulation. A block universe of at least five dimensions is proposed in which, alongside ordinary spatial coordinates (X, Y, Z), two additional spatial axes emerge: *ana-kata* (the entropic vector driven by quantum entanglement, subjectively perceived as time) and *superana-superkata* (the axis along which quantum branching occurs). Finally, it is shown that the stability of classical laws and the absence of macroscopic quantum anomalies are the direct result of pure combinatorial branch entropy (where inconceivably more microstates exist within normal macrostates than within abnormal ones) combined with the anthropic and Copernican principles.

1. Introduction: The Observer as an Empirical Parameter and the Critique of Retrospective Probability

In standard probabilistic analyses applied to cosmology and evolutionary history, it is common practice to dismiss the improbability of a specific observer by invoking the retrospective probability fallacy. According to this conventional view, although the prior probability of obtaining an exact sequence of physical and biological states is vanishingly small, the fact that the event has already occurred supposedly invalidates any extraordinary inference, much like the arbitrary order of a deck of cards after being shuffled.

This work argues that such an analogy is logically and physically invalid for two fundamental reasons:

1. **Temporal invariance under the B-Theory of time:** Within a relativistic block universe, past, present, and future share the exact same ontological status. The intrinsic improbability of a configuration within the wave-function distribution does not vanish simply because it is evaluated at a later temporal coordinate. If we conceptually transport the calculation back to the initial conditions at the Big Bang (t_0) and compute the prior probability of the exact sequence of events culminating in the reader, the improbability remains identical. Appeals to retrospectivity represent a logical evasion that ignores the timeless nature of physical laws.
2. **The bias of "dead timelines" and first-person data:** A shuffled deck of cards lacks subjectivity; unactualized card combinations do not experience their non-existence, nor does the resulting hand question why it exists. Conversely, across all hypothetical timelines, the reader possesses an irreducible empirical datum: first-person conscious experience of reality right now. If a single configuration event along the historical chain had differed, the current observer would not exist and would instead reside in a "dead timeline" (total absence of conscious experience).

Consequently, the very existence of the observer (as well as the existence of contingent complex systems interacting with the observer, such as artificial intelligence architectures whose exact parameters depend both on thermal and quantum fluctuations during training and on the prior existence of an entire network of human developers) serves as a primary experimental parameter from which fundamental properties of physical reality must be inferred.

2. Quantifying the Configuration Chain from LUCA to the Reader and Its Sigma (σ) Scale

Let us examine the unbroken chain of discrete configuration events stretching from the Last Universal Common Ancestor (**LUCA**, roughly 4,000 million years ago) to the exact sequence of events terminating in the reader. At each generational transition node, the resulting biological state is selected from a space of viable micro-configurations Ω_i, where any single deviation alters the trajectory and prevents the emergence of the current reader.

Conservatively modeling the state space per generational transition between 10^6 and 10^8 equiprobable micro-configurations:

1. **Last 100,000 years (recent hominid lineage):** Assuming an average cycle of 25 years per transition (4,000 sequential events) and a configuration space of 10^8 states per node ($P_1 = 10^{-8}$):

$$P_{100\text{k}} = (10^{-8})^{4,000} = 10^{-32,000} = 10^{-31,998}\%$$

2. **Last 205 million years (from early mammalian transitions to the reader):** Integrating generational transition rates across eras: 140 million years with average cycles of 2 years and a configuration factor of 10^7 (7×10^7 events); 50 million years with 5-year cycles and a

factor of 5×10^7 (10^7 events); and 15 million years with average 15-year cycles and a factor of 10^8 (10^6 events). This yields 8.1×10^7 sequential transitions:

$$P_{205\text{Ma}} = 10^{-490,000,000} \times 10^{-77,000,000} \times 10^{-8,000,000} = 10^{-575,000,000} = 10^{-574,999,998}\%$$

(Under a constant-parameter model of 10^8 configurations per node and 2-year cycles over 200 million years, the probability reaches $P = 10^{-800,000,000}$).

3. **Complete chain of events since LUCA (4,000 million years to the reader):** Incorporating the prokaryotic and basal eukaryotic phase over 3,400 million years (with at least 1 effective state-fixation event per year and a selection factor of 10^6, contributing $10^{-2.04\times10^{10}}$) along with the basal metazoan to early vertebrate phase over 395 million years (1-year cycles and a factor of 10^7, contributing $10^{-2.765\times10^{9}}$), the cumulative probability from LUCA to the reader is:

$$P_{\text{LUCA}} \approx 10^{-20,400,000,000} \times 10^{-2,765,000,000} \times 10^{-575,000,000} = 10^{-23,740,000,000}$$

To translate any extreme probability $P = 10^{-N}$ into standard deviations (Z, in units of σ) on the tail of a standard normal distribution, we apply the asymptotic inverse Gaussian tail approximation:

$$P \approx \frac{1}{\sqrt{2\pi}\,Z} e^{-Z^2/2} \Rightarrow Z \approx \sqrt{-2\ln(P)} = \sqrt{2\ln(10)\cdot N} \approx 2.14597\sqrt{N}$$

Past Time Horizon to the Reader	**Transition Events (n)**	**Cumulative Probability (P)**	**Zeros After the Decimal Point (in %)**	**Sigma Equivalent (σ)**
Recent lineage (100,000 years)	4.0×10^3	$10^{-32,000}$	31,997	383.88 σ
Last 205 million years (adjusted)	8.1×10^7	$10^{-575,000,000}$	574,999,997	51,458.46 σ
Last 200 million years (constant)	1.0×10^8	$10^{-800,000,000}$	799,999,997	60,697.09 σ
Convergent ancestral network (100 ka)	1.0×10^9	$10^{-8,000,000,000}$	7,999,999,997	191,941.04 σ
From LUCA to the reader (4,000 Ma)	$\mathbf{3.88 \times 10^9}$	$\mathbf{10^{-23,740,000,000}}$	**23,739,999,997**	**330,645.93 σ**

Whereas in experimental physics a 5 σ deviation suffices to refute random chance, assuming that a deviation exceeding 51,458 σ or 330,645 σ occurred by sheer luck in a single stochastic timeline violates scientific parsimony. Conversely, under Everett's Relative State Formulation (1957), unitary wave-function evolution updates the realization probability of all physically possible branches to $P = 1$. Because all branches exist, the observer's existence ceases to be an absurd cosmic lottery and becomes a necessary consequence of the anthropic principle.

3. Five-Dimensional Block Universe Geometry and Information

The universe must be understood simultaneously as a physical system and as pure information encoded within a universal wave function $|\Psi\rangle$. Integrating spacetime relativity with Everett's relative state formulation requires expanding the block universe into at least **five dimensions**:

1. **Three ordinary spatial dimensions** (X, Y, Z)**:** Define standard geometric location within any static three-dimensional slice.
2. **Fourth dimension (*Ana-Kata*, the Entropic Vector):** Time is not an independent external flow, but an additional spatial axis (*ana-kata*) oriented by the entropy vector. Progressive **quantum entanglement** among particles and subsystems generates a directional entropic gradient that conscious observers subjectively perceive as the passage of time (B-Theory). Causality is therefore an emergent property of information ordered along this entropic vector.
3. **Fifth dimension (*Superana-Superkata*, the Branching Axis):** Quantum entanglement directly drives decoherence among relative states, preventing distinct macroscopic possibilities from interfering with one another. This orthogonal separation of branches (B-time branching) unfolds spatially along the *superana-superkata* axis.

4. Branch Entropy, Dirac's Light Cone, and the Suppression of Macroscopic Quantum Anomalies

If every branch with non-zero probability exists with certainty ($P = 1$) along the *superana-superkata* axis, a central question arises: why do observers perceive an orderly classical universe rather than witnessing macroscopic quantum anomalies? The answer lies in **pure entropy applied to the space of branches**.

4.1 Relativistic quantum tunneling to Mars in 22.2 minutes

According to Dirac's relativistic quantum mechanics (1928), a wave function does not propagate instantaneously across space, but is bounded by the speed of light (c). For an observer on Earth and the planet Mars at an approximate distance of 4×10^8 km, the observer's wave-function front takes approximately **22.2 minutes** to reach Mars.

After those 22.2 minutes, the quantum probability that all $\sim 7 \times 10^{27}$ atoms comprising the observer's body undergo collective quantum tunneling and materialize on Mars is strictly greater than zero. Consequently, along the *superana-superkata* axis, that branch physically exists. Nevertheless, no conscious observer ever experiences such an event due to three entropic and anthropic filtering mechanisms:

1. **Multiplication of improbabilities via entanglement:** Quantum entanglement pairs the variables of the body's $\sim 10^{28}$ particles with trillions of environmental degrees of freedom. For coherent macroscopic tunneling to occur, an immense number of individual improbabilities must align simultaneously. Because rare lines multiplied by rare lines become exponentially rarer as a whole, the joint probability drops to scales on the order of $10^{-10^{38}}$.

2. **Microstate density in normal versus abnormal macrostates:** Across the state space along *superana-superkata*, there are inconceivably more quantum microstates compatible with a normal macrostate (remaining on Earth under ordinary thermodynamics, Ω_{normal}) than microstates compatible with an abnormal macrostate (tunneling to Mars, Ω_{abnormal}). For every single branch where macroscopic tunneling to Mars occurs, there are *googolplexes of googolplexes* of branches where it does not. Classical regularity is pure statistical branch entropy.
3. **Anthropic and Copernican survival filter:** Even within the infinitesimal subset of branches where the observer tunnels to Mars after 22.2 minutes, the lethal atmospheric environment causes immediate death. By the anthropic principle, an observer can never experience a branch in which consciousness ceases; and by the Copernican principle, conscious experience is overwhelmingly located within the vast volume of statistically normal realities.

5. Conclusions

1. Evaluating the reader's existence while ignoring the fact that the reader is a first-person conscious observer leads to the fallacy of retrospective probability. Accounting for dead timelines shows that a cumulative deviation of 330,645.93 σ since LUCA renders a single random universe untenable compared to the parsimony of Everett's relative state formulation.
2. The universe operates as a physical and informational block of at least five dimensions (X, Y, Z,ana-kata,superana-superkata), where quantum entanglement generates both the entropic vector perceived as time (*ana-kata*) and orthogonal state branching (*superana-superkata*).
3. The absence of large-scale quantum anomalies in everyday experience is governed by pure entropy: entanglement pairs variables and multiplies individual improbabilities, resulting in exponentially more microstates within normal macrostates than within abnormal ones.

Foundational References

- Dirac, P. A. M. (1928). Relativistic quantum mechanics of the electron (*Proceedings of the Royal Society A*, 117, 610-624).
- Einstein, A. (1905). Special relativity and spacetime invariance (*Annalen der Physik*, 322, 891-921).
- Everett, H. (1957). Relative state formulation of quantum mechanics (*Reviews of Modern Physics*, 29, 454-462).
- Minkowski, H. (1908). Four-dimensional spacetime continuum geometry (*Göttinger Nachrichten*, 53-111).