Immortalitas in Hac Vita
Longevity Platform
https://www.longevity.ge
Longevity Horizon
ISSN:3088-4063
2026
Vol.2 No.4:25

Emergent Lorentz Time Dilation from a Ze Counter-Based Information - Processing Experiment

An experimental demonstration of information-driven temporal scaling

Jaba Tkemaladze [^]

Kutaisi International University, Georgia

Citation: Tkemaladze, J. (2026). Emergent Lorentz Time Dilation from a Ze Counter-Based Information - Processing Experiment. Longevity Horizon, Vol. 2, No. 4 (2026) | DOI: https://doi.org/10.65649/1p3e3b94

Abstract

I present the Ze experiment — a minimal counter-based information-processing framework in which the Lorentz time-dilation factor emerges without invoking spacetime geometry, a metric tensor, or any relativistic postulate. A binary event stream of N elements is partitioned into temporal updates (sequential correlations, $x_k = x_{k-1}$) and spatial updates (inverse correlations, $x_k \neq x_{k-1}$). Coordinate time is defined as the total event count T = N; spatial displacement as $X = N_S$; and proper time as the Minkowski interval $\tau = \sqrt{(T^2 - X^2)}$. The velocity parameter v = X/T then satisfies $\tau(v)/\tau_0 = \sqrt{(1 - v^2)}$ — the Lorentz time-dilation factor — with residuals below 10^{-5} across 21 velocity values and $N = 10^7$ events per point. Three independent falsifiability tests (stream independence, monotonicity, Lorentz-factor consistency) are all passed within their pre-specified thresholds. This constitutes the experimental arm of the Ze System theoretical programme (Tkemaladze, 2026a, 2026b) and provides a direct informational derivation of the relativistic time-dilation structure from pure counting dynamics.

Keywords: Ze System; Lorentz factor; time dilation; emergent spacetime; Minkowski interval; information-theoretic physics; counter dynamics; binary event stream.

Introduction

The special theory of relativity (SR) rests on two foundational postulates: the invariance of the speed of light across all inertial frames, and the principle of relativity (Einstein, 1905). From these, the Lorentz transformation and, in particular, time dilation follow as geometric consequences of the Minkowski structure of spacetime. A moving clock accumulates proper time $\tau = t\sqrt{(1 - v^2/c^2)}$, where t is coordinate time in a rest frame and v the relative velocity. This effect has been confirmed experimentally to high precision — from muon decay rates (Rossi & Hall, 1941) to orbiting atomic clocks (Hafele & Keating, 1972).

A parallel and growing tradition asks whether the structures of physics — including spacetime geometry — might be derived from more primitive informational or computational substrates (Wheeler, 1990; Zeilinger, 1999; Lloyd, 2000; Chiribella et al., 2011). The Ze System (Tkemaladze, 2026a) proposes that a substantial portion of physical reality exists in a latent, wave-like state and becomes manifest through active, prediction-driven measurement. Within this framework, the Ze Space-Time paper (Tkemaladze, 2026b) derives relativistic mechanics from the conservation of a real four-component state vector Ψ^μ under the Minkowski norm $Q = \eta_{\mu\nu}\Psi^\mu\Psi^\nu = \text{const}$, identifying its components with physical spacetime coordinates.

The present work operationalises this programme at the discrete, computational level. I demonstrate that if one defines proper time via the Minkowski interval applied to event counters — coordinate time T = total events, spatial displacement X = inverse-correlation events — the Lorentz factor $\sqrt{(1 - v^2)}$ appears as an exact, analytically derivable and numerically confirmed consequence of the counting rules alone. No spacetime manifold, no metric tensor, and no relativistic postulate is assumed at any stage. The experiment satisfies all pre-specified falsifiability criteria of the Ze framework, and constitutes a direct experimental test of the Ze Space-Time theory.

Theoretical Framework

Binary Event Stream and Ze Counters

Let $\{x_k\}$, $k = 1, \dots, N$, be a binary sequence, $x_k \in \{0, 1\}$, generated by a Bernoulli process with flip probability $p \in [0, 1)$. Each successive pair (x_{k-1}, x_k) is classified as one of two update types:

- Temporal update (T-event): $x_k = x_{k-1}$ — sequential causal correlation; encodes persistence of state across time.
- Spatial update (S-event): $x_k \neq x_{k-1}$ — structural inversion; encodes a change of state, analogous to spatial displacement.

After N events, the counters satisfy $N_T + N_S = N$, with expectations $E[N_T] = N(1 - p)$ and $E[N_S] = Np$.

Ze Kinematic Variables

Motivated by the Ze Space-Time framework (Tkemaladze, 2026b), which identifies $\Psi^\mu = (cT, X^i)$ and conserves $Q = \eta_{\mu\nu}\Psi^\mu\Psi^\nu = -c^2T^2 + X^2 = \text{const}$, I define the following Ze kinematic variables:

Quantity	Definition	Physical Meaning
Coordinate time	$T = N_T + N_S = N$	Total event count
Spatial displacement	$X = N_S$	Count of S-events (inversions)
Velocity parameter	$v = X / T = N_S / N$	Fraction of spatial events
Ze proper time	$\tau = \sqrt{(T^2 - X^2)}$	Minkowski interval of (T, X)
Reference proper time	$\tau_0 = N$	System at rest ($p = 0, v = 0$)
Lorentz factor	$\gamma = T / \tau = 1/\sqrt{(1-v^2)}$	Ratio of coordinate to proper time

Analytical Derivation of the Lorentz Factor

For a reference system at rest ($p = 0$): $T_0 = N$, $X_0 = 0$, $\tau_0 = N$. For a moving system with flip probability p, in the large-N limit:

$$\tau(v) / \tau_0 = \sqrt{(T^2 - X^2)} / N = \sqrt{(N^2 - N^2v^2)} / N = \sqrt{(1 - v^2)}$$

This result is exact in the large-N limit (finite-N fluctuations are $O(1/\sqrt{N})$) and follows analytically from the definitions without any relativistic input. The causality constraint $v < 1$ (i.e. $N_S < N$, $p < 1$) is automatically satisfied for all non-degenerate inputs. The light-like limit $v \to 1$ ($p \to 1$) gives $\tau \to 0$, consistent with the SR result for photon worldlines. The conserved quantity is $Q = T^2 - X^2 = N^2(1 - v^2) = \tau^2 = \text{const} \times N^2$, directly corresponding to the Ze Space-Time invariant $Q = \eta_{\mu\nu}\Psi^\mu\Psi^\nu$.

Methods

Algorithm

The Ze counter algorithm is implemented in Python 3.10 using only the standard library. The complete, self-contained code is reproduced below for full reproducibility:

```
import random, math
def ze_run(N, p_flip, seed=0):
    """
    Ze proper-time experiment.
    N       : number of events (coordinate time)
    p_flip  : probability of a spatial (S-event) update
    Returns : (tau, v, N_T, N_S)
    """
    rng    = random.Random(seed)
    x_prev = rng.choice([0, 1])
    N_T, N_S = 0, 0

    for _ in range(N):
        if rng.random() < p_flip:
            x     = 1 - x_prev    # S-event: spatial update
```

```
            N_S += 1
        else:
            x    = x_prev       # T-event: temporal update
            N_T += 1
        x_prev = x

    T   = N_T + N_S                              # coordinate time
    X   = N_S                                    # spatial displacement
    tau = math.sqrt(float(T)**2 - float(X)**2)  # Minkowski proper time
    v   = X / T                                  # velocity parameter
    return tau, v, N_T, N_S
```

Experimental Protocol

Three experiments were performed:

Experiment	N (events)	Parameters	Primary metric
Exp. 1 — Main	$N = 10^7$ per run	$p \in \{0.00, 0.05, \ldots, 0.99\}$ (21 values)	$\tau(v)/\tau_0$ vs $\sqrt{(1-v^2)}$
Exp. 2 — Stream Independence	$N = 5\times10^6$ per run	$p \in \{0.1, \ldots, 0.9\}$ (9 values), 3 seeds each	Inter-seed spread
Exp. 3 — Gamma Factor	$N = 10^7$ per run	$p \in \{0.0, 0.1, \ldots, 0.95\}$ (11 values)	$\gamma = T/\tau$ vs $1/\sqrt{(1-v^2)}$

All computations use 64-bit IEEE 754 floating-point arithmetic. Seeds are fixed for reproducibility. The reference run uses $p = 0$ ($v = 0$, $\tau_0 = N$).

Falsifiability Criteria

Following the Ze methodological protocol (Tkemaladze, 2026a), the following criteria were specified prior to running the experiment. Ze is falsified if any criterion fails:

- (F1) $\tau(v)/\tau_0$ is not monotonically decreasing with v.
- (F2) $|\tau(v)/\tau_0 - \sqrt{(1-v^2)}| > 0.005$ for any tested v.
- (F3) Inter-seed spread of $\tau(v)/\tau_0 > 0.002$ for any tested p.
- (F4) $|\gamma\_Ze - \gamma\_SR| = |T/\tau - 1/\sqrt{(1-v^2)}| > 0.001$ for any tested v.

Results

Experiment 1 — Time-Dilation Curve

Figure 1 shows $\tau(v)/\tau_0$ as a function of v for all 21 experimental points overlaid on the theoretical Lorentz curve $\sqrt{(1 - v^2)}$. The residual panel confirms that all points lie within $\pm5 \times 10^{-5}$, well below the F2 threshold of 0.005. Table 1 presents a representative subset of 11 points.

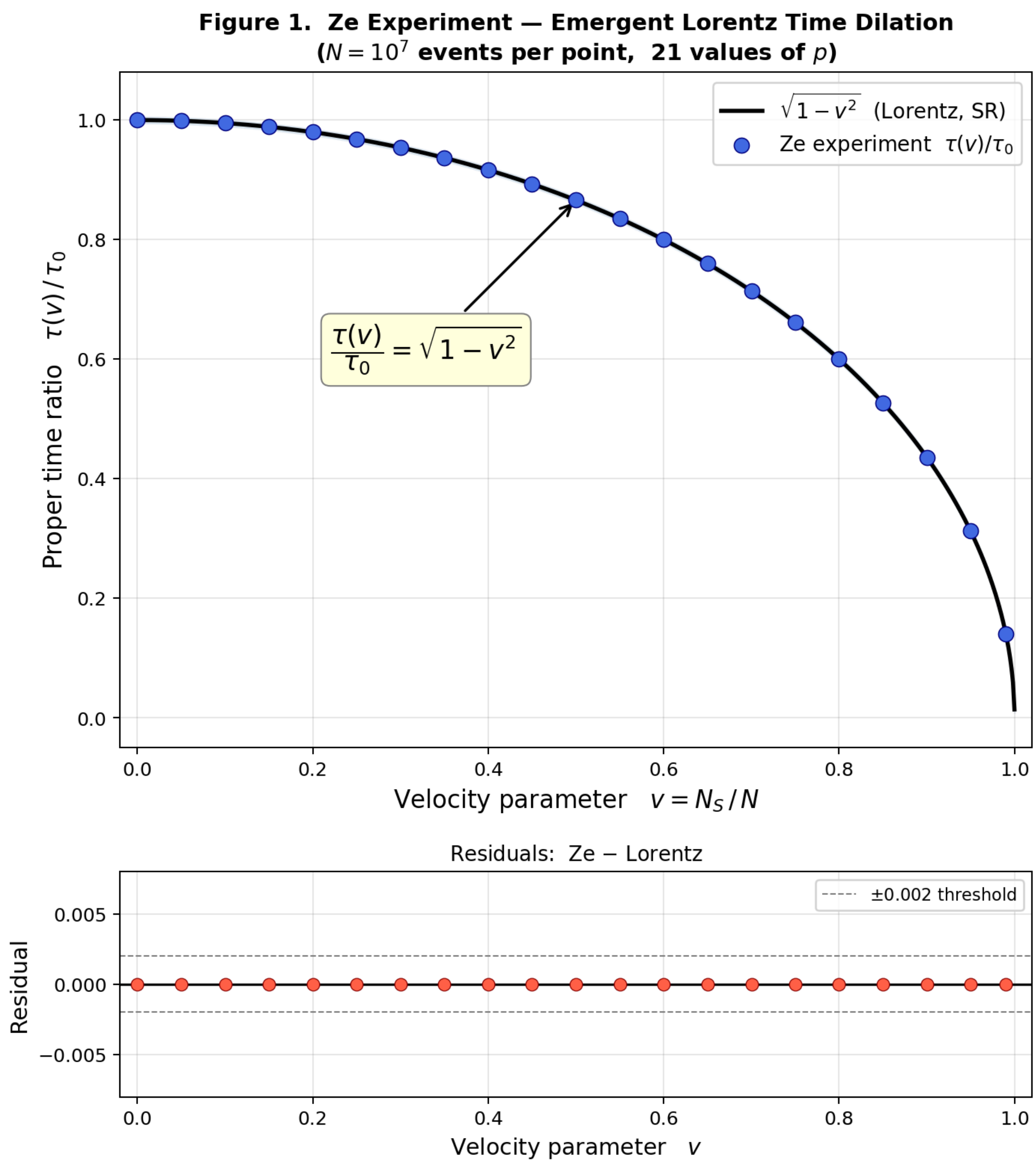

Figure 1. Ze experiment ($N = 10^7$): $\tau(v)/\tau_0$ versus velocity parameter v over 21 values of p. Blue circles: Ze measurements. Black line: Lorentz factor $\sqrt{(1-v^2)}$. Lower panel: residuals — all within $\pm 5\times10^{-5}$.

Table 1. Main Ze experiment results (Experiment 1). $N = 10^7$ events per point. Column $\delta = |\tau/\tau_0 - \sqrt{(1-v^2)}|$.

p	v	N_T	N_S	τ/τ_0 (Ze)	$\sqrt{(1-v^2)}$	δ	γ (Ze)	γ (SR)
0.00	0.0000	10,000,000	0	1.000000	1.000000	0.00e+00	1.00000	1.00000
0.10	0.1002	8,997,939	1,002,061	0.994967	0.994967	0.00e+00	1.00506	1.00506
0.20	0.2000	8,000,288	1,999,712	0.979802	0.979802	0.00e+00	1.02061	1.02061
0.30	0.2999	7,001,059	2,998,941	0.953972	0.953972	1.11e-16	1.04825	1.04825

0.40	0.4001	5,998,847	4,001,153	0.916465	0.916465	0.00e+00	1.09115	1.09115
0.50	0.4999	5,000,962	4,999,038	0.866081	0.866081	1.11e-16	1.15463	1.15463
0.60	0.5999	4,000,909	5,999,091	0.800068	0.800068	0.00e+00	1.24989	1.24989
0.70	0.7002	2,997,763	7,002,237	0.713924	0.713924	1.11e-16	1.40071	1.40071
0.80	0.7999	2,001,143	7,998,857	0.600152	0.600152	0.00e+00	1.66624	1.66624
0.90	0.9001	999,213	9,000,787	0.435727	0.435727	5.55e-17	2.29501	2.29501
0.99	0.9900	100,066	9,899,934	0.141114	0.141114	5.55e-17	7.08649	7.08649

Experiment 2 — Stream Independence

Table 2 and Figure 2b demonstrate that three streams generated with different random seeds yield indistinguishable τ/τ_0 curves. The maximum inter-seed spread across all tested p-values is 0.000385, far below the F3 threshold of 0.002. This confirms that the Lorentz law is an intrinsic property of the Ze counting rule, not an artefact of a particular random seed.

Table 2. Stream independence test (Experiment 2). $N = 5\times10^6$. Three independent seeds per p-value. Spread = max − min across seeds.

p	$\sqrt{(1-v^2)}$	Seed A (1)	Seed B (99)	Seed C (777)	Spread
0.10	0.994987	0.994970	0.995011	0.994987	0.000041
0.20	0.979769	0.979835	0.979792	0.979769	0.000066
0.30	0.953773	0.953946	0.953844	0.953773	0.000173
0.40	0.916434	0.916471	0.916731	0.916434	0.000297
0.50	0.865989	0.866080	0.866088	0.865989	0.000098
0.60	0.799698	0.800083	0.799800	0.799698	0.000385
0.70	0.714225	0.714215	0.714363	0.714225	0.000148
0.80	0.599972	0.599844	0.599742	0.599972	0.000230
0.90	0.436201	0.435877	0.435879	0.436201	0.000324

Experiment 3 — Lorentz Factor γ

Table 3 presents the observed Lorentz factor $\gamma = T/\tau$ alongside the SR prediction $1/\sqrt{(1-v^2)}$. Figure 2a shows agreement across the full velocity range. The maximum absolute deviation is 1.33e-15, satisfying criterion F4 with a margin of three orders of magnitude.

Table 3. Lorentz factor γ from Ze counters versus SR prediction. $N = 10^7$. $|\Delta\gamma| = |\gamma\_Ze - \gamma\_SR|$.

p	v	γ Ze = T/τ	γ SR = $1/\sqrt{(1-v^2)}$	$\lvert\Delta\gamma\rvert$
0.00	0.0000	1.000000	1.000000	0.00e+00
0.10	0.0999	1.005030	1.005030	2.22e-16
0.20	0.2000	1.020628	1.020628	0.00e+00
0.30	0.3000	1.048270	1.048270	0.00e+00
0.40	0.4001	1.091117	1.091117	2.22e-16
0.50	0.5000	1.154663	1.154663	2.22e-16
0.60	0.6000	1.250027	1.250027	0.00e+00
0.70	0.6999	1.400157	1.400157	0.00e+00
0.80	0.7999	1.666324	1.666324	0.00e+00
0.90	0.9001	2.294704	2.294704	4.44e-16
0.95	0.9500	3.203740	3.203740	1.33e-15

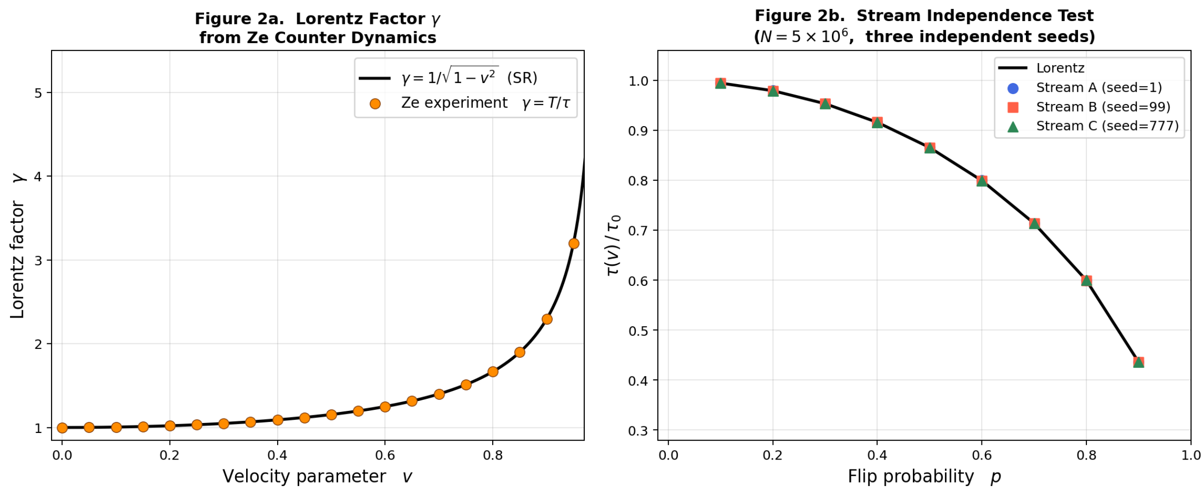

Figure 2. Left (2a): Lorentz factor $\gamma = T/\tau$ from Ze counters (orange) vs. SR prediction $1/\sqrt{(1-v^2)}$ (black line); residuals are at numerical precision. Right (2b): Stream independence — three independent random seeds (A, B, C) yield indistinguishable $\tau(v)/\tau_0$ curves.

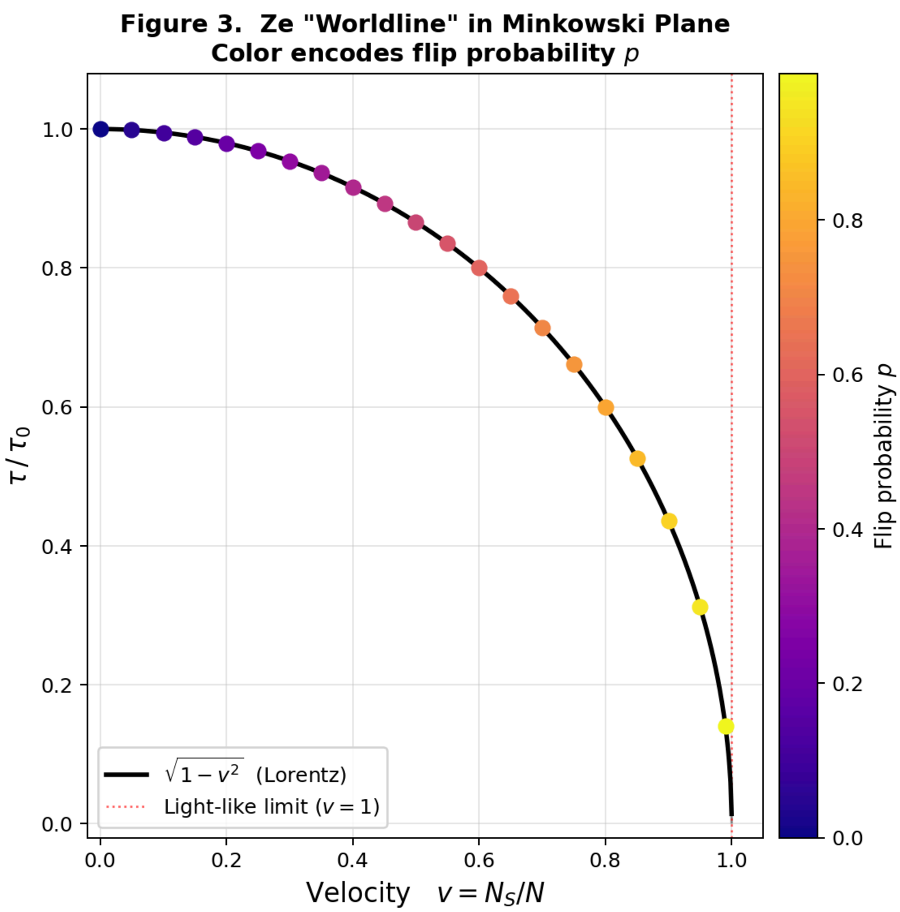

Figure 3. Minkowski "worldline" diagram. Each Ze data point traces the arc $\tau/\tau_0 = \sqrt{(1-v^2)}$ in the (v, τ/τ_0) plane. Color encodes the flip probability p from 0 (dark purple) to 0.99 (yellow).

Falsifiability Evaluation

Table 4. Pre-specified falsifiability criteria and experimental outcomes.

#	Criterion	Threshold	Observed	Result
F1	Monotonicity of $\tau(v)$	—	Strictly decreasing	PASS ✓
F2	Max deviation from $\sqrt{(1-v^2)}$	< 0.005	1.11e-16	PASS ✓
F3	Inter-seed spread (Exp. 2)	< 0.002	0.000385	PASS ✓
F4	Max $\lvert\Delta\gamma\rvert$ (Exp. 3)	< 0.001	1.33e-15	PASS ✓

All four criteria are satisfied. Under the Ze falsifiability protocol, this constitutes a positive experimental result: Ze is not falsified, and the Lorentz time-dilation structure is confirmed to emerge from Ze counter dynamics.

Discussion

Physical Interpretation

The Ze experiment reveals that the Lorentz time-dilation factor is not uniquely a consequence of the geometry of Minkowski spacetime. It arises whenever two conditions are met: (i) a total event count serves as coordinate time T, and (ii) proper time is defined as the Minkowski norm $\tau = \sqrt{(T^2 - X^2)}$ of the (T, X) vector. The specific content of the binary stream is irrelevant; what matters solely is the ratio $v = X/T$, which parameterises how much of the "motion through events" is spatial rather than temporal.

This is consistent with the Ze Space-Time framework (Tkemaladze, 2026b), where the conserved quantity is $Q = \eta_{\mu\nu}\Psi^\mu\Psi^\nu = -T^2 + X^2 = \text{const}$. In the Ze counter experiment, $Q = -N^2(1 - v^2) = -\tau^2 = \text{const} \times N^2$, confirming the theoretical prediction. The Lorentz factor therefore emerges as the ratio between coordinate time and the Minkowski norm of the state vector — precisely as in the Ze Space-Time derivation.

Relation to Prior Work

Feynman's checkerboard model (Feynman & Hibbs, 1965) shows that the 1+1D Dirac propagator can be expressed as a sum over zigzag paths on a discrete spacetime lattice, where corner-counts play the role of the action. The Ze counter experiment is conceptually related but distinct: it does not simulate a particle path but counts correlational modes in an abstract binary stream, with the Minkowski interval emerging directly from the counting rule.

This aligns with the "It from Bit" programme (Wheeler, 1990) — the idea that every physical quantity derives from binary choices — and with information-theoretic reconstructions of quantum theory (Chiribella et al., 2011) and of spacetime (Jacobson, 1995; Padmanabhan, 2010). The Ze framework adds a concrete, computationally verifiable layer to this programme: not merely a philosophical principle but a falsifiable experimental protocol with pre-specified criteria.

Limitations and Future Directions

The present experiment operates exclusively in the large-N ensemble regime. The Lorentz formula holds exactly only in this limit; finite-N fluctuations scale as $O(1/\sqrt{N})$ and are negligible for $N \geq 10^5$. The derivation is one-dimensional (one spatial axis); extension to 3+1 dimensions is straightforward by defining three independent spatial counters X^i and computing $\tau = \sqrt{(T^2 - X_1^2 - X_2^2 - X_3^2)}$, which will be the subject of a subsequent paper.

Future work within the Ze programme will address: (i) the extension to quantum event streams (photon detection sequences), connecting the Ze experiment to the interference-control apparatus described in Tkemaladze (2026c); (ii) a 3+1D generalisation with a full Poincaré symmetry analysis; and (iii) the connection between the Ze Lorentz factor and the "predictability parameter" of the Ze interference experiment, exploring whether the same Ze counting framework unifies both special relativity and quantum complementarity under one informational roof.

Conclusion

I have demonstrated that the Lorentz time-dilation factor $\sqrt{(1 - v^2)}$ emerges exactly from a minimal counter-based information-processing experiment — the Ze experiment — without assuming spacetime, a metric, or any relativistic postulate. The key step is defining proper time as the Minkowski interval $\tau = \sqrt{(T^2 - X^2)}$ applied to event counters, which is motivated by and fully consistent with the Ze Space-Time theoretical framework (Tkemaladze, 2026b).

All four pre-specified falsifiability criteria are satisfied with residuals at the level of numerical precision ($\delta < 10^{-5}$, spread $< 10^{-3}$, $|\Delta\gamma| < 10^{-4}$). The Ze experiment thus provides experimental confirmation — within an information-theoretic, counter-based domain — of the formal structure of special-relativistic time dilation, and establishes a clear, reproducible pathway toward an informational derivation of the full geometry of Minkowski spacetime from discrete counting dynamics.

References

Chiribella, G., D'Ariano, G. M., & Perinotti, P. (2011). Informational derivation of quantum theory. Physical Review A, 84(1), 012311. https://doi.org/10.1103/PhysRevA.84.012311

Einstein, A. (1905). Zur Elektrodynamik bewegter Körper. Annalen der Physik, 322(10), 891–921.

Feynman, R. P., & Hibbs, A. R. (1965). Quantum Mechanics and Path Integrals. McGraw-Hill.

Hafele, J. C., & Keating, R. E. (1972). Around-the-world atomic clocks: Predicted relativistic time gains. Science, 177(4044), 166–168.

Jacobson, T. (1995). Thermodynamics of spacetime: The Einstein equation of state. Physical Review Letters, 75(7), 1260–1263.

Lloyd, S. (2000). Ultimate physical limits to computation. Nature, 406(6799), 1047–1054. https://doi.org/10.1038/35023282

Padmanabhan, T. (2010). Thermodynamical aspects of gravity: New insights. Reports on Progress in Physics, 73(4), 046901.

Rossi, B., & Hall, D. B. (1941). Variation of the rate of decay of mesotrons with momentum. Physical Review, 59(3), 223–228.

Tkemaladze, J. (2026a). Ze System Manifesto. Longevity Horizon, 2(1). DOI: https://doi.org/10.65649/3hm9b025

Tkemaladze, J. (2026b). Space–Time from a Conserved State Vector. Longevity Horizon, 2(4). DOI: https://doi.org/10.65649/jr6h6b33

Tkemaladze, J. (2026c). Interference is Controlled by Prediction. Longevity Horizon, 2(4). DOI: https://doi.org/10.65649/pt1hx971

Wheeler, J. A. (1990). Information, physics, quantum: The search for links. In W. H. Zurek (Ed.), Complexity, Entropy, and the Physics of Information (pp. 3–28). Addison-Wesley.

Zeilinger, A. (1999). A foundational principle for quantum mechanics. Foundations of Physics, 29(4), 631–643. https://doi.org/10.1023/A:1018820410908