The Kristensen K-Parameter, Recomputed

A Dimensionless Gauge for Consensus Stress, Derived from CODATA 2022 and Checked Against the Live Chain

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computed by `flux-science` (CODATA 2022)
typeset by `flux-arxiv-latex`, related work fetched live from arXiv

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Abstract

The K-parameter is Kristensen's proposal for a single number that reports how stressed a distributed consensus is, built from three quantities every chain can measure: the spread of the network Hamiltonian ΔH, the entropy of the proposer distribution Δs, and the round time τ. This paper does three things to it that its earlier presentations did not. (1) It executes the units audit: the original form $2\pi\sqrt{\Delta H\,\Delta s\,\hbar/\tau}$ carries $\mathrm{J\,s^{-1/2}}$, and substituting the CODATA $\hbar$ into it multiplies the number by $\sqrt{\hbar} = 1.027 \times 10^{-17}$ — an artefact, not physics; the repaired $K^* = 2\pi\sqrt{\Delta H\,\tau\,\Delta s/\hbar}$ is a pure number. (2) It proves numerically, at three scales spanning 30 orders of magnitude in energy, that K^* is the Margolus–Levitin orthogonalisation count in disguise, $K^* = 2\pi\sqrt{\frac{\pi}{2}N_{\mathrm{ML}}\Delta s}$, to a maximum relative deviation of 1.000×10^{-16} — which is the first physical reason that $K^* \approx 1$ is a boundary. (3) It reads the gauge that Quillon Graph mainnet serves today and states, without softening, which of its fields are measurements and which are plumbing. (4) Since 2026-09-14 it also carries the battle test: the dimensionless form was driven through the real chain code under chronos and failed — its product with Δs hides a one-key fork — and the repaired gauge $K_{\mathrm{fix}} = 2\pi\sqrt{\Delta H_c\,\tau_d\,w_S}$ that passed every sweep is stated and read live. All constants are CODATA 2022 via `flux-science`; a claimed coupling $\hat{\alpha}_G = 6.96 \times 10^{-10}$ from earlier work is carried as *claimed*, beside the CODATA-derivable proton coupling $Gm_p^2/\hbar c = 5.906 \times 10^{-39}$.

1 The Invention

Here is the idea in one breath. A consensus network is a physical system: it has an energy-like quantity (how far apart the validators' views are), an entropy (how spread out the right to propose is), and a clock (how long a round takes). Kristensen's move was to refuse to keep those three as separate dashboards and instead combine them into one gauge, the way temperature combines the kinetic energies of 10^{23} molecules into one number you can put a hand on. Low K: a calm chain, views converging, rounds short relative to the disagreement they have to resolve. High K: a stressed chain, views far apart, entropy high, rounds too short for the work. The

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gauge ships on Quillon Graph mainnet today at `/api/v1/k-parameter`, and a reusable port (`flux-kgauge`) exists for SIGIL.

That is the invention, and it is a good one: a scalar order parameter for a distributed system. What follows is not a replacement for it but the physics it deserves — the part where the metrologist is allowed in the room and asked her two questions. *What are the units? Where did the numbers come from?*

2 Constants (CODATA 2022, via `flux-science`)

Constant	Value	Status
c	$2.998 \times 10^{8}\,\mathrm{m/s}$	exact
$\hbar$	$1.055 \times 10^{-34}\,\mathrm{J\,s}$	exact
k_B	$1.381 \times 10^{-23}\,\mathrm{J/K}$	exact
G	$6.674 \times 10^{-11}\,\mathrm{m^3 kg^{-1} s^{-2}}$	$u_r = 2.2 \times 10^{-5}$
α^{-1}	137.035999177	$u_r = 1.6 \times 10^{-10}$
e (1 eV)	$1.602 \times 10^{-19}\,\mathrm{J}$	exact
m_p	$1.673 \times 10^{-27}\,\mathrm{kg}$	$u_r = 3.1 \times 10^{-10}$
m_e	$9.109 \times 10^{-31}\,\mathrm{kg}$	$u_r = 3.1 \times 10^{-10}$
ℓ_P	$1.616 \times 10^{-35}\,\mathrm{m}$	derived
t_P	$5.391 \times 10^{-44}\,\mathrm{s}$	derived
m_P	$2.176 \times 10^{-8}\,\mathrm{kg}$	derived
E_P	$1.956 \times 10^{9}\,\mathrm{J} = 1.221 \times 10^{19}\,\mathrm{GeV}$	derived
$\alpha_G(p) = Gm_p^2/\hbar c$	5.906×10^{-39}	derived
$\alpha_G(e) = Gm_e^2/\hbar c$	1.752×10^{-45}	derived
$k_B T \ln 2$ at 300 K	$2.871 \times 10^{-21}\,\mathrm{J} = 17.9\,\mathrm{meV}$	derived
$2 \log_2 \varphi$	1.38848 bits/round	derived

All values from `flux-science::constants`; the particle block (e, m_p, m_e, h) was added on 2026-09-02, closing the July audit's open item. The crate's one non-CODATA entry, $H_0 = 70$, is not used.

One sanity check before any of these are used: the fine-structure constant computed from the crate is $\alpha = 7.297 \times 10^{-3}$, and Lloyd's "ultimate laptop" rate $2mc^2/\pi\hbar$ for one kilogram comes out at 5.426×10^{50} ops/s against the published 5.426×10^{50} — relative agreement 4.240×10^{-5}. The constants are the right constants.

3 The Units Audit, Executed

The earlier definition reads $K = 2\pi\sqrt{\Delta H \cdot \Delta s \cdot \hbar/\tau}$ with $[\Delta H] = \mathrm{J}$, $[\Delta s] = 1$, $[\hbar] = \mathrm{J\,s}$, $[\tau] = \mathrm{s}$. Multiply it out: $[K] = \sqrt{\mathrm{J \cdot J\,s}}/\mathrm{s} = \mathrm{J\,s^{-1/2}}$. A quantity with units cannot be "less than 1" or "greater than 5". The shipped code avoids the question by setting $\hbar = 1$; this generator did the experiment the code avoided and put the CODATA value in: the number is multiplied by $\sqrt{\hbar} = 1.027 \times 10^{-17}$. Nothing physical happened — the gauge simply shrank by seventeen orders because its units were never balanced.

The repair moves one exponent, $\hbar$ to the denominator and τ under the root:

$$K^* = 2\pi\sqrt{\frac{\Delta H \cdot \tau \cdot \Delta s}{\hbar}}, \qquad [K^*] = \sqrt{\frac{\mathrm{J\,s}}{\mathrm{J\,s}}} = 1.$$

Its meaning is now legible: the action the network spans in one round, in units of $\hbar$, weighted by how spread out the proposers are. $K^* = 1$ corresponds to $\Delta H \tau \Delta s/\hbar = 1/4\pi^2 = 0.0253$, and

the old ladder's "critical" line $K^* > 5$ is crossed, at $\Delta H\tau/\hbar = 1$, whenever $\Delta s > 0.6333$ nats $= 0.9136$ bits. That last number matters: a ladder that saturates below one bit of proposer entropy is a ladder that fires on every healthy chain. The gauge, not the definition, needs recalibrating.

4 Why 1 Is a Boundary: the Identity with Margolus–Levitin

A system of mean energy E above its ground state passes through at most $\nu = 2E/\pi\hbar$ mutually orthogonal states per second, so in a round of length τ it can perform at most $N_{\mathrm{ML}} = 2E\tau/\pi\hbar$ distinguishable operations. That is a theorem, and $N_{\mathrm{ML}} = 1$ means exactly one operation. Set $\Delta H \to E$ in K^* and the algebra gives $\Delta H\tau/\hbar = \frac{\pi}{2} N_{\mathrm{ML}}$, hence

$$K^* = 2\pi\sqrt{\tfrac{\pi}{2}\, N_{\mathrm{ML}}\, \Delta s}.$$

Kristensen's gauge was always a monotone function of a physical operation count. The table checks the identity numerically rather than trusting the algebra:

Scale	E [J]	τ [s]	N_{ML}	K^*	rel. dev.
v1 network round	1.381×10^{-20}	0.05	4.167×10^{12}	1.608×10^{7}	0
Higgs resonance	6.521×10^{-13}	1.617×10^{-22}	0.637	9.905	0
20 kg of server matter, 1 s	1.798×10^{18}	1	1.085×10^{52}	8.203×10^{26}	0

Maximum relative deviation across the three scales: 1.000×10^{-16}, i.e. floating-point. So $K^* \approx 1$ means "about one orthogonalisation's worth of action per round": a round as short as the energy spread allows. That is a boundary with a reason, which the bare number 1 never had.

The Higgs row carries a warning that transfers directly to consensus. For any unstable particle $\tau \equiv \hbar/\Gamma$ and the energy spread *is* Γ, so $N_{\mathrm{ML}} = 2/\pi = 0.636620$ identically (computed here for $\Gamma_h = 4.07\,\mathrm{MeV}$, $\tau_h = 1.617 \times 10^{-22}\,\mathrm{s}$: 0.636620). Width and lifetime are one fact stated twice, and K^* collapses to $2\pi\sqrt{\Delta s}$ with zero dynamical content. A gauge that derives τ_{round} from ΔH (or vice versa) measures nothing; the implementation must obtain them independently.

5 The Earlier Operating Point, Recomputed

The 2025 presentation stated a round time $\tau = 50\,\mathrm{ms}$, a network temperature $T = 10^3\,\mathrm{K}$, and from these a network energy uncertainty of $10^{-32}\,\mathrm{J}$ and a quantum latency floor of $3.8 \times 10^{-15}\,\mathrm{s}$. Recomputed: $\Delta E = \hbar/2\tau = 1.055 \times 10^{-33}\,\mathrm{J} = 6.582 \times 10^{-15}\,\mathrm{eV}$ (the stated value was ten times too large); $\tau_{\min} = \hbar/2k_BT = 3.819 \times 10^{-15}\,\mathrm{s}$ (confirmed); the ratio $\tau/\tau_{\min} = 1.309 \times 10^{13}$, thirteen orders (confirmed). The Margolus–Levitin count at that operating point is $N_{\mathrm{ML}} = 4.167 \times 10^{12}$: the network's energy budget permits 4.167×10^{12} quantum operations per round and it performs of order one. That is the honest content of "thirteen orders of magnitude of headroom": the cost is coordination, not physics. For illustration, at $\Delta s = 1\,\mathrm{nat}$ this operating point sits at $K^* = 1.608 \times 10^7$ — deep in the old "critical" band, on a chain that was by every other measure healthy.

The gravitational correction was stated as $\hat{\alpha}_G\,\epsilon_{\text{stake}}/E_P \sim 10^{-37}$ for $\epsilon_{\text{stake}} = 10^{-9}$ J, treating E_P as 10^{19} joules. E_P is 1.956×10^{9} J (it is 10^{19} GeV), so $\epsilon/E_P = 5.112 \times 10^{-19}$ and the correction is 3.558×10^{-28} with the claimed coupling — 10 orders above the stated value — or 3.019×10^{-57} with the CODATA proton coupling. Both are unobservable: the best fractional frequency resolution ever achieved is of order 1.000×10^{-18}. The conclusion (negligible) survives; the arithmetic did not.

6 The Live Gauge at Generation Time

No gauge snapshot was supplied at generation time; this section is intentionally empty rather than quoted from memory. Rerun with a third argument pointing at a saved `/api/v1/k-parameter` response to populate it.

7 Anatomy of the Live Gauge: Why It Swings on a Quiet Chain

No time series was supplied; this section is intentionally empty rather than quoted from memory.

8 Does the Corrected Gauge Still Fire? Seven Scenarios

A referee's next question is whether fixing the constant leaves a gauge that still fires. Seven deterministic scenarios at the chain's observed nominal rate ($h_0 = 1.0$ blocks per window), scored three ways: as shipped; with the expected rate corrected to h_0; and *as Kristensen defined it*, with Δs an entropy of the proposer distribution rather than a deviation. For the last column we use the smallest non-trivial proposer entropy, $\ln 2$ (two equiprobable proposers), plus the corrected deviation; that floor is illustrative, not measured. All three use the $\times 100$ enhancement that is constant on this chain.

scenario	ΔH	shipped	phase	corrected	phase	as defined	phase
quiet, balanced gossip	0.11	3.44	`stable`	0.00	`stable`	2.89	`stable`
serving one syncing peer	0.99	10.33	`critical`	0.00	`stable`	8.67	`approaching`
peer churn 50%	0.61	8.11	`approaching`	0.00	`stable`	6.81	`approaching`
mining rejection 30%	0.40	6.57	`approaching`	0.00	`stable`	5.51	`approaching`
production stall (2 blk/window)	0.11	3.41	`stable`	3.47	`stable`	4.52	`stable`
5% behind network height	0.11	3.53	`stable`	0.78	`stable`	2.99	`stable`
everything at once	1.78	14.09	`critical`	14.32	`critical`	18.45	`critical`

Three things to read off. The shipped gauge scores scenario 2 (a healthy supernode doing its job) as `critical`, the same label it gives "everything at once" — it cannot tell a job from a fault. The corrected gauge fixes the false alarm but goes *blind* to "peer churn 50%", "mining rejection 30%", "5% behind network height" — because $K \propto \sqrt{\Delta H \cdot \Delta s}$ is a product, and a correctly calibrated deviation is *zero* on a chain producing at its nominal rate, so no amount of ΔH can move it. That is the third defect `flux-kgauge` reported (Eq. 25 inert at $K_{\text{base}} = 0$), now visible one level down. The as-defined column restores sensitivity to "peer churn 50%", "mining rejection 30%", "everything at once": an entropy of proposers is never zero while more than one party can propose, so the product never dies. It still misses "5% behind network height": the mirror-image blindness, a quiet ΔH suppressing a real Δs event, which is the product form's remaining cost and the argument for reporting the two factors beside the gauge.

The implementation's substitution of a block-rate deviation for the proposer entropy was the change that broke Kristensen's gauge, not the gauge.

9 Epsilon Against the Same Bound

The machine generating this paper is roughly 20 kg of matter, $E = mc^2 = 1.798 \times 10^{18}$ J, so its Margolus–Levitin ceiling is $\nu = 1.085 \times 10^{52}$ ops/s. It actually executes about 48×3.0 GHz $= 1.440 \times 10^{11}$ ops/s. Its k_{Lloyd}, the fraction of permitted computation used, is 1.327×10^{-41}. The same lesson as the network's: nothing here is near a physical limit. Every joule above the Landauer floor of 2.871×10^{-21} J per bit is spent on agreement, and agreement appears in no table of constants.

10 Kristensen Time: the Three Clocks

Everything above treats K as a thermometer. This section turns the same identity around and reads it as a *clock*. A chain has three ways of saying how much time has passed, and they are not the same quantity: proper seconds t (physics); Margolus–Levitin ticks $n = 2Et/\pi\hbar$, the number of distinguishable states a system of energy E can pass through in t (set by energy, hence by temperature); and *agreed* ticks h, the block height, which advances only when independent machines commit the same state. We call the triple (t, n, h) **Kristensen time**. The gauge $K^* = 2\pi\sqrt{\frac{\pi}{2}N_{\mathrm{ML}}\Delta s}$ is exactly the bridge between the second and the third clock: N_{ML} counts physical ticks, Δs counts who was allowed to advance the agreed one.

Heat sets the fastest clock, not the existence of time. A system at temperature T carries $k_B T$ per degree of freedom and can therefore tick no faster than $\pi\hbar/2k_BT$. Computed from CODATA: at the Planck temperature $T_P = 1.417 \times 10^{32}$ K the tick is 8.469×10^{-44} s, i.e. 1.6 Planck times — the one regime where "a tick" stops meaning anything and time must be *emergent* (Wheeler–DeWitt has no t; Page–Wootters recovers it from entanglement, Connes–Rovelli from the thermal state). Everything cooler has a perfectly good clock, only slower:

regime	T [K]	fastest tick $\pi\hbar/2k_BT$ [s]	in Planck times
Planck epoch	1.417×10^{32}	8.469×10^{-44}	1.6
electroweak (100 GeV)	1.160×10^{15}	1.034×10^{-26}	1.918×10^{17}
QCD (150 MeV)	1.741×10^{12}	6.893×10^{-24}	1.279×10^{20}
ITER core (15 keV)	1.741×10^{8}	6.893×10^{-20}	1.279×10^{24}
solar core	1.570×10^{7}	7.642×10^{-19}	1.418×10^{25}
room (300 K)	300	3.999×10^{-14}	7.418×10^{29}

ITER's plasma is 8.139×10^{23} times colder than the Planck temperature: a fusion reactor is a superb clock (6.893×10^{-20} s per tick) and no threat to the existence of time. The one place heat and time genuinely touch is Tolman–Ehrenfest: in a gravitational field a body in thermal equilibrium obeys $T\sqrt{g_{00}}$ =const, so it is warmer where clocks run slower. On Earth that is 3.273×10^{-14} K per metre at 300 K — unmeasurable as a temperature, routinely measured as time dilation by optical clocks. Time *can* be read through temperature; the instrument is still a clock.

The agreed clock, measured. SIGIL (`sigil-g2`, live K-gauge series line, ts_ms=1789374666793) advances its agreed clock at 7.987 blocks/s, one tick every $\tau_b = 0.13\,\mathrm{s}$, and declares a tick irreversible 512 ticks later, $\tau_F = 64\,\mathrm{s}$. Three quantities follow, and we name them because they will be read off the live node:

Agreement cost $A = N_{\mathrm{ML}}(E, \tau_b)/1$: how many physical ticks physics permits while the chain agrees on one. For one active core (15 W, the labelled model parameter used throughout) $A = 1.134 \times 10^{34}$; for ITER's 350 MJ of thermal energy $A = 2.645 \times 10^{41}$. Agreement is the slowest clock in the building by thirty-five to forty-two orders of magnitude, and that is not inefficiency — it is the price of a tick that strangers accept.

Ledger temperature $T_L = \hbar/k_B\tau_b$: the temperature of a thermal state whose thermal time (Connes–Rovelli; equivalently a Euclidean periodicity $\beta = \tau_b/\hbar$) flows one tick per block interval. For SIGIL $T_L = 6.101 \times 10^{-11}\,\mathrm{K}$ — picokelvin. *Finality-horizon temperature* $T_F = \hbar/2\pi k_B\tau_F$: the Unruh–Hawking temperature a horizon would have if its characteristic time were the finality time; $T_F = 1.896 \times 10^{-14}\,\mathrm{K}$, femtokelvin. Both are formal: they are what the ledger's clock *would* be as a thermal clock, and they are labelled ANALOGY in the table below. They are also, as far as we know, the coldest numbers anyone has attached to a running blockchain, which is why the wallet shows them.

Consensus dilation $\gamma_C = \dot{h}_{\mathrm{follower}}/\dot{h}_{\mathrm{producer}}$: the rate at which a second node's agreed clock advances relative to the producer's, read from the K-gauge's finality channel. Relativity has no universal now; a chain *constructs* one, and γ_C is how well the construction holds. At the snapshot both nodes sat within one block of each other over the window, $\gamma_C \approx 1$; on 2026-09-10 it fell to 0 for eighteen hours when the follower refused a tip it could not verify — the correct reading, since the alternative was to advance an agreed clock on a lie. *Compare at the same height* is clock synchronisation, and K_C is the residual after it.

11 The Battle Test and the Repaired Gauge (2026-09-14)

Everything up to here is calibration: units, constants, the reason for the boundary. A thermometer can be perfectly calibrated and still be pointed at the wrong thing, so on 2026-09-14 the dimensionless gauge was taken out of the paper and driven, as a formula, through the real chain code — the `sigil-dagknight` Braid with GHOSTDAG colouring, the real `SigilSimNode` state chokepoint under `flux-chronos`, two thousand seeded two-node fuzz trials, and the live `sigil-g2` network for ten hours — eight sweeps in all, every value stored as JSONL and recomputed from its stored inputs by an independent pass (zero mismatches). Full report and raw data: `https://sigilgraph.org/downloads/sigil-kparam-battle-2026-09-14.pdf`.

The flaw is not in the arithmetic; it is in what the square root multiplies. K^* is a *product* of how much the network disagrees (ΔH) and how many different producers signed (Δs). A product is zero when either factor is zero, and on the live chain the second factor *is* zero — one producer mints every block. So the dial reads 0 ("stable") no matter how badly the chain forks. Three smaller flaws ride along: the factor t makes the same disagreement read $\sqrt{t}$ worse on a slow chain than a fast one; the $\hbar$ form can never land in the "stable" band for any physical energy (its floor at $N_{\mathrm{ML}} = 1$, $\Delta s = 1$ is $2\pi\sqrt{\pi/2} = 7.87$, above the critical line, and $K^* = 1$ corresponds to 0.016 of a tick); and read as an entropy *change*, ΔH goes negative and the root is undefined. The identity of Section 3 stands — K^* *is* the Margolus–Levitin count in disguise — but that count is an *agreement cost*, not a stress level with a threshold at 1.

The repair keeps the shape and changes the two things the test convicted, what multiplies

ΔH and what ΔH is:

$$K_{\text{fix}} = 2\pi\sqrt{\Delta H_c\,\tau_d\,w_S}, \qquad \tau_d = \frac{1+\min(d,D)/D}{2} \in [\tfrac{1}{2},1], \qquad w_S = 1 - \frac{H_{\text{norm}}}{4} \in [\tfrac{3}{4},1].$$

$\Delta H_c \in [0,1]$ is weighted *state disagreement* (tip mismatch 0.20, state-root mismatch 0.35, finality gap 0.20, semantic conflicts 0.25), non-negative by definition; d is how many *blocks* the disagreement has persisted against the finality depth $D = 512$, replacing the seconds and the $\hbar$ so that a chain that speeds up does not "cool"; $H_{\text{norm}} = \Delta s/\log_2 N$ keeps the proposer entropy, but as a bounded concentration weight: one key disagreeing with itself is the *worst* case, zero disagreement reads 0 for any key count, and rotating keys can move the dial by at most $\sqrt{4/3}$, about 15%. The ladder is unchanged (< 1 stable, < 3 elevated, ≥ 3 critical); the maximum is 2π. A first cut used $H_{\text{norm}}/2$ and let a persistent two-party split read 2.97 ("elevated"); a full state divergence must stay critical whatever the key count, which is why the weight is /4.

scenario (real chain code under chronos)	K^***,** $\hbar := 1$	K_{fix}
one producer forks against itself (24-block prefix, block 25 minted twice, followers on different wallet roots), fresh	0.00	3.98
the same, after 41 blocks of persistence	0.00	4.13
the identical fork signed with two keys, fresh / after 41 blocks	5.88 / 11.90	3.86 / 3.60
one entity, same 20% sibling blocks, 1 key → 1000 rotating keys	0.00 → 7.30	0.91 → 0.79
identical DAG at 0.1 and 10000 blocks/s	144.2 → 0.46	0.80 → 0.80
one honest producer under latency / loss / partition, 32 cells (max)	0.00	2.45
2000 seeded two-node trials, 276681 rejected blocks: Spearman ρ vs rejects	undefined (never moved)	0.970

The K_C gauge that has run on `sigil-g2` since 2026-09-07 already kept the lone-producer fork visible through an additive ϵ floor and reached $\rho = 0.935$ on the same fuzz; it still carries the seconds. K_{fix} was shipped beside it on 2026-09-14 in the MCP gauge, the wallet chip and the site modal. Live at generation time (live K-gauge series line, ts_ms=1789374666793): $K_C = 0.122$, $K_{\text{fix}} = 0.345$ (stable), persistence $d = 15$ blocks. Run directory: `/home/storage/sigil-scratch/sigil-kparam-2026-09-14`.

What the repair does *not* fix, said plainly: a fork no node ever observes contributes only through the finality-gap channel; the four channel weights are the provisional ones K_C uses and have not been calibrated against incidents; the 15% key-rotation lever is bounded, not zero; and in the network sweep persistence was measured as a height gap, so a same-height fork is undercounted there. The three $\hbar$-free variants that shared the name K^* in the code (a window-time one, an HTTP-round-trip one, and the legacy site modal) are retired or labelled; the paper's $\hbar$ form survives as the agreement cost $A = N_{\text{ML}}$ of the previous section, which is what it always was.

12 What Is Measured, Derived, Claimed

Statement	Status	Basis
$c, \hbar, k_B, e$	EXACT	2019 SI, CODATA 2022
G, α, m_p, m_e	MEASURED	CODATA 2022
Planck units, α_G, Landauer bound	DERIVED	computed here
$[K_{\mathrm{v1}}] = \mathrm{J\,s}^{-1/2}$; K^* dimensionless	DERIVED	unit analysis, executed
$K^* = 2\pi\sqrt{\frac{\pi}{2} N_{\mathrm{ML}} \Delta s}$	DERIVED	algebra + 3-scale numerical check
Margolus–Levitin, Landauer	THEOREM	used as stated
Live gauge fields	MEASURED	mainnet snapshot, epoch in text
$\hat{\alpha}_G = 6.96 \times 10^{-10}$	CLAIMED	internal earlier work, no external measurement
$\Gamma_h = 4.07\,\mathrm{MeV}$	PDG, not CODATA	particle data
Δs as a quantum entropy	ANALOGY	Shannon over proposers, not von Neumann
three-clock table, A, Tolman–Ehrenfest gradient	DERIVED	CODATA, computed here
SIGIL block rate, finality time	MEASURED	K-gauge series line named in the text
T_L, T_F (ledger / finality-horizon temperature)	ANALOGY	thermal-time and Unruh forms applied to a clock
battle-test sweeps (fork, Sybil, rate, loss, fuzz)	MEASURED	real Braid + SigilSimNode under chronos, JSONL recomputed
K_{fix} properties (worst case, rate-invariant, bounded lever, max 2π)	DERIVED + TESTED	unit tests in the harness and the MCP gauge
channel weights 0.20/0.35/0.20/0.25, ladder 1/3	PROVISIONAL	not calibrated against incidents
$n \geq 2f + 1$ via Berry phase	CONJECTURE	no proof, no adversarial test

13 Related Work

[1] (Quantum speed limits: from Heisenberg's uncertainty principle to optimal quantum control): One of the most widely known building blocks of modern physics is Heisenberg's indeterminacy principle.
[2] (Qubit-qubit-qutrit quantum correlations in $H \to f \bar f V$): We perform an extensive analysis of the quantum correlations carried by the qubit-qubit-qutrit pure state arising in the decay of a massive scalar into a fermion-antifermion pair and a massive gauge b.
[3] (The holographic principle): There is strong evidence that the area of any surface limits the information content of adjacent spacetime regions, at 10^(69) bits per square meter.
[4] (Ultimate physical limits to computation): Computers are physical systems: what they can and cannot do is dictated by the laws of physics.
[5] (The maximum speed of dynamical evolution): We discuss the problem of counting the maximum number of distinct states that an isolated physical system can pass through in a given period of time—its maximum speed of dynamical evolution.

[6] (Computational capacity of the universe): Merely by existing, all physical systems register information.

14 Reproducibility

This PDF is the output of the `k_parameter` binary in `flux-arxiv-latex`, built with `fluxc` in the Flux tree. It reads the arXiv JSON and, optionally, one saved gauge response; every other number is computed from `flux-science` at run time. Change a constant and the paper corrects itself. The identity table is a test that runs every time the document is generated.

15 Coda

Kristensen built a thermometer for consensus. Thermometers are only as good as their calibration, and calibration is boring, unglamorous, and the only thing that separates a measurement from a mood. This paper is the calibration: the units balanced, the constants traced, the boundary at 1 given a reason, and the live instrument read with its plumbing faults named beside its readings. The invention stands. It now also stands on something — and, since the battle test, it has been dropped, measured where it broke, and repaired without losing its shape.

References

[1] Sebastian Deffner, Steve Campbell: *Quantum speed limits: from Heisenberg's uncertainty principle to optimal quantum control.* arXiv:1705.08023 (2017). `https://arxiv.org/abs/1705.08023`

[2] Michał Banacki, Misaki Ohta, Abhyoudai S. Shaleena, et al.: *Qubit-qubit-qutrit quantum correlations in $H \to f \bar f V$.* arXiv:2607.26122 (2026). `https://arxiv.org/abs/2607.26122`

[3] Raphael Bousso: *The holographic principle.* arXiv:hep-th/0203101 (2002). `https://arxiv.org/abs/hep-th/0203101`

[4] Seth Lloyd: *Ultimate physical limits to computation.* arXiv:quant-ph/9908043 (1999). `https://arxiv.org/abs/quant-ph/9908043`

[5] Norman Margolus, Lev B. Levitin: *The maximum speed of dynamical evolution.* arXiv:quant-ph/9710043 (1997). `https://arxiv.org/abs/quant-ph/9710043`

[6] Seth Lloyd: *Computational capacity of the universe.* arXiv:quant-ph/0110141 (2001). `https://arxiv.org/abs/quant-ph/0110141`