The Law of Graphic Equalisation — Physics Grounding

Change, c, the Reconciliation of Special and General Relativity, the Recovery of the Born Rule, the Dimensional Constants, and the Second Law

Matthew Parslow
Independent Researcher

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DRAFT — draft-2026-09-06.1r45 (6 September 2026). This document is under active revision and is circulated for comment, not as a finished result. It is a companion to *The Law of Graphic Equalisation — Theory* (referred to below as Graphic Equalisation), and inherits that paper's definitions, epistemic boundary, and level-of-claims. The other documents of the programme named below carry short names too, and those are the only forms used: *Is*, the mind companion (*… Mind and Self Grounding*), the momentum paper, and the Born note (*… Born Recovery*). Sections marked as falsifiability commitments are the intended points of attack.

Abstract

This companion to Graphic Equalisation develops the physics groundings of the change-substrate. Its central move is that a frame's time is an inferred count of *cycles* and that the invariant speed c is the frame's own change-throughput unit, 1 by construction rather than by postulate; from that one economy the relativities, the dimensional constants, and the second law follow as *shapes*. Special relativity's c-invariance becomes a definitional consequence; the two relativities reconcile as one fixed change-budget spent two ways, on motion or on change-load; the dimensional constants $(c, \hbar, k_B, G)$ are each a frame's own base unit and their magnitudes are cross-frame artefacts; the uncertainty principle is the finite-aperture floor, the Landauer bound the information–energy conversion, quantization the aperture cell, and the Planck scale the frontier. The second law is no-copy accumulated, with entropy frame-relative, the demon exorcised by cost, and local order affordable as paid minting. On this one substrate quantum theory and relativity reconcile at the level of shape: c-invariance and the special–general reconciliation are definitional consequences given the substrate's own units, and the Born rule is recovered — not forced — on the same primitives (closure, no-privilege, free continuation). The same primitives give entanglement as a superframe dimension, the double slit as possibility structure under superframe forcing, and identical particles as functional identity, while the seed, the gauge group, the dimensionless constants and the number of spatial dimensions are contingent rule-content answered by self-location. The claims are information-level, physics taken as an embodiment: the paper mechanises shapes and derives no field equation, no dimensionless constant, and no theory of quantum gravity.

1 Scope

This paper is a grounding, not a physical theory. It inherits Graphic Equalisation's position that the claims are about information — distinction, frame, admissibility, realisation — of which physical theory is one embodiment, and that a physical result bears on an information-level claim when it settles an informational fact. Everything below is at that level. The strong claims are structural: that there is a c, a $\hbar$, an uncertainty principle, a Landauer floor, a second law, and that special and general relativity reconcile as one change-economy. To these the quantum arc adds collapse as frame-relative realisation, entanglement as a superframe dimension, and — the one place a number is reached — the Born rule, *recovered* given contingent rule-content rather than derived as a necessity, with the uniqueness supplied by cited theorems. The weak part is otherwise anything carrying a number: no field equations, no quantitative metric, no exact Lorentz factor, no dimensionless constant, and no theory of quantum gravity. Each grounding is a *promoted* constraint exposed to falsification, in the manner of Graphic Equalisation's collapse bridge, not a result asserted from within.

The minimal-universe argument that licenses the contingency verdicts below — a rock is a universe, and the minimal universe does without time, the gauge group, the constants and the dimensions, so none can be compulsory — together with the run/record axis, free will, personal identity, and death, is developed in the mind companion (its Section 2 and Proposition 2.1), which treats philosophy of mind as applied physics of the run.

2 c as the change-to-time rate

Graphic Equalisation establishes that time is not a substrate dimension but is *inferred* by a frame, whose unit is a *cycle* — one traversal of a closed rule-loop, of no fixed length. Once time is the inferred count of cycles, the invariant speed c has a natural reading, consistent with the missing-denominator result (Graphic Equalisation's Remark 13.5: there is no rate *in* substrate-time, since there is no substrate-time to divide by). c is the fixed *rate* at which change is realised — per unit of the substrate's throughput, a cycle consuming a variable amount of it — from which a frame's time is inferred. So c is prior to time: the conversion between change-count and inferred duration, which is exactly what a constant relating the temporal and spatial parts of an interval is. That is *runner c*, the first of the three things the word names here, and the separation has to come before anything is claimed of any of them.

Definition 2.1 (Three things called c). *Three things are called c in this paper and only the third is empirical, while only the first is what the substrate is about.* Runner *c is the rate at which the substrate running the frame actually runs; it is never readable from inside, and no route described here reaches it.* Unit *c is* 1 *by construction in the frame's own closure units; it is definitional, carries no risk, and is what makes the invariance a definitional consequence rather than a coincidence.* Observed *c is the number a frame obtains by measurement, retention and inference through whatever counters its rules happen to provide. The first two are fixed; the third is contingent rule content.*

Proposition 2.2 (Unit c is each frame's own unit, hence invariant by construction). *A frame's own closure rate is its unit, and a unit is read as* 1 *— not because anything has been measured, but because the frame holds nothing else in its own terms for the unit to be read against. The invariance of* unit *c is therefore a definitional consequence and not a postulate: not that all frames happen to agree on a speed, but that each is reporting its own unit. Nothing is thereby claimed of runner c, which is not readable, or of observed c, which is contingent (Definition 2.1).*

A value *other* than 1 is a cross-frame quantity: the familiar number appears only when one frame is compared with another — change-throughput against a spatial metric, seconds against metres — which is where the continuous lives, in the maps between frames rather than in a frame's own discrete states. One can give time a number at all only by comparing frames; in its own frame c is the unit, and its particular value (299 792 458 in SI) is an artefact of the comparison, not a fact about the substrate. And c is a *limit* because a signal is a sequence of changes and none can be realised faster than the frame's throughput.

It matters what is and is not being stipulated here, because the nearest neighbouring account stipulates precisely what this one does not. Discrete-substrate derivations of relativity typically assign a metric quantity and obtain c-constancy from the assignment: in the Wolfram model, constancy of the speed of light is, in the author's own words, "enforced axiomatically by our definition of the edge lengths in causal graphs" (Gorard, 2020a). Nothing is assigned here. A cycle is a closure event, not a length: how much substrate throughput one traversal consumes depends jointly on the rules and on the graph those rules are applying to, so there is no fixed unit available to be set. A frame reads its own c as 1 because it counts its own cycles and possesses no in-frame length against which to compare them — the unit is unavailable, not chosen.

The difference is not verbal, because it is where the empirical content sits. A stipulated edge length is constant by construction and can therefore predict nothing further. A cycle whose length *varies* with rules and graph predicts a great deal: that concentrating change-load lengthens cycles and slows clocks, that mass is throughput reserved for internal change, and that the whole of Section 3 follows as consequences rather than as further postulates. The honest residual is that this does not make c-invariance an empirical prediction — a frame counting its own cycles will read 1 whatever the substrate does — and the paper does not claim it as one. What it claims is that the invariance costs nothing to assume because it is a fact about self-measurement, and that the variation in cycle length, which is not a fact about self-measurement, carries the physics.

3 The change-budget: speed, dilation, mass, aperture

The budget is the substrate's throughput per cycle, and c is its *unit* rather than its size (Definition 2.1); nothing below turns on the number, only on the fixity. That fixed throughput splits between *spatial motion* and *internal change* (proper time) — in squares, the two shares summing to one, which is the constant-magnitude four-velocity below — and a speed is the share spent on motion. At rest the whole budget is internal change and the clock ticks fully; increasing speed moves budget to motion, leaving less for internal change, so the clock slows — time dilation as budget re-allocation — and at c the whole budget is motion and no proper time remains. Mass is what holds the internal share *above zero at every finite speed*: a massive graph's motion share approaches one and never reaches it, so it asymptotes to c and the energy to approach diverges, while a massless one has no internal share at all and *is* at c, with no proper time.

Because observation is funded by internal-change throughput, approaching c coarsens a frame's *aperture*. The transformation between frames in relative motion — time dilation and length contraction — is an aperture transformation between different budget-splits, and each frame's aperture self-calibrates so that its own c still reads 1. The Lorentz factor is the aperture change that holds $c = 1$ across the split. (The constant-magnitude four-velocity of Minkowski geometry (Minkowski, 1908) is this budget-split stated as a metric fact rather than as a mechanism.)

Remark 3.1 (c is not directly readable from inside, and knowing it costs retention). Being 1 by construction has an epistemic consequence that is easy to miss and belongs with the rest. A well-formed set of primitives does not leak its provenance (Graphic Equalisation's Definition 7.13, where the contingency of that is set out), and c *is* the rate at which whatever supplies them supplies them, as the frame meets it. So c is not a datum a frame can read off directly: any in-frame attempt to measure it is itself funded by the same throughput, and returns 1 whatever the underlying rate — a clock cannot time its own tick. That is exactly why the unit-reading carries no risk and no content.

Remark 3.2 (The indirect route is available, and it is priced). It does not follow that c is unknowable, and the opposite end has to be stated with equal firmness, because it has been exercised for three centuries. A frame with measurement, retention and inference obtains c *indirectly*, as a number in its own other units — Rømer from eclipse timings held across months, Fizeau's toothed wheel and the rotating-mirror measurements after it from distance set against duration — and that route is available to any frame that can hold a predecessor and compare. The two ends are not in tension: what is absent is the direct read, and what is present is the inference, exactly as with a frame's own aperture limit, which leaves no direct residual and is nevertheless inferable — weakly, from imposed change the frame cannot attribute — as the mind companion's Proposition 6.1 sets out.

Two things follow. Knowing c has a price, and it is the one the write-economics already names: the inference needs at least two events and a retained record of the first, and retention is the paid copy (Graphic Equalisation's write-economics, Proposition 7.12). A frame with no memory does not have a poor estimate of c; it has no access to the question. And the indirection is what makes the claim *empirical* at all. If c were directly readable it would be definitional and unfalsifiable; because the only route to a number runs through measurement and inference, a disagreement could in principle show up there, which is where the falsifiable content of Section 18 sits — not in $c = 1$, but in the claim that two frames taking that indirect route cannot be exhibited reaching different answers for one signal.

This is also, notably, not a proposal. Metrology reached the same conclusion and acted on it: since 1983 the metre has been *defined* from c rather than c measured in metres, and the 2019 revision kept c among the defining constants (BIPM, 2019). A quantity whose value is fixed by definition is not a fact about the world that experiment reports; it is a conversion between a frame's length and time units. What the substrate adds is not that convention but a reason it could be adopted without loss.

What this remark has been about throughout is the third of the three (Definition 2.1): runner c is unreachable and unit c is fixed, so everything empirical sits in observed c. That is contingent rule content, and the following remark is about what the contingency permits.

Remark 3.3 (The one-way speed of light is not a hard measurement but an absent quantity). The immediate consequence is a known result, and it is worth being clear at the outset that the result is not this paper's. The one-way speed of light cannot be determined without first stipulating a synchronisation for spatially separated clocks, and any such stipulation already fixes the answer; what is measurable, and measured to great precision, is the two-way speed over a closed path. The freedom in the choice is Reichenbach's ε, and the equivalence of the resulting theories has been worked out in detail (Reichenbach, 1958; Anderson et al., 1998). Nothing below revises that. What the substrate supplies is a reason for it that is not specific to light.

The reason is the unit. A frame does not count changes but *cycles*, each one traversal of a closed loop, so the unit of inferred time is a closure (Graphic Equalisation's Proposition 13.7). A round trip closes: it departs from and returns to one location, is timed against one retained record, and needs no agreement with anything elsewhere. A one-way path does not close. There is accordingly no unit *derived from the frame's own closure* in which its duration is expressed — not a duration too small or too fast to catch, but a quantity for which that unit has no measure. The obstruction is structural rather than instrumental, which is the difference between hard and impossible.

It is the same obstruction as the one above, arrived at from the other side. To time an open path a frame needs two separated clocks that agree on simultaneity, and establishing that agreement requires sending something between them at the rate being measured. The apparatus presupposes its own result, exactly as an in-frame measurement of c returns 1 because it is funded by the throughput it is trying to read.

Remark 3.4 (The inaccessibility is rule content, not a theorem). The qualification that makes this contingent rather than necessary has to be stated, because the argument as given proves more than it is entitled to. Nothing forbids rules under which some dimension steps N times per closure cycle, and those steps would be perfectly observable from inside — they are in-frame events, not hidden variables. A frame holding such a dimension has a counter finer than its own cycle, and if that counter also runs at a common rate across separated locations it *is* a global simultaneity, in which case the one-way speed is measurable in that universe and the argument above does not apply to it. So the inaccessibility is a fact about rule content, not a theorem about frames. What can be said generally is narrower and survives: a frame cannot establish that any counter it holds is faithful to the rate beneath its primitives. Provenance is not sealed — primitives leak, and inference from in-frame observables is exactly how a number for c was ever obtained (Graphic Equalisation's Proposition 14.3) — but every such inference is itself performed by primitives whose provenance is open in the same way, so the check relocates rather than closing. Where the counter is locked to the closure cycle, observed c tracks unit c and nothing is measurable one-way; where it is not, observed c may differ from the cycle rate, by location or by direction, and the frame has no way to tell which case it is in. *Observed c is always a report about a frame's counters, and reaches what supplies its primitives only by inference from them and never by reading it.* That much holds without qualification; what does not is the stronger claim that such inference is unavailable — it is available, it is what three centuries of measurement did, and it constrains without settling.

Remark 3.5 (The locked case is the cheaper hypothesis, which is not a proof). There is an economic reason to expect the locked case without needing to legislate it. A dimension stepping at a common rate everywhere is structure the substrate must maintain across every location, and maintenance is paid (Graphic Equalisation's Proposition 7.12); the closure cycle already supplies a unit at no such cost. The locked case is in that sense the *better-formed* one — fewer parts, nothing held that does no work, the same well-formedness Graphic Equalisation's cost result turns on (Proposition 7.12). It is therefore both the cheaper hypothesis and the shorter description, and a frame with no direct access should assume it on those grounds (Rissanen, 1978). Such dimensions are accordingly expected to be rare, which is not a reason they cannot occur; our own universe's apparent lack of one is an empirical finding rather than a derived necessity.

That licenses the assumption without forcing the fact, and the distinction is the whole of it. Being better formed makes something likely, expected, and rational to assume; it does not make it necessary, and there is no step from the one to the other. It is also why the standard synchronisation feels non-arbitrary rather than merely stipulated — it is the minimum-description choice, which is exactly the kind of thing that gets adopted universally without ever being proved. The failure to guard against is therefore not the assuming, which is correct practice. It is the promotion of a well-founded assumption to a theorem.

Both ends need stating, because the negative half is the smaller half. A frame learns a great deal here: the two-way speed, its isotropy, and the constraints that isotropy places on any anisotropic account are all in hand and tightly bounded by experiment. The sharpest item on that side is one-way after all, and it is worth spelling out because it reads at first like a counterexample. The *absolute* one-way speed is unavailable; the *ratio* of one-way propagation times through two media is not, and is measured as a matter of routine — a pulse sent along a fixed path through a medium arrives late against the same path in vacuum by an amount that is a real datum. That media slow light by large factors is itself routine: the group velocity in an ultracold gas has been reduced to seventeen metres per second and read off (Hau et al., 1999). The synchrony convention cancels: whatever offset ε assigns to the far end is a function of the separation, both signals cross the same separation, so the offset is common to them and absent from the difference (Anderson et al., 1998). The condition carrying that is *along the same path* — two one-way measurements in different directions do not share an offset under an anisotropic convention, and their ratio is convention-dependent again.

Proposition 3.6 (Closure sorts three cases)**.** *The closure criterion sorts three cases rather than two, and sorts them by one rule. The two-way speed closes and is measurable; the absolute one-way speed does not close and is not; the one-way ratio closes at the comparison though neither leg does, and is. A ratio is dimensionless and so never needed expressing in the frame's* *cycle at all, and the comparison is local — two arrivals set against one record at one place, which closes.*

This is the closure criterion delivering the positive result rather than an exception to it, and getting all three cases from the same criterion is a check the account passes rather than a convention it adopts. And the impossibility is indexed to frames *inside* the structure being measured, which is Axiom -1 in its plainest form. That qualification has to be read as a real one and not as decoration. The framework supplies outsides routinely: a superframe is one, and Section 6's reading of entanglement as a superframe dimension is load-bearing for the recovery of the Born rule two sections later. *Not measurable in frame* is therefore the whole of the claim, and it does not extend to *not measurable.*

Remark 3.7 (Reichenbach and Malament are the two halves of one situation)*.* The strongest reply is worth engaging rather than omitting, and it is congenial. Standard synchrony is not merely one convention among equals: it is the only nontrivial simultaneity relation definable from causal connectibility together with an inertial worldline (Malament, 1977), so $\varepsilon = \frac{1}{2}$ is canonical rather than arbitrary. That does not restore measurability of the one-way speed, and it is not offered against the reading here — causal connectibility *is* the round trip, so Malament's derivation and the cycle unit privilege the same object for what appears to be the same reason.

It is worth being explicit that this is not a third position between Reichenbach and Malament, because the two are not rivals and the substrate says why. They answer different questions, and both answers stand as given. Reichenbach's question is whether distant simultaneity is a fact independent of stipulation; the answer is no, and that is the substrate's absent direct read — no observation selects ε because every observation is funded by the throughput it would have to measure. Malament's question is whether a unique nontrivial simultaneity relation is *definable* from causal connectibility together with an inertial worldline; the answer is yes, and that is the substrate's closure cycle stated in causal terms, since causal connectibility is the round trip. Definable is not measurable, and unmeasurable is not arbitrary. The two results are the negative and positive halves of one situation — the direct read is absent, the closure is present — which is why both had to come out true, and the appearance of conflict comes only from reading them as competing answers to a single question.

A third question is then left over, and it is the one the preceding paragraphs answer: not whether $\varepsilon = \frac{1}{2}$ is factual, nor whether it is definable, but why it is universally *adopted* rather than merely available. That is the well-formedness answer — shortest description, cheapest to maintain — and it is an account of an inference rather than a further position on the metaphysics. This deflation is not the consensus reading, and should not be presented as one: Malament is frequently cited as telling against conventionality rather than as orthogonal to it, and the disagreement about how much conventionality *matters* survives everything said here. What does not survive is the impression that the two results contradict.

Remark 3.8 (One move: removing time as a primitive)*.* It is worth naming the general move this is an instance of, because the result looks specific and is not. *Removing time as a primitive is what makes the pair coherent.* Where time is a background against which events are laid out, distant simultaneity is a fact about the world that a frame may fail to reach, and the conventionality result reads as an epistemic limitation — something is there, and we cannot get at it. Where time is inferred, built by a frame out of its own closure cycles rather than supplied to it (Graphic Equalisation's Section 13, *Time is not a dimension of the substrate*), there is no such fact to fail to reach: simultaneity is a relation within a constructed axis, and two separated frames have not constructed one axis between them. Reichenbach's negative is then not a discovery about a hidden quantity but the expected shape of a question that was never well posed, and Malament's positive is the report of what structure is genuinely there. The pair is what a substrate without primitive time predicts, rather than something it has to accommodate.

The family is worth seeing together, since its members are usually met one at a time and look unrelated: a frame's temporal extent is bounded by its own inference rather than by the world; causal order is prior to time rather than read off it; one-dimensional time is not forced; a block reading is not prohibited; a frame running no rules has no time at all while things continue to happen to it from outside; and now, distant simultaneity has no fact behind it to be ignorant of. Each is argued in its own place. They are one move.

Sized honestly, because the parts of this that are old are most of it. That time is not primitive is a long relational tradition and this framework is a late entrant to it (Rovelli, 1996), and the link between conventionality of simultaneity and relationalism about time is not new either. What is narrower here is that a single mechanism delivers both halves — the absent direct read and the available closure — so the two results need no reconciling and arrive together. It also cuts as evidence rather than only as interpretation: a framework holding time primitive must treat the conventionality as a brute epistemic limit, where one that does not, predicts it. The falsifier is correspondingly sharp, and it is sharper for being narrower. Exhibit a determination of the one-way speed in *this* universe that rests on no synchrony stipulation, and what fails is the empirical claim that our rules supply no unlocked counter — the cycle unit itself would survive, since a second dimension's step count is a different unit and not a finer reading of the same one.

Remark 3.9 (Energy is the price of forced concurrency). The same c bounds *concurrency*, which gives the high-energy regime a reading. Within a frame, change is self-change and strictly ordered, so forcing two changes onto one rule-step is the paid exception; a particle accelerator is the machine that pays it, spending energy to push particles' interactions to the same step, where the frame — built to sequence — cannot order them and the interaction is *decoherent* in that frame. Two changes cannot be crowded closer than a step, and forcing them there costs more the closer one gets: the diverging energy above is this same ceiling read at the change-rate. The strong reading is "energy is the price of forced concurrency, and forced concurrency is frame decoherence"; anything with a number is weak.

Remark 3.10 (Two uses of "decoherence", and what relates them). This paper uses the word in two ways and they should be separated before either does more work. The sentence above is the *substrate* sense: a frame cannot hold the configuration, so nothing continues in it as that configuration — the sense Graphic Equalisation treats generally (its Proposition 9.1), where what varies between cases is the frame and not the failure. Everywhere else below it is the *standard* sense: environmental coupling averaging over relative phase so that branches stop interfering and a preferred basis is selected (Zurek, 2003). Nothing here derives that mechanism; einselection is imported, not recovered, and the reader should not take its appearance as a result of this account.

What relates them is a shape rather than an identity, and stating it that way is deliberate. In both, a frame fails to hold something as one coherent structure and the difference passes to the container: the environment absorbs the phase in one case, the ordering the frame cannot supply is available only above it in the other. What differs is the *outcome* — the standard case selects exactly one branch, the substrate case realises none — and on this account that difference is not in the failure but in whether the container can absorb what it receives, which is Graphic Equalisation's frame-indexing applied here. The two are therefore plausibly one operation at different containers, and that is offered as a reading rather than a derivation: it would be established by showing the selection follows from absorption alone, which is not shown here.

4 Special and general relativity reconciled

The two relativities are one mechanism, because the one fixed throughput budget — whose unit is c — can be drained two ways.

Proposition 4.1 (SR and GR are one change-budget spent two ways). *Special relativity is the budget spent on* motion*: a moving graph puts throughput into spatial motion, leaving less for internal change, so its clock slows. General relativity is the budget spent on* change-load*: mass is throughput tied up in internal change, and concentrating change-load (dense mass) consumes the local budget, so local clocks slow. Both dilations are the same act — the one fixed budget drained, by motion or by mass, each leaving less for proper time.*

The equivalence principle is the seam. Accelerating (changing one's motion) and standing in a gravitational field (change-load) draw on the budget identically, so inertial mass (resistance to a change of motion — the impulse relation of the momentum paper, its Remark 10.1, with mass as the exchange rate) and gravitational mass (change-load consuming throughput and slowing local time) are one quantity, "how much change this matter loads onto the ruleset," measured two ways. General relativity assumes their equality and does not explain it; here they coincide by construction.

Corollary 4.2 (Relativity reconciles because c is defined, not postulated). *Because c is here* defined *(Proposition 2.2) rather than postulated, special relativity's postulate of c-invariance becomes a definitional consequence, and its effects follow rather than arriving as separate surprises, with the classical paradoxes dissolving into aperture differences — each moving clock right, each reading its own $c = 1$. Special and general relativity then reconcile (Proposition 4.1) as velocity- and gravity-dilation of one budget, joined at the equivalence principle.*

4.1 Relativity and collapse

Relativity also reconciles with the collapse picture of quantum measurement, by the division of Section 2: the continuous in the maps between frames, the discrete in a frame's own states. The continuous geometry of general relativity is a cross-frame *map*; the collapse of quantum measurement is the in-frame *event*; and c — the change-to-time rate — is the seam joining the discrete event to the continuous metric. The two are the map and the event of one change-substrate, not rival ontologies, and the standing incompatibility is the artefact of treating them as rivals. This is a claim about the *shape* of the reconciliation, not a derivation: that the field equations follow is not asserted, and no theory of quantum gravity is offered.

5 The measurement problem is frame-relative collapse

Collapse in Graphic Equalisation is a local write that realises one continuation *relative to the frame that interacts.* It is not a physical process needing a mechanism — no dynamical collapse, no spontaneous localisation — but the in-frame realisation that occurs when frames couple. So there is no frame-independent "when": each frame realises its own outcome upon interaction, and a frame that has not interacted holds no collapse. This is Axiom -1 and relational quantum mechanics (Rovelli, 1996) — facts indexed to interactions, not assigned from nowhere.

Proposition 5.1 (Wigner's friend is the map and the event of two frames). *The friend measures the system and realises an outcome — collapse relative to the friend, who interacted. Wigner, not having interacted with friend-and-system, holds relative to himself the continuous unitary* map *(Section 4.1). Both are correct: the friend holds the in-frame* event*, Wigner the cross-frame* map*. The apparent contradiction requires a single frame-independent fact about whether collapse occurred, which Axiom -1 forbids; without that demand the friend's definite result and Wigner's superposition coexist without strain.*

That there is no observer-independent fact of the matter is, in this literature, a theorem and not only a stance. Brukner (2018) shows that the existence of observer-independent facts, together with locality and freedom of choice, is inconsistent with quantum predictions in an extended Wigner's-friend setting, and Frauchiger and Renner (2018) show that agents who use quantum theory to reason about other agents who use quantum theory can be brought to contradictory conclusions about the same run. Neither result is evidence for the change-substrate — they constrain every account equally — but they remove the option Proposition 5.1 declines to take, that of a single frame-independent record the friend's and Wigner's descriptions must both be answerable to. Axiom −1 forbids that record on structural grounds; these results forbid it on quantum-mechanical ones, given the auxiliary assumptions each names.

Corollary 5.2 (Any coupling is a measurement; outcomes are definite; no special observer)**.** *Any coupling is a measurement relative to the coupled frames, so no conscious or privileged observer is required and none is distinguished — a plate, a rock, or a friend measure relative to whatever they couple to. Outcomes are definite because collapse realises* one *continuation, and the basis in which they are definite is set by the distinctions the interaction makes — the aperture of the coupling, which is decoherence selecting the pointer basis. There is no cut and no collapse mechanism to locate.*

Remark 5.3 (Measuring is not observing). *Measure* here is the coupling itself and not an act: *Is* holds (its Proposition 5) that what stands in relation without transformation or grammar can be observed and cannot observe, and that is consistent with this, because observing in its sense is *making* a distinction and requires rules, while measuring in this sense is standing in the relation that makes an outcome definite relative to a partner. A rock does the second and not the first.

This dissolves the measurement *problem* — the when, the how, the who, and the definiteness. That outcomes are realised frame-relatively is the shape; how their probabilities are weighted is a separate question, taken up in Section 7.

6 Entanglement is dimensional access through frames

An entangled pair is one system in the superframe, described by a joint dimension — the correlation — that is a first-class quantity of the superframe and NULL in each subframe individually (Graphic Equalisation's Proposition 10.8, higher-frame first-class structure). Each subframe has dimensional access to it only through its own boundary, and only in part; the full dimension lives one level up, along the structural-depth axis rather than the spatial one.

That the subframe/superframe split is itself frame-relative is not only assumed here. Ali Ahmad et al. (2022) prove, in the quantum-reference-frame setting, that the decomposition of a composite system into subsystems is frame-dependent — what counts as "the parts" changes with the frame relative to which the whole is described. That result takes frame-covariance as its premise and derives the relativity of subsystems from it, so it does not establish the non-privilege of frames — that remains this framework's own commitment, held as an axiom and not borrowed as a theorem. What it does establish is that the subframe carving inherits the non-privilege: no single decomposition into parts is preferred, so the joint dimension below is a claim about a decomposition, made from inside it, and not a claim about a preferred carving of the world.

Proposition 6.1 (A subframe's local state is mixed because the purity is a superframe dimension)**.** *Described alone, an entangled particle has no pure state — it is mixed — because its pure description requires the joint dimension, which is* NULL *in its subframe. Tracing out the partner is not discarding locally-available information; the missing information was never a subframe dimension. The reduced state is mixed exactly because the purity is a superframe dimension, inaccessible from below.*

Corollary 6.2 (Nonlocality is up, not across; Bell forbids only subframe-local variables)**.** *The connection between the parties is not* across *the space between them but* up*, to the superframe they are both subframes of. No cross-frame write passes between the subframes; each accesses* *the same superframe dimension locally, and the joint fact appears only when their accesses are compared (a further coupling), so no signal is sent. Bell forbids* local *— subframe-level — hidden variables (Bell, 1964), and the framework has none: the correlating variable is a superframe dimension, so the violation is expected, not paradoxical. Kochen–Specker contextuality (Kochen and Specker, 1967) is the access itself — measuring projects the superframe dimension into the subframe's aperture, so a realised value is context-dependent by construction.*

Quantum mechanics is the standing demonstration that the in-frame description is not exhaustive, and it is an empirical one rather than an interpretive preference. Correlations violating Bell's inequality are not functions of the separated subframes' own states (Bell, 1964), which is precisely what this paper means by a dimension held at the superframe, and they have been exhibited without the loopholes that once allowed the conclusion to be resisted (Hensen et al., 2015). So structure beyond a subframe's own description is not merely coherent in this framework; it is measured. The superframe account is nevertheless a *shape claim*, not an additional measured variable: it earns the mapping from the measured failure of subframe-local descriptions to a joint first-class dimension. It fails if a complete account of the observed correlations can be given from the separated subframes' own state alone, without joint structure or an equivalent containing relation. Bell tests do not select this vocabulary over every interpretation; they expose the subframe-local shape that this vocabulary says is unavailable.

Remark 6.3 (Ascent yields a different somewhere, not a view from nowhere). The limit on that optimism should be stated in the same breath, because the obvious route is closed by an established result rather than an open question. No-signalling means entanglement cannot carry information between separated locations, so it cannot be used to synchronise their clocks, and the superframe access we demonstrably have is therefore not access to distant simultaneity (Proposition 3.6). What a superframe does deliver is worth being exact about, since it is more than nothing and less than an outside: holding both locations, it has units that close across them, so quantities the subframes cannot obtain are ordinary in *its* terms — and being a frame, it is blind to its own runner in precisely the way they were to theirs. Each level dissolves the one below's restriction and reproduces the restriction at its own. So "impossible" was the wrong word twice over: wrong for a restriction that holds of one frame and is lifted by the frame above it, and wrong again for suggesting that some sufficient ascent would lift it altogether, when what ascent yields is a different somewhere rather than a view from nowhere.

Remark 6.4 (Spookiness is an aperture artefact: the light-switch identity). The confusion entanglement provokes is identical in structure to that of a person who has never seen a light switch and does not understand electricity: flip a switch, a far light obeys, with no connection inside the aperture, so action at a distance is inferred. In both cases the inference is wrong for the same reason — there is a connection, through a dimension the observer cannot see: the wiring in the walls for the switch (the opaque runner), the superframe's joint dimension for entanglement (structural depth). Spookiness is therefore a property of the aperture, not of the phenomenon; a switch is mundane once one sees the wiring, entanglement once one sees the superframe. This is the sequence science has run before — magnetism was action at a distance until the field, gravity until curvature, disease until germs — each "spooky" a real connection through a not-yet-visible dimension, each dissolved by the aperture widening rather than the phenomenon changing. "We do not understand entanglement" is structurally "I do not understand the light switch."

Honest boundary: seeing the connecting dimension dissolves the *spookiness*, not the *numbers* — the Tsirelson bound, the correlation strength and the Born weights are not derived; they become ordinary physics questions rather than spooky ones.

7 Amplitudes are a rule on Narrative; recovering the Born rule

An amplitude is not a foreign number-structure but the directional Narrative of the momentum paper, acted on by a rule. That paper's directional momentum $p = \phi_W(\mathcal{N})\,\hat{\mathbf{d}}$ (its Definition 4.1) is a magnitude $\phi(\mathcal{N})$ — the operative-history measure — times a direction $\hat{\mathbf{d}}$. The complex amplitude is therefore the directional Narrative, its dynamics a rule applied to it, and its phase the direction $\hat{\mathbf{d}}$ read as position in the cycle (Section 2). The complex structure of quantum amplitudes is thus grounded, not imported.

Proposition 7.1 (Closure makes the weight a conjugate pair)**.** *A realised outcome is a* closed cycle *— the realised "now" is one traversal of the closure loop, and a loop that closes. A probability is the weight of a realised outcome, hence of a closed loop: the Narrative carried forward and carried back to close it, the amplitude and its return. The weight is then the amplitude applied twice, amplitude times its conjugate, $|amplitude|^2$. The Born square would on this reading be the closure itself — a realisation must close its loop, and closing requires the directional Narrative both ways.*

This is a candidate, not a derivation, and a real advance on leaving the amplitude a blank.

7.1 An attempt to close it

The candidate can be pushed further than a candidate, though not all the way. Take the amplitude as a directed magnitude — a Narrative's size r times a phase — and follow four steps, marking what each earns. *This subsection is an attempt, flagged as such, not a claimed result.*

Complex (motivated). The phase is position on the realisation cycle, and a cycle's traversal parameter is one-dimensional: $S^1 = U(1)$. So an amplitude is $r\,e^{i\theta}$, a complex number — real would be a phase-less (cycle-less) magnitude, and the one-dimensional closure loop gives a single angle, not the three of a quaternionic phase. Motivated by closure, not forced.

Linear (a candidate mechanism, not a proof). Independent contributions to one outcome superpose by addition. This has a candidate mechanism rather than a bare posit. Free evolution is the amplitude's own Narrative, and a Narrative is what a subgraph runs when *no rule fires* — the free continuation simply carried forward (the momentum paper's free continuation, its Definition 5.2, and the free-continuation default of Section 11). With no rule firing on them, nothing *couples* the components of a superposition; each free-continues independently, and uncoupled independent continuation *is* linear superposition, since a nonlinearity would need a rule reading one component and acting on another — exactly what does not fire here. Linearity is on this reading the signature of free continuation. What stays a residual is the rigorous step from "uncoupled" to full additivity and norm-preservation (unitarity), and the linearity of the imposed supergraph map is not handed over for free: the mechanism motivates linearity, it does not yet prove it.

Phase-independent (from no privilege). A cyclic direction has no privileged origin, so a global phase rotation is a change of nothing (Graphic Equalisation's no-privilege principle applied to the phase). The realised probability must therefore be invariant under a global $U(1)$, hence a function of the modulus alone, $P = f(|a|)$. This step is earned, and it is the no-privilege thesis — Graphic Equalisation's Axiom -1, carried through the mind companion — doing physics work.

Squared (forced, given the above). Two alternatives with no privileged relative phase — decohered, their relative phase averaged over — are classically exclusive, so their probabilities must add. Averaging the combined modulus over the relative phase,

$$\langle f(|a\,e^{i\theta} + b|)\rangle_\theta = f(|a|) + f(|b|),$$

since the cross term $2\,\mathrm{Re}(a^* b\,e^{i\theta})$ averages to zero. The square, $f(x) \propto x^2$, satisfies it, and the obvious alternatives do not: a quartic overshoots by the surviving $\langle\cos^2\rangle = \frac{1}{2}$ term, the linear undershoots ($a = b = 1$ gives $4/\pi \neq 2$), the square lands exactly; normalisation fixes the constant. This selects the square among the natural candidates rather than proving it unique — the uniqueness is what Gleason's theorem supplies below, over all measurement contexts. The weight is real because closure (a returned cycle) is net-zero phase.

The Gleason residual, reconsidered. The internal Narrative is relative in the *reading*: it is the same standing structure *read as* a vector in the basis the frame's current rule set fixes, so a superposition is rule-set-relative — definite in one rule set, superposed in another — which is the same *form* as relational quantum mechanics (Rovelli, 1996) without being the same claim: that programme relativises a physical fact to an interacting physical system, never to a descriptive framework or rule set, so what is borrowed here is the shape of the relativisation and not its warrant. Because no rule set is privileged (the no-privilege principle again), the probability rule must be the *same* across every rule set, which is exactly the context-independence Gleason's theorem assumes. The framework thus supplies Gleason's premises — a vector-valued state (the linearity step above) and a context-independent measure (no privileged rule set) — from its own principles, and Gleason (Gleason, 1957) supplies the uniqueness: $|\cdot|^2$ is the only such measure in dimension ≥ 3, leaving the vector-structure rigour of the linearity step as the one posit.

The Hilbert posit, reconsidered: linearity as projection through frames. That one posit — the state lives in a complex Hilbert space and free evolution is unitary — is what treating Hilbert space *as a frame* is meant to reach. Read the inner product $\langle a \mid b\rangle$ as the projection of one frame's Narrative into another's rule set: how much of b shows up when b is read in the rule set a fixes. So the inner product is not imported structure but the framework's own cross-frame reading.

Linearity is then that projection distributing over components: during a free (empty-rule-set) segment no rule couples the Narrative's parts, so reading a superposition is superposing the readings — the same uncoupling, applied to the projection. Unitarity is that a free continuation *destroys* no distinction: it is an information-preserving write and not the absence of one, so the prior Narrative is recoverable from it and every cross-frame projection of it is preserved, norms and inner products conserved (the free-continuation conservation of Section 11).

The Narratives, directional magnitudes that superpose, form the complex vector space; the inner product, a cross-frame map, makes it Hilbert; and its *completeness* — the defining Hilbert property — is the continuum living in the maps between frames, $\mathrm{Hom}(\mathrm{frame}, \mathrm{frame})$, never in a frame's own stepped states (Section 2).

This meets the informational reconstructions of quantum theory, which *derive* the complex Hilbert space and the Born rule from a few operational axioms (Hardy, 2001; Chiribella et al., 2011); Masanes and Müller (2011) obtain finite-dimensional quantum theory from five physical requirements on states and transformations, Höhn (2017) obtains qubit quantum theory from rules on an observer's acquisition of information (Section 17), and Müller (2021) surveys the programme as a whole. Among the post-2011 reconstructions the nearest to this paper in *formal register* is Selby et al. (2021), which states every postulate diagrammatically — wires and processes, with symmetric purification the central axiom — rather than convex-geometrically. That matters for form and not for content: a compositional, diagrammatic axiom set is written in the same currency as a typed-graph substrate with subframe nesting, so the mapping attempted here is a translation between two graphical calculi rather than between a graph and a convex body. It is a reason to think the mapping can be checked, not evidence that it holds.

This is the same move again, one level deeper, and the mapping has been worked axiom by axiom against the Hardy and CDP reconstructions in the Born note (its Section 4), with a result worth stating rather than promised. The two *most* quantum axioms are supplied natively, and each from a different substrate principle (the Born note's Proposition 4.1): Hardy's continuous reversible transformation between pure states by free continuation (an information-preserving write is reversible, and the cycle-phase is continuous), and CDP's purification — every mixed state is pure in a larger system — by entanglement as a superframe dimension (Section 6).

Context-independence is no privileged rule set, and composition is subframe nesting. Most of the rest match native commitments rather than statements (probability from realisation, compression and simplicity from the substrate's minimum description length, subspaces from subframe-as-frame), and the Born note rates them as genre-matches on that ground. Given the mapping, Hilbert space and the Born rule follow by the cited reconstructions, as $|\cdot|^2$ followed from Gleason. A closure-phase frame is likewise consistent with complex amplitudes at one system (the Bloch sphere, $K = 4$, rather than the real disk's $K = 3$), though a phase-less frame is equally constructible and the substrate does not require either. The remaining question — *local tomography*, which selects complex over real — is, correctly framed, *not a gap the substrate must close by forcing.* Almost everything in a graph substrate is optional: the compulsory core is structure, rules, subgraph-hood, and an admissibility grammar (the minimal-universe argument of the mind companion, its Proposition 2.1), and everything else — self-similarity, complex-over-real, the number of spatial dimensions, the gauge group — is contingent rule-content. The substrate therefore *admits* complex quantum theory (the self-similar complex composition gives $K_{AB} = 16$) rather than forcing it, exactly as it admits, without forcing, one value of N or one gauge group; a real-amplitude composition ($K_{AB} = 10$) is another admissible configuration, and our universe's selection of the complex one is self-location (the Born note tabulates the fiducial counts and states the verdict as its Proposition 5.1). Given that contingent choice the Born rule and Hilbert structure follow, which is how this paper treats all physics — shapes from contingent rule-content, the content never forced. Complex quantum theory has here the same status as $N = 3$ — admitted and self-located, not compelled. In a word, the framework *recovers* the Born rule rather than deriving it per se: it reproduces the known rule within its own structures — some steps forced given the premises (the squared modulus), the premises themselves admitted and contingent (complex, linear, self-similar) — not forcing it from necessity. Recovery, not derivation, is the honest verb and the right one: a contingent law is recovered given its rule-content, never derived as compelled (the Born note holds this as its Remark 2.1). A rival recovery starting from a comparably admissibility-flavoured base — constructor theory's, in which probability is not fundamental at all but emerges from the unpredictability of measurement on superinformation media (Marletto, 2016) — reaches a different answer from the same kind of premises, and is engaged directly in Section 17.

Honest residuals. The recovery rests on one posit of this paper's own: the rigorous step from "uncoupled" to full additivity and norm-preservation is not made here, and the linearity of the imposed supergraph map is not handed over for free — the mechanism motivates linearity and does not prove it. The remaining residuals belong to the mapping rather than to the physics, and the Born note holds them rated, item by item, in its Section 7: the Level-0 hygiene conditions, the reach of the phase-average selection against Gleason, the composition seam, and the genre-match ratings.

7.2 The reconciliation: Born, SR, and GR on one substrate

The recovery has a consequence larger than the Born rule. Special and general relativity are already reconciled here as one change-budget spent two ways (Proposition 4.1, Corollary 4.2), with c's invariance a definitional consequence rather than a postulate (Proposition 2.2) — definitional given the substrate's own units. Quantum collapse and relativity are already joined at c as the event and the map of one change-substrate (Section 4.1). With the Born rule now *recovered* on the very same primitives — closure for the phase, no-privilege for phase- and context-independence, free continuation for the reversible structure — Born, SR, and GR stand reconciled on one substrate: the same c, the same no-privilege, the same closure loop underwrite all three.

Honest boundary: the strength is uneven — the SR–GR half a definitional consequence given c-as-unit, the quantum–relativity half structural. This is emphatically *not* a quantum theory of gravity: no field is quantised, no metric is derived, no dimensionless constant is fixed.

What is reconciled is the *conflict* — that quantum theory and relativity are two aspects of one change-substrate rather than incompatible frameworks — not the quantitative unification the scope explicitly disclaims.

8 Interference and the double slit

The double slit is obvious once two established facts are held together: causality is ordering *in a frame*, and a superframe applies changes to a subframe without passing through the subframe's admissibility.

A superframe *applying* a change to a subframe is not itself a measurement coupling: it makes no distinction the subframe holds, so it realises nothing for that subframe — which is why the superframe forcing below leaves an interference pattern intact while a which-path coupling destroys it.

Proposition 8.1 (Superposition is the possibility structure; interference is amplitudes combining by phase)**.** *Superposition is Graphic Equalisation's possibility structure $\mathcal{P}(G)$ — the admissible continuations a graph holds before collapse — so a particle "in superposition" is a graph whose $\mathcal{P}$ has more than one admissible continuation, none yet realised. Each continuation carries a directional Narrative (Section 7), an amplitude with a cyclic phase, and before collapse the alternatives' amplitudes combine, constructive where the phases align and destructive where opposed. The outcome weight is the combined closed loop, $|\sum amplitude|^2$.*

Two established facts make this un-mysterious. First, causality is ordering *in a frame*: there is no global fact about "which path the particle really took," because which-path is *undetermined*, not *undisclosed*, until a coupling realises it — a question with no answer of any kind until a coupling settles it. The "both paths" is not a particle in two places but the frame's $\mathcal{P}$. Second, a superframe applies changes to a subframe *without* passing through the subframe's admissibility (Graphic Equalisation's Proposition 6.5: admissibility is self-governance, not armour — a graph's grammar governs its self-originated transformation, not world-caused forcing). So the interference is the superframe applying its combined-amplitude structure to the particle; the particle does not select a path by its own rules, and cannot veto the combination.

Corollary 8.2 (The double slit, duality, and delayed choice)**.** *Both paths are admissible continuations in $\mathcal{P}$; the superframe applies their combined amplitudes at the screen, giving fringes. A which-path coupling collapses before the screen — one continuation realised, the other no longer in the sum — so the superframe applies a single-path change and the fringes vanish. Wave–particle duality is the map/event distinction: the "wave" is the amplitudes combining (the map, the held $\mathcal{P}$), the "particle" the realised outcome (the event, one continuation collapsed), and "which is it really" names no difference. Delayed choice adds no retrocausality: collapse attaches to the actual interaction, not a retroactive rewrite (cost is a local write; no write reaches the past), so interference-or-not depends only on whether the which-path coupling occurs.*

Honest boundary: this grounds the shapes — superposition as possibility, interference as phase-combination, the double slit, duality, and delayed choice without retrocausality. The quantitative fringe pattern needs the amplitude phases computed, i.e. the Hilbert formalism, which is the Born-rule frontier of Section 7.

9 Dimensional constants are frame-units; dimensionless ones are not

The reading of c as a frame's own base unit generalises. Each dimensional constant is the base unit of one of a frame's own economies — 1 in-frame, a number only cross-frame.

- c is the change-rate unit (Section 2).
- $\hbar$ is the *aperture quantum*, the smallest resolvable cell: observation is funded by finite internal-change throughput, so fine resolution in one dimension trades against another and the trade floors at a minimum cell — which is the uncertainty principle, $\Delta x\, \Delta p \geq \hbar/2$ being the finite-aperture budget stated as a bound, with $\hbar$ its quantum.
- k_{B} is the information–energy conversion: Landauer's $k_{\mathrm{B}}T \ln 2$ (Landauer, 1961) — the floor cost of change of Graphic Equalisation's economics — is one bit's change converted from the information frame into the energy frame at that rate.
- G is the change-load–geometry coupling, mass deforming the containing frame.

That physics sets $c = \hbar = k_{\mathrm{B}} = G = 1$ (natural units) is then not a convenience but a recognition: each is a frame-unit, read as 1 in the frame's own terms with its familiar magnitude a cross-frame artefact (Proposition 2.2).

Proposition 9.1 (The dimensional/dimensionless boundary)**.** *A dimensional constant is a frame-unit and reads as* 1 *in its own terms; a dimensionless one — the fine-structure constant* $\alpha \approx 1/137$*, the mass ratios — cannot be set to* 1 *by any unit choice, being a genuine cross-frame* ratio*. The framework says nothing about their values. About their type it says: a constant is a ratio or it is a unit artefact, and there is no third kind. There are no magic numbers — standalone quantities that simply are, attached to nothing.*

The type claim is forced rather than preferred, and the forcing is at the floor. A ratio is a relation between two quantities: two ends and something carried across. A magic number is a *label* — a value borne by one thing, answering to nothing else — and the base has no labels for it to be written as, carrying relata and relations and no marks on either (*Is*'s floor, made explicit in its Section 6). *So a standalone constant has nowhere to live.* Where a theory carries one anyway, it is carrying a value whose relata it has not identified, which is a write nobody can read back — the silent fourth cost of Graphic Equalisation's well-formedness (Definition 7.13) — and the defect is in the theory rather than in the world.

What this does to the open question is change its shape and not its status. *It explains no constant's value and does not pretend to.* What it denies is that the value is the right thing to ask after first. "Why is α about 1/137" asks for the provenance of a number; on this account the number is what a relation carries, so the question is which two things stand in it and what fixes their relative size — and the standard framing, in which the Standard Model has some two dozen free parameters, is then not a list of two dozen mysteries but a list of two dozen relations whose relata are unnamed. That is a harder question and a better-posed one, and nothing here answers it.

The commitment is checkable in the one direction that matters. *Exhibit a dimensionless constant that is a ratio of nothing* — irreducibly standalone, not expressible as one quantity against another even in principle — and the type claim fails. The candidates all survive it so far, and survive it trivially: α compares a coupling against $\hbar c$, the mass ratios are ratios by construction, θ_{QCD} is an angle and an angle is an arc against a radius, Λ in Planck units is one energy density against another. Counts are the case worth naming, since a count looks like the counterexample: the number of spatial dimensions, or of generations. A count is a ratio to the unit of what is counted, which is degenerate but is not standalone — there is still something it is a count *of*, and that is the second end.

And the consequence that makes this empirical rather than taxonomic: a constant is constant except when the things that set it change. Constancy is a property of the relation's stability and not of the number, so *constant* names a state that can fail rather than a category that cannot. Nothing in this account enforces it. That is not a prediction that constants do vary — it is the removal of a reason to expect they cannot, and exact constancy maintained forever would be a fact wanting an explanation rather than the default it is usually taken for.

The split above then does work it is not usually asked to do. *Only a ratio can vary, because only a ratio is anything.* A claim that c has changed is not a claim about the world: c is the frame's own unit, read as 1 in its own terms, and a varying ruler measured by itself is no measurement — which is Duff's point arrived at from this side. A claim that α has changed is a claim with content, because α compares two things and one of them could have moved. So the varying-constants question is well posed exactly for the dimensionless remainder and ill posed everywhere else, and this is why searches quote $\Delta\alpha/\alpha$ and never Δc.

What a measured variation would be is a measurement of the relata, which is the part worth having. If α drifts, the relation between the quantities it compares has changed, and the structure of the drift — with position, with epoch, with environment — constrains which of them moved. On this account that is not an embarrassment to be explained away but the one observation that would name the ends of a relation the theory currently carries unnamed. The empirical position is that the bounds are tight: reactor, clock-comparison and nucleosynthesis constraints all limit any drift severely (Uzan, 2011), and the reported spatial dipole in α from quasar absorption (Webb et al., 2011) is contested and not independently confirmed, so nothing here rests on it. *It is named as the shape a confirmation would have*, not as evidence.

And a ratio can look constant without being constant, which the tightness of those bounds does not distinguish. Write the ratio $R = A/B$. Its fractional response is $\delta R/R = \delta A/A - \delta B/B$, so a large denominator does not suppress a fractional change in B — the condition worth stating rather than hiding. What a large denominator suppresses is an *absolute* one: a perturbation of fixed size δ enters as δ/B and vanishes as B grows. Wherever what can move a quantity is bounded in absolute terms, which is the ordinary case, a ratio with a large enough denominator reads as constant whether or not it is.

That is the finite aperture of $\hbar$ above, arriving at the constants. A frame cannot resolve a change below its own cell, so *constant* and *varying beneath resolution* are the same reading to it, and constancy joins the list of properties that are aperture-relative rather than intrinsic. What is constant to one frame need not be to a finer one, and no frame is entitled to read its own resolution as a fact about the world (Axiom -1 again, at the measurement).

Two consequences follow and the second is the useful one. First, the empirical bounds say exactly what they say and not more: they bound variation *below the resolution achieved*, which is a statement about the aperture of the measurement and not about the world. Nothing here disputes them and nothing licenses reading them as an absence.

Second — and this is where the diagnostic hope of the previous paragraph becomes a search strategy rather than a wish — *the constants most likely to yield a measurable variation are not the ones deemed most fundamental, but the ones whose denominators are smallest against the perturbations available to them.* Apparent constancy is then predicted to track denominator size rather than depth, and a programme aimed at whichever constant seems most basic is aimed by the wrong criterion. This account cannot rank the candidates, having no access to the relata that would fix the denominators; what it supplies is the ordering principle and the claim that it is the right one.

One consistency check on the section before it. The decay constant of Section 13 is a rate, and a rate carries a dimension, so by this proposition it is a frame-unit and not a fact about the world either. What would be a fact is the ratio of one decay rate to another, and it is that ratio which the argument there requires to be stable — not the half-life in anybody's seconds. It sharpens the real question rather than answering it: the numbers that need explaining are the dimensionless ones, while the pseudo-mysteries — why c, why $\hbar$ — are unit conventions. This is the standard observation that the number of fundamental *dimensional* constants is a matter of convention (Duff et al., 2002), landing on the side that they are units; the dimensionless remainder is left exactly as open as it was found.

10 The Planck scale, quantization, and fine-tuning

Three consequences follow. First, the *Planck scale* is where the *cross-frame ratios* between the four economies all reach unity together ($\ell_P = \sqrt{\hbar G/c^3}$ and its companions). Each constant reads 1 in its own frame always, so this is not a scale at which they become 1; it is the coincidence, visible only in the comparison between economies, of the aperture cell ($\hbar$), the change-rate ceiling (c) and the change-load–geometry coupling (G) — an artefact of comparison in the same sense the SI value of c is. Below it a frame cannot resolve, cannot order, and horizons its own geometry, so nothing there is representable — the " ? " of Graphic Equalisation's epistemic boundary with a location. The Planck scale *is* the frontier, which is why physics predicts its own breakdown there: not a failure of theories but the exhaustion of a frame's units, below which the pre-relational substrate begins.

Second, *quantization* is the aperture being cellular: because $\hbar$ is a minimum cell rather than an infinitesimal, action and energy come in $\hbar$-steps, so the "quantum" of quantum mechanics is Graphic Equalisation's discrete sufficiency (its Hypothesis 3.13) read at the resolution axis — the granularity of the aperture, not a separate granularity of the world.

Third, the *dimensionless* constants are contingent rule-content: the framework cannot derive α or the mass ratios, but it can say what kind of thing they are — the contingent specifics of this substrate's rule-set (Graphic Equalisation's Remark 7.19), so "why α" is not "why this necessary value" but "why this rule-set," answered by self-location (Proposition 14.2). Two type claims are now in play and they agree: a dimensionless constant is contingent rule-content, and it is a *ratio* rather than a label (Proposition 9.1).

The second sharpens what a fine-tuning argument is doing. *Such an argument treats a constant as a dial* — a value that could have been set otherwise with everything else held fixed — which is to treat it as a magic number, the one thing this account says no constant is. Turning a dial on a ratio is not holding everything else fixed: it is altering the relation between the two quantities the ratio compares, and whether that is a coherent counterfactual at all is the question such arguments skip rather than answer. That is a second reason the framing misprices its question, and it is independent of the first — self-location would dissolve fine-tuning even if constants were labels, and this would bite even if self-location failed. Both relocate fine-tuning at its root, which Section 14 takes up.

11 Symmetry and conservation

A symmetry is a transformation that produces no residual: a change the structure does not feel, free and reversible, a no-op in the container's grammar. Noether's theorem, symmetry $\leftrightarrow$ conserved quantity, is then the cost side of that. A quantity is conserved precisely when altering it would cost — produce residual, require a paid write — so the symmetric direction is free and the quantity perpendicular to it cannot move without paying. What a transformation leaves untouched is what it costs to change.

Proposition 11.1 (Momentum conservation is the free-continuation default)**.** *Space-translation symmetry — the rules the same everywhere — produces no residual under translation, and momentum is conserved. Momentum conservation is the free-continuation default Graphic Equalisation states (its Remark 4.3): the un-rewritten Narrative, Newton's first law, continuation costing nothing. Noether's momentum case and inertia are one statement.*

Proposition 11.2 (Energy conservation is contingent on time-translation symmetry)**.** *Time-translation symmetry — the rules the same each cycle — conserves the change-budget, which is energy. The failure case is checkable: where the rules effectively change across cycles there is no time-translation symmetry and energy is not globally conserved. This is the standard general-relativistic result that a time-dependent spacetime has no global energy conservation —*

in an expanding universe photons redshift their energy away — here from the same principle: rules changing across cycles (cosmic expansion, or minting) means no conserved energy.

Charge conservation follows from the *global* phase symmetry — a uniform re-description carrying no in-frame residual, which is the shape above. *Local* gauge symmetry is a different thing: a redundancy of description rather than a symmetry of states, and by Noether's second theorem it yields identities and constraints rather than an independent conserved charge. The framework's reading applies to the first; the second is the cross-frame freedom (in the maps, where the continuous lives) that leaves the physics untouched, and carries no charge of its own to conserve.

Remark 11.3 (The gauge group is contingent rule-content). The framework grounds *that* a symmetry yields a conservation law — the shape, residual-free $\leftrightarrow$ cost-to-change — but *which* symmetries hold, the $\mathrm{U}(1)\times\mathrm{SU}(2)\times\mathrm{SU}(3)$ of the Standard Model, is a fact about this substrate's rule-set, not a necessity. "Why this gauge group" is "why this rule-set," the same relocation as "why α" (Section 10), answered by self-location (Proposition 14.2). The conservation *structure* is universal; the particular symmetries are this universe's.

12 The second law

Entropy and its arrow follow from the same economy.

Definition 12.1 (Entropy is what a frame does not distinguish)**.** *The entropy a frame holds is the log-count of the microstructure it carries but cannot tell apart — what falls below its aperture. Entropy is therefore frame- and aperture-relative from the start: a finer aperture resolves more and reads less entropy, a coarser one more.*

This is the Gibbs–Jaynes reading, in which entropy is a property of the observer's coarse-graining rather than of the world in itself (Jaynes, 1957); here it is grounded rather than assumed — entropy is *what this frame does not distinguish.*

Proposition 12.2 (The second law is no-copy accumulated)**.** *Every* write *of the discarding class discards its predecessor: the prior state goes* NULL *unless paid to keep, so each write pushes structure below the aperture, into the un-distinguished. Change therefore accumulates entropy, because change forgets by default and forgetting is exactly this demotion. The arrow of entropy is the no-copy asymmetry, which is the same asymmetry as accumulated change-cost (the Landauer floors summing) and as causation (a change enables its successor, not its predecessor); a free continuation discards nothing and is the neutral case.*

Two restrictions are carried in that statement and neither is decoration. Graphic Equalisation prices reversible operation rather than forbidding it, so the proposition restricts to the discarding class rather than claiming it of all writes, and what is claimed is that the class is the general case. And a free continuation is not an event in the frame's own terms at all — Graphic Equalisation has it as the absence of one, and nothing re-applies the standing structure. What makes it a *write* here is this grounding's container rather than the substrate: the physical superframe charges for persistence, so what is free to the frame is paid in the frame that holds it, and it is then the reversible, entropy-neutral case. That is a claim about these rules and not about all of them, which is why the arrow tracks writes and not mere succession.

Remark 12.3 (Absence is not residual). A clarification is needed here, because Graphic Equalisation separates two things this could run together. What falls below an aperture is *absent* to that frame rather than held-and-unresolved, and absence is not residual — they have opposite consequences there. Entropy as defined above is the microstructure a frame cannot tell apart, which is absence at its grain, and it is *not* the same quantity as un-absorbed residual, which is inadmissibility a grammar did see and left in place. The two rise together under coarsening and remain distinct in kind.

Remark 12.4 (The increase is one-sided accounting). One further separation, and it is what makes the proposition a reading rather than a law. Demotion below an aperture is not loss: what falls below one frame's grain is above another's, so the transfer *balances* across the boundary and is unbalanced only when accounted from one side. The increase is therefore a property of *one-sided accounting*, not of the whole — a cross-frame quantity read in-frame, which is the category this programme's own discipline says produces exactly this kind of artefact. That is why the law is asymptotic and statistical rather than exact, and why it can be locally reversed by anything that pays: the payer is the other side of a ledger that was balanced all along.

Remark 12.5 (A relocation of the arrow's source, not a new arrow). Nothing in that is new physics. Open-system thermodynamics already has entropy falling locally while rising globally, and the demon is already answered by accounting for the demon. What this account adds is only where the boundary is: the boundary is a *frame*, so the asymmetry is not a fact about systems but about individuation, and the second law is what the balance looks like from inside one of the two frames it balances between. The claim is a relocation of the arrow's source, not a new arrow.

Corollary 12.6 (The demon is exorcised, and local order is affordable)**.** *Landauer's* $k_{\mathrm{B}}T\ln 2$ *(Section 9) is the price of* erasing *one bit — pushing one distinction back down into the undistinguished, which is the discarding write of Proposition 12.2. Maxwell's demon is exorcised by exactly this: a demon with finite memory must erase to keep operating, and that erasure is the entropy it thought it removed for free (Bennett, 1982). Acquiring the distinction need not cost — a copy into blank structure discards nothing — which is why the cost sits in the reset and not in the observing, and why on this account it is the* no-copy *asymmetry and not the act of distinguishing that carries the arrow. Yet local entropy reduction is possible: minting resolves residual and builds structure, but it is a write, so it is paid, and the payment is Landauer heat exported to the surroundings — local order bought by global entropy increase. This is Schrödinger's "life feeds upon negative entropy" (Schrödinger, 1944) grounded: an organism, a learner, a growing graph is a region that pays to mint local structure and dumps the cost as heat. Life does not violate the second law; it is the second law with a subsidy.*

Remark 12.7 (The arrows unify). The thermodynamic arrow (entropy up), the causal arrow (change enables forward), and the psychological arrow (memory is present structure of a discarded past) are not three arrows that happen to align — but the unification is between two of them, and the third joins for a different reason. The thermodynamic and psychological arrows are one thing: the accumulation of change under no-copy, memory being present structure of a discarded past and entropy being the same discarding counted. The *causal* arrow is not that. It is the asymmetry of enablement itself — a change makes another possible and the second does not thereby make the first possible — and it holds whether or not a predecessor survives, which is why Graphic Equalisation rests the event order on it rather than on no-copy. So two arrows are identical and the third agrees with them without being them, and the "why do they agree" puzzle is answered in two parts rather than one: two descriptions of a single asymmetry, and a second asymmetry that runs the same way because the changes carrying it are the changes doing the discarding.

13 Decay is determinate; the phase is unretained

Radioactive decay is the standard exhibit for irreducible chance: the law is exact in aggregate and the individual event unpredictable. On this substrate the two halves come apart, and the interesting one is the aggregate.

Proposition 13.1 (Exponential decay is what an unretained phase looks like)**.** *A decaying nucleus is a frame with its own closure cycle, and its decay is determinate in its own cycle* *count. What no frame holds is* how far through that count it is*: a cycle has no fixed length and each does a variable amount of change (Graphic Equalisation's Proposition 13.7, that the unit of inferred time is a cycle and requires closure), so there is no frame-free conversion from the nucleus's count to the observer's. Retention is paid, and nothing here pays to retain the phase.* So there is no age for a decay probability to depend on*, and a hazard with nothing retained to depend on is constant* with respect to everything the nucleus holds*.*

The qualification in that last clause is load-bearing rather than cautious. A hazard constant *simpliciter* is exponential decay and nothing else, and exact exponentiality turns out to require something this account denies — which is the subject of the deviations below.

The qualification is what earns the proposition, because it is where the account says more than its rival. *Irreducible chance does not predict a distribution.* That decay is undetermined is consistent with any law whatever — peaked, heavy-tailed, bimodal — and the exponential has to be put in by hand alongside it, as an observed fact about nuclei rather than a consequence of their being undetermined. Here the exponential is forced: memorylessness is not an extra postulate but the absence of a retained quantity, and constant hazard has exactly one survival law. *A nucleus that carried its own age would be a more expensive object*, and Graphic Equalisation's write-economics (Proposition 7.12) says who pays for the carrying. A determinate countdown — a nucleus that knows its remaining ticks — is the model this proposition is most likely to be mistaken for, and it is refuted by the data it is meant to explain: survivors of a countdown are nearer their deadline, the hazard rises with age, and the observed law would be peaked rather than exponential.

Nothing here is a local hidden variable of the kind Bell forbids. Decay times of separated nuclei are not a correlation between separated measurements, so no inequality is engaged; and where one *is* engaged, the account's answer is the superframe dimension of Section 6 and not this phase, which must not be promoted into one.

The exposure is the deviations, and they are real. Standard quantum mechanics predicts departures from exponentiality at both ends: quadratic behaviour at short times, and a power-law tail at long ones (Khalfin, 1957). Both have been reported — the short-time departure in the tunnelling of ultracold atoms (Wilkinson et al., 1997), the long-time one in the luminescence decay of organic molecules (Rothe et al., 2006). A constant hazard admits neither, so the proposition owes an account of both.

It has one for the short end and it is a prediction rather than a repair. Graphic Equalisation's cycle-unit result (Proposition 13.7) makes inferred time a *cycle* and requires closure for it, so below one closure cycle of the *observing* frame there is no inferred-time interval for a law to be exponential in. Exponentiality is a statement in inferred time; short of a cycle there is no such statement, and a departure there is expected on this account and unexplained on the bare irreducible-chance one.

The long end inverts, and the inversion is worth stating carefully because it is easy to overstate. Khalfin's argument is that exactly exponential survival requires the state's energy distribution to be exactly Lorentzian, and a Lorentzian has support on the whole line, including arbitrarily far below any threshold; a Hamiltonian with a ground state is bounded below, so the distribution vanishes on a half-line and its transform cannot decay exponentially (Khalfin, 1957). *Exact exponentiality therefore requires a spectrum unbounded below* — which is to say, it requires a continuum quantity of unbounded support to be a frame's own state distribution. This paper has already denied exactly that: continuum structure lives in the maps between frames and never in a frame's own stepped states (Section 2). So exact exponentiality is a cross-frame idealisation that no frame exhibits, and a departure from it at long times is what this account should have predicted rather than what threatens it.

What that earns is the deviation in kind, and not its form. The power law and its exponent follow from the threshold branch point, which is a fact about the composite system's spectrum and not about what the nucleus retains; nothing here derives them, and treating the inversion as though it did would be claiming the result rather than the direction. So the standing exposure is narrower than it was and is still an exposure: *if the long-time tail is confirmed with an exponent this account cannot reach, the proposition is bounded and not exact.* What is no longer available as an objection is that the deviation exists at all.

One further thing the account does supply is the *visibility* structure, which is worth separating from the derivation it does not supply. The deviation is not absent through most of a decay and then present at the end. It is there throughout and sits beneath the aperture (Section 9), and what changes at long times is not the tail but the exponential: a power law and a falling exponential cross once $e^{-\Gamma t}$ has dropped below t^{-n}, which is many lifetimes in: Rothe et al. (2006) report the crossing at around ten lifetimes. The exact crossing depends on the tail's prefactor and is not estimated here. *So the tail becomes visible because the thing hiding it decays away, not because the tail grows*, and "deviations appear at long times" is a fact about what is resolvable rather than about what is happening.

That is not the missing derivation. The gap is that the constant hazard here is a claim about what the *nucleus* retains, while the deviation comes from the *composite* spectrum being bounded below. Those are different objects. What reconciles them is that the floor is a fact about *any* frame, so it holds of the composite and of the nucleus alike: the constant hazard is what the nucleus retains, the required deviation is what the container's floor imposes, and neither is a claim about the other.

Proposition 13.2 (The spectrum is bounded below because absence is)**.** *A frame's spectrum is bounded below because absence is: occupation is a count, so it is non-negative, and the sign of a frequency is an orientation rather than a rate. With both, $H = \sum_k n_k \hbar\omega_k \geq 0$ term by term. What is derived is that a floor* exists*, not where it reads.*

Stepping alone gives no floor: the integers are stepped and run both ways. *One substrate fact is needed and it is applied in two places*, the second of which is where the sign problem hides.

Occupation is a count, so it is non-negative. A frame's energy is carried by quanta present, $\sum_k n_k \hbar\omega_k$, and each n_k is a cardinality of what is there. Absence is zero and not a negative quantity; there is no less-than-nothing to count down into. The substrate's unbounded direction for a count is the extensive frontier — always one more step outward — which is $\mathbb{N}$, floored at zero by construction, never $\mathbb{Z}$. What is required here is that occupation is a count, not that the ladder is evenly spaced; the $\hbar$-steps of Section 10 are the action quantum and are not needed for this.

Remark 13.3 (The sign of a frequency is an orientation, not a rate)*. And the sign of a frequency is not a rate.* An ω_k appears as $e^{\mp i\omega t}$ with either sign, and this is where the negative-energy problem historically entered. The negative case is *not* a cycle run backwards: it is the same cycle traversed in the opposite *phase*, running forward like any other. *Negative time does not exist and phase does*, which is the distinction Graphic Equalisation states in general (its Remark 13.8, that a cycle reads two ways — how many, and where within): a count of completed cycles has no direction to run backwards in, while a phase is oriented and carries no duration at all. Reading the second as the first is what manufactures a backwards time, and the manufactured object is then what needs forbidding. So the sign is an *orientation* — which way round the relation is read, carried by the edge and not by any magnitude — while the rate itself is a count of cycles against the frame's own cycle (Graphic Equalisation's Proposition 13.7), non-negative for the reason occupation is. *So this is one premise applied twice and not two*: absence floors the count, and the apparent second sign was never a quantity. What looked like a negative-energy state is a positive-energy state read in the opposite orientation — the reinterpretation physics adopted, with the sea of filled states as the alternative that is not needed here.

That is both premises, and the proposition follows.

The zero of energy is a choice of origin, and an origin is read in-frame exactly as a unit is (Section 9), so a spectrum running to arbitrarily negative numbers is no counterexample: a binding energy is negative against a conventional zero and the system is still bounded below by its own ground state, which is the floor this proposition is about. The claim is boundedness, which is invariant. The number at which the bound sits is not, and nothing here needs it to be.

That is the *spectrum condition* — positivity of the energy in every frame, which is where it is usually taken as an axiom (Streater and Wightman, 1964) — arriving as a consequence rather than a postulate: each frame floors its own spectrum for the same reason, and none is privileged, and it closes the argument the other way round from how it was posed. Exact exponential survival needs spectral support running to $-\infty$; the floor forbids it; so *the deviation is not merely permitted by this account but required by it*, and required by the same fact about absence the substrate uses everywhere else. So the leading behaviour is exponential because nothing is retained, and the departure is required because a floor exists — two facts about two objects, not one derivation across them.

The exponent is a different matter and the account is right not to fix it. For a spectral density behaving as $(E - E_{\mathrm{min}})^{\beta}$ just above the floor, the survival amplitude falls as $t^{-(1+\beta)}$ and the probability as $t^{-2(1+\beta)}$, so the exponent is set by β — how many distinguishable configurations sit just above absence. That is a fact about how the frame's dimensions are arranged, which is contingent rule-content (Section 15) and not substrate structure. *So the substrate fixes that there is a tail and cannot fix its exponent, and the reason is principled rather than a shortfall*: the exponent is contingent, and a substrate result that delivered a universal one would be claiming more than the substrate knows.

Which converts the exposure into a test. *The exponent should track the density of states at threshold and not be universal* — differently structured systems should tail differently, and the free-particle s-wave case with $\beta = \frac{1}{2}$ giving t^{-3} is one value among the available ones rather than the value. A universal exponent, the same across systems with different threshold structure, would falsify this.

One identification is doing the work and is worth marking rather than burying: *in-frame energy is a count of quanta.* That is clean in the occupation-number picture and less clean for interacting systems, where the count is not sharp and the physical states are dressed. Nothing above survives if that identification fails for the interacting case, and this section does not establish that it holds there.

14 Cosmology: the initial state, the seed, and self-location

By Graphic Equalisation's Proposition 11.4 the event order has no intrinsic first, so the beginning of the universe is not an intrinsic edge but a *chosen entry* — a boundary condition imposed from the containing frame. This is why physics supplies initial conditions separately from its laws: the laws are the ordering, which fixes no start, so the entry must come from outside. The Big Bang is that entry, the seed; what is "before" it is not an earlier time but the frontier, the pre-relational substrate, unrepresentable from within, the same " ? " that sits below the Planck scale (Section 10).

Proposition 14.1 (The Past Hypothesis is a seed, hence a hypothesis)**.** *The low-entropy initial state from which the second law takes its direction — the Past Hypothesis — is a seed: the initial rule-and-state configuration installed from the container. Its long-standing status as an assumption rather than a derivation is therefore correct in kind, since a seed cannot be derived from within (a mint cannot authorise its own installation). The arrow of time then splits cleanly: its* mechanism *is no-copy accumulation (Section 12), and its* origin *— that there is a low-entropy state to rise from — is the seed. The direction points away from the imposed low-entropy start; the running is no-copy.*

Proposition 14.2 (Why this seed: self-location)**.** *Why* this *seed — and, equally, why this α, this gauge group — is dissolved rather than declined, and what dissolves it is self-location. A* *map is referenced from "you are here," and the seed is the here: the origin the frame is drawn from, as $c = 1$ is the unit it is measured from. The observer is not independent of it — by frame-relative identity a different seed is a different observer — so "why this seed rather than another" assumes a trans-seed observer who could compare, and there is none (Axiom -1). It is that way because we are this way, and we are this way because it is that way: one determination read from inside, not two facts one explaining the other.*

This inverts the fine-tuning inference. The constants are not tuned *to* a pre-existing observer; the observer is what those constants produce, so the apparent coincidence is the co-determination of observer and seed mistaken for a tuning aimed at a target. What remains out of reach is only *derivation*: no formula computes α or the seed. The *why* is answered; the *value* is not derived. Reference points take no "why" — they are where the why is asked.

15 Dimensions are contingent; time is optional

Time is not a must. A frame whose rules are not firing — inert, a rock — has no time at all: nothing happens in it, there is no succession, and in its own frame it merely *is*. What an external clock calls "later" is, for the rock, only another *is*; the weathering it undergoes is the *supergraph's* succession applied to it from above (Graphic Equalisation's Proposition 6.5: admissibility is self-governance, not armour), not the rock's own. Time belongs to active, inferring frames — those with a firing closure loop to iterate (Graphic Equalisation's Proposition 13.7) and the inference to represent the succession. The rock has neither, so it has no time; its rules exist but are inert *at the grain at which it is a rock.* Nothing here claims a grain at which nothing runs.

Proposition 15.1 (The observed time is one-dimensional)**.** *Every observed time is one-dimensional, and one succession is what self-change lays down: a frame's own changes are strictly ordered and none are concurrent. Independent successions are not prohibited; the single observed axis is selected, not forced, and time itself is optional, absent from every inert frame.*

Remark 15.2 (The selection of one time axis is conjectured, not derived). What selects the single observed time axis is conjectured here to be the same filter that selects three spatial dimensions — decoherence and stability — and not a necessity. That is a conjecture and is marked as one: unlike the $N = 3$ case, which has Ehrenfest's stability result behind it, no comparable result is cited for the time axis and none is claimed. So one-dimensional time is observed and selected, not forced; multi-dimensional time is unobserved, not forbidden.

Space is N-dimensional by contingency: the number of positional coordinates the rules address is rule-content, so "why N" is "why this rule-set," answered by self-location (Section 14). Why $N = 3$ specifically is that self-location filtered by stability — Ehrenfest's result that stable orbits and stable atoms exist only in three spatial dimensions (Ehrenfest, 1917), so observers occur in the three-dimensional rule-sets and we are the observers such a rule-set produces. And the $3 + 1$ *signature*, time set apart from space, is the succession/position distinction: time is the change-axis, the one succession, space the config-axes, the many positions; one time and N space is one-succession-and-many-positions read as a signature.

The contingent-not-necessary status of these verdicts — and of the gauge group, the dimensionless constants, the arrow, and the value of c — is licensed by the minimal-universe argument (Section 1; the mind companion's Proposition 2.1): a rock is a universe at the grain at which it is a rock, and the minimal universe does without them, so none can be compulsory.

16 Identical particles are functional identity

Graphic Equalisation's Axiom -1 holds that there is no operational view from nowhere; that two things with no difference that makes a difference are the same is its *consequence* — functional identity — and its Theorem 6.10 adds that one cannot say which of two is which independently of an individuating frame. This is the quantum treatment of identical particles exactly: two electrons carry no label, and "which is which" names no difference and so has no content. Classical physics labels identical objects — treats two identical bodies as distinct in principle — and that label is a fiction, a distinction imposed where none exists.

Proposition 16.1 (Quantum statistics, and the Gibbs paradox, are functional identity)**.** *Classical Maxwell–Boltzmann counting labels identical particles and over-counts arrangements; quantum Bose–Einstein and Fermi–Dirac counting treats them as one where they are indistinguishable. The Gibbs paradox — the spurious entropy of mixing two identical gases — resolves by not labelling them, which is Axiom* -1*, and ties to Section 12: mixing entropy counts arrangements the frame can tell apart, and an exchange of identical particles is not one. The* $1/N!$ *Gibbs correction is functional identity made quantitative.*

Corollary 16.2 (Pauli exclusion is "distinct things need a distinction")**.** *If two fermions were in the same state — the same in every quantum number — they would carry no distinguishing distinction, and by Axiom* -1 *would be one, not two. To be two they must differ somewhere. The exclusion principle is therefore the requirement that distinct things be distinguishable: there is no such thing as two indistinguishables in one state, because that "two" names no difference. Exclusion is on this reading consistent with the arithmetic of identity rather than a force.*

Remark 16.3 (The honest limit: the identity argument does not select fermions)*.* The corollary's argument is weaker than it looks, and the boson case shows why: it applies verbatim to two bosons in one state, which is observed and which the Gibbs count above needs to be genuinely two. So Axiom -1 does not *derive* exclusion — exclusion is *consistent* with it, and what actually distinguishes the fermion case from the boson case (the minus sign under exchange, tied to a 2π rotation) is the spin–statistics theorem, which needs structure this account does not supply. Nor does "same in every quantum number" by itself individuate: two electrons in distant atoms differ by position, and it is the full state including that which the argument must range over. The framework grounds *that* particles are indistinguishable, and hands the fermion/boson split back untouched.

17 Positioning and prior art

The pieces are individually established; the contribution is the conjunction under one change-economy and the mechanisation of shapes prior art postulates, geometrises, or offers heuristically.

Discrete substrates and emergent spacetime. Several programmes derive relativistic structure from a discrete substrate, and two are closer to the change-budget of Section 3 than any continuum account. D'Ariano and Tosini (2013) obtain the metric from *pure event-counting* on topologically homogeneous causal networks, with time dilation appearing as an increased density of foliation leaves within one tick of a clock and length contraction as the corresponding decrease in event density. That is the same move made here and made earlier, and the counting reading of dilation is theirs, not this paper's. Concretely, where D'Ariano–Tosini compare the density of foliation leaves associated with a clock tick, this paper compares how a cycle's variable throughput is divided between motion and internal change: the former supplies a metric-counting account, while the latter is the additional mechanism claimed for dilation, mass, and change-load. Three things are added rather than repeated. Their result is stated for *topologically homogeneous* networks, which they argue costs no generality since connected events can always be coarse-grained until homogeneity holds. That defence is sound at the coarse-grained grain, and it is exactly the grain this paper does not work at: a cycle's length varying with the rules and the graph is the mechanism here, and coarse-graining until it does not vary would discard the quantity the budget is about. The difference is therefore real but narrower than it first appears — not that homogeneity is a defect in their account, but that the variation it averages over is what carries the physics in this one. Their counting delivers the metric; the budget additionally *splits* — throughput spent on motion or on internal change — which is what yields mass as reserved budget, general relativity as change-load rather than only the special-relativistic metric, and the equivalence principle as the seam between the two (Section 4). And their result is a result about spacetime; the same economy is run here through collapse, entanglement and the amplitude weights (Sections 5 to 7), and belongs to a substrate of which physics is one embodiment rather than to physics alone. Knuth and Bahreyni (2014) derive the Minkowski metric and the Lorentz transformations from consistent quantification of a causally ordered set with respect to an *embedded observer*, explicitly without assuming the constancy of c; that is the closest existing result to the reading of c given above, and it reaches it by a quantification argument rather than by a throughput economy. The Wolfram model (Wolfram, 2020; Gorard, 2020a) derives general covariance from causal invariance and Lorentz covariance from flat foliations, but stipulates c-constancy in its definition of edge lengths (Section 2) and, in the quantum companion (Gorard, 2020b), introduces the Born weights as an a-priori rule rather than recovering them — which is the respect in which Section 7 differs from it. Causal set theory (Bombelli et al., 1987; Surya, 2019) takes order and counting as primitive without rewriting dynamics. The honest summary is that emergence of relativistic structure from a discrete substrate is established prior art with several independent routes, and this paper does not claim the emergence. What it claims is narrower and, so far as these sources go, unoccupied: one budget, split two ways, carrying the special and general cases together and continuing into the quantum content of the same substrate without a further postulate at either seam.

Deriving c, and mass as internal motion. That c should be *derived* rather than postulated has precedent by a different route. Ignatowsky (Ignatowsky, 1910) and, cleanly, Lévy-Leblond (Lévy-Leblond, 1976) obtain the Lorentz transformation from the relativity principle together with homogeneity, isotropy, and group structure alone, with an invariant speed *emerging* rather than assumed and its value left empirical; those derivations use symmetry as the engine where the present one uses the change-substrate — c as each frame's own change-throughput unit, 1 by construction. The reading of mass as the budget reserved for internal change has two standing precedents, offered heuristically rather than mechanised: Schrödinger's *zitterbewegung*, the electron's rest energy as internal motion at c (Schrödinger, 1930), developed as a rest-mass-from-internal- circulation interpretation by Hestenes (Hestenes, 1990); and the elementary result that confined massless radiation — light in a box — carries rest mass E/c^2, internalised c-motion appearing as inertia. The budget-split itself is the constant-magnitude four-velocity of Minkowski geometry (Minkowski, 1908).

Relativity as postulate. Einstein's special (Einstein, 1905) and general (Einstein, 1916) relativity take c-invariance and the equivalence principle as postulates; the present account renders the first a definitional consequence (Proposition 2.2) and the second a common cause (Section 4), at the cost of claiming only the shapes.

Observer-first programmes. The starting point of Sections 5–7 — states relative to a frame, no god's-eye fact — is shared with several live programmes, and the disagreements matter more than the agreement.

Müller (2020) is the most direct competitor. It takes the first-person observer state as primitive and adds one postulate — that algorithmic universal induction fixes the chances of what the observer sees next — from which it derives, as an asymptotic statistical consequence rather than an assumption, that observers find themselves in an external world governed by simple computable probabilistic laws. The target is exactly the target here: an objective world *emerging* from an observer-first base rather than being assumed behind it. The mechanism is incompatible. Solomonoff induction over sequences of observer states is not graph rewriting under an admissibility grammar, and nothing in this paper reduces to it, reproduces it, or is supported by it. The two accounts owe the same debt — why any shared world at all — and pay it in different currency; if Müller's route is the right one, the substrate proposed here is at best a redundant second description of it, and this paper claims no agreement it has not earned.

Höhn (2017) and Höhn and Wever (2017) are the closest in *shape*. An observer interrogates a system with binary questions; the system's state *is* the observer's catalogue of answers, held by the observer and not by the system; and four rules on information acquisition yield the projective measurement structure, entanglement, and monogamy. A knowledge structure over a question graph, with constraints governing which questions may be jointly asked, is typed structure plus admissibility with states relative to a frame — nearer to the machinery used here than QBism is, and reaching qubit quantum theory where Section 7 only recovers the Born weight given contingent rule-content. Worth noting on the other side of the ledger: those four rules yield the correlation structure of qubits *and rebits* alike, so they do not by themselves select complex over real. That is independent support for the verdict of Section 7 — an observer-first reconstruction, pursued to its own conclusion, leaves the same choice open.

QBism (Fuchs and Schack, 2013) shares the observer-first premise and the refusal of agent-independent states, then goes the opposite way on precisely what this paper cares about. It declines to derive an objective world, and it treats the Born rule as a normative addition to Bayesian coherence — a rule an agent *ought* to obey when gambling on its own experiences — rather than as something recovered from deeper structure. Section 7 attempts the recovery, and Section 14 keeps the objective world; QBism is therefore the cleanest available foil, not an ally, and the contrast is the sharpest test of whether the recovery is worth anything.

Relational quantum mechanics (Rovelli, 1996) is the nearest ancestor of Section 5, and the standing problem it has had to answer — how different observers' accounts cohere into anything shareable — is addressed by cross-perspective links (Adlam and Rovelli, 2023), on which one observer's record of another's outcome is required to agree with that outcome. That is the same problem the admissibility grammar is asked to solve here and that algorithmic induction solves for Müller. Three different answers to one question; which is right is open.

Constructor theory. Deutsch (2013) proposes re-founding physics on which physical transformations are *possible* and which *impossible*, and why, with counterfactuals primitive rather than derived from dynamical laws plus initial conditions. That is the nearest philosophical relative of the present account: "which transformations are admissible, and why" is close to "typed graphs plus an admissibility grammar," and both take the possibility structure to be prior to the trajectory. On the Born rule the relation inverts to competition. Marletto (2016) attempts the same recovery from that admissibility-flavoured base and arrives somewhere else: probability is not fundamental, and what look like probabilities emerge from the *unpredictability* of measurement on superinformation media, giving a non-probabilistic account where Section 7 recovers a probability weight from closure, no-privilege, and phase-averaging. The two are not quite rival derivations of one rule, since the explananda differ — Marletto accounts for the *appearance* of stochasticity in a theory carrying no probability weight, where Section 7 recovers the weight itself — and that is a deeper disagreement than a rival derivation would be, not a shallower one. The honest position is that constructor theory reaches its answer with more formal apparatus and less contingency than is claimed here, and that this paper's recovery is exposed to it rather than reinforced by it.

Entropy and the demon. The observer-relative reading of entropy is Jaynes's (Jaynes, 1957); the resolution of Maxwell's demon by the cost of *erasing* information is Landauer's and

Bennett's (Landauer, 1961; Bennett, 1982); life as locally paid negative entropy is Schrödinger's (Schrödinger, 1944) — his phrase is *negative entropy*, the contraction *negentropy* being Brillouin's later coinage. The present account ties all three to one substrate law — cost is the write.

Dimensional constants. That the count of fundamental *dimensional* constants is conventional is Duff's position in the Duff–Okun–Veneziano exchange (Duff et al., 2002); the present account gives the reason (they are frame-units) and draws the boundary at the dimensionless remainder.

18 Falsifiability commitments

On the tags. Each commitment below is marked [SHAPE] or [DETAIL]. A [DETAIL] failing is a revision: the account survives with that mechanism replaced. A [SHAPE] failing costs *range* rather than a mechanism, because what fails is something the substrate is claimed to require or to permit — so the account does not hold where it claimed to, which is the more serious of the two and is still a boundary rather than an annihilation. Each is exposed to attack; the scope caveat of Section 1 applies throughout.

1. [SHAPE] c **as frame-unit.** That a frame reads its own base rate as 1 is definitional and not itself at risk (Definition 2.1: unit c); the falsifiable claim is about *observed* c. Fails if two frames, each obtaining c by the indirect route — measurement, retention and inference — are exhibited reaching different values for one signal, that is, if aperture does not self-calibrate; or if c-invariance requires a postulate that cannot be recovered as the unit reading.

2. [SHAPE] **One budget, two dilations.** Fails if velocity time dilation and gravitational time dilation cannot be exhibited as the same fixed budget spent on motion and on change-load respectively — if the equivalence principle is not their common cause here. Concretely, the account predicts no *third* dilation channel: a clock slowed by something that is neither relative motion nor local change-load would exhibit the failure, and a demonstration that the two known channels draw on separately budgeted throughputs would too.

3. [SHAPE] **Dimensional/dimensionless boundary.** Fails on exhibition of a dimensionless constant that is a ratio of nothing — irreducibly standalone, not expressible as one quantity against another even in principle — or if a dimensional constant carries an irreducible value not absorbable into a frame's units.

4. [SHAPE] **The uncertainty principle is the finite-aperture floor.** Fails if the conjugate trade is not an aperture budget — if a frame can be exhibited resolving two conjugate dimensions jointly past the floor without a compensating loss elsewhere, or if the bound must be postulated independently of the finiteness of internal-change throughput rather than read off it (Section 9). ($\hbar$'s *value* is not claimed; that it is the cell's quantum is.)

5. [SHAPE] **Second law as no-copy.** Fails if entropy can rise in a frame whose *writes* preserve their predecessors, or fall in one without a paid write exporting cost. (Free continuations preserve their predecessors and so are the entropy-neutral case; the claim concerns predecessor-discarding writes, which are the only priced ones.)

6. [SHAPE] **Indistinguishability is functional identity.** Fails if identical particles carry a frame-free label distinguishing them, or if the Gibbs $1/N!$ correction and Fermi exclusion cannot be read as "distinct things require a distinguishing distinction." (The boson/spin–statistics content is not claimed.)

7. [SHAPE] **Measurement is frame-relative collapse.** Fails if a frame-independent fact about whether collapse has occurred is required to describe a Wigner's-friend scenario — if the

friend's outcome and the outside frame's superposition cannot both stand as the event and the map of two frames. (The Born-rule probabilities are not claimed.)

8. [SHAPE] **Entanglement is a superframe dimension.** Fails if the correlation of an entangled pair is a subframe-local quantity rather than a joint dimension NULL in each subframe, or if a reduced single-particle state can be pure — i.e. if the mixedness is not the inaccessibility of a superframe dimension. (The Tsirelson bound and correlation strengths are not claimed.)

9. [DETAIL] **Conservation is the cost side of symmetry.** Fails if a continuous *global* symmetry of the action (a residual-free transformation) carries no conserved quantity — local gauge redundancies are excluded, carrying constraints rather than charges — or if a conserved quantity persists across a genuine change in the rules — in particular, if global energy is conserved in a time-dependent (rules-changing) regime such as cosmic expansion. (The gauge group is claimed to be contingent, not derived.)

10. [DETAIL] **The Past Hypothesis is a seed.** Fails if the low-entropy initial condition is derived from within — from the dynamics, with no boundary condition imposed from a container (Proposition 14.1). What is claimed is that the seed cannot be derived from inside, not that its content is beyond reach.

11. [DETAIL] **Amplitude is directional Narrative; Born reduces to linearity.** Fails if the complex amplitude cannot be identified with a magnitude-times-direction operative-history structure, or if the Born square admits no closed-loop (conjugate) reading. Sharper: given complex, *linearly superposing* amplitudes and no privileged phase, $|a|^2$ is selected (by phase-independence and the additivity of decohered alternatives, with uniqueness from Gleason), so the claim fails if all of those premises hold yet the probability is not the squared modulus. It fails also if the mapping onto the informational reconstructions cannot be made good. (Linearity is *not* claimed derived; the residue is stated in Section 7.)

12. [DETAIL] **Interference is possibility plus superframe forcing.** Fails if interference requires the particle's own admissibility to select among paths, or if a which-path coupling that collapses before the screen does not remove the fringes — i.e. if superposition is not the possibility structure and the superframe does not apply the combination without passing through the subframe's grammar.

13. [SHAPE] **Time is optional.** Fails if an inert frame (no firing rules) nonetheless has an in-frame succession.

14. [DETAIL] **The one-way speed is an absent quantity.** Fails on a determination of the one-way speed *in this universe* that rests on no synchrony stipulation. What fails then is the empirical claim that our rules supply no unlocked counter, not the cycle unit itself: a second dimension's step count is a different unit and not a finer reading of the same one (Remark 3.4).

15. [DETAIL] **The decay tail is required, its exponent is not.** Fails if the long-time exponent is universal across systems with different threshold structure. The substrate fixes that there *is* a tail — exact exponentiality would need spectral support running to $-\infty$, which the floor forbids — and cannot fix the exponent, which tracks the density of states at threshold (Section 13).

16. [SHAPE] **In-frame energy is a count of quanta.** Fails if in-frame energy is not a count of quanta for interacting systems, where the count is not sharp and the physical states are dressed. Nothing in the spectrum-floor argument survives if that identification fails there, and this paper does not establish that it holds (Proposition 13.2).

17. [DETAIL] **Apparent constancy tracks denominator size.** The constants most likely to yield a measurable variation are those whose denominators are smallest against the perturbations available to them, and not the ones deemed most fundamental. Fails if a measured variation, when found, appears first in constants ordered by depth rather than by that ratio (Proposition 9.1).

Self-location (Proposition 14.2) is stated here rather than counted in the list above, being a consequence rather than a wager: "why this seed, this constant, this gauge group" can be posed only from a trans-frame standpoint that could have obtained a different one, which Axiom -1 together with frame-relative identity already denies, so what would have to fail for it to fail is the base axiom and not a risk of its own.
Scope note (not a falsifier). The paper claims shapes only; it would be overclaiming if any passage were read to derive a field equation, a dimensionless constant, or a quantum-gravity result — none is asserted. The Planck-scale claim carries no separate wager: it is covered as a consequence of the finite-aperture floor together with the dimensional/dimensionless boundary, and needs no falsifier of its own. That the observed time is 1-D is claimed decoherence-selected, not forced — multi-dimensional time is unobserved, not prohibited; that space is N-D with $N = 3$ is likewise contingent and self-located. The minimal-universe licence (the mind companion's Section 2), the block universe, free will, personal identity, and death are treated in that companion and carry their falsifiers there.

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