From Possibility to History

How Time Works in VERSF

We usually picture time as a stage that exists whether or not anything is on it. It flows, clocks measure it, and events take place within it.

VERSF is a theoretical framework for the foundations of physics. Within it, time is not an independent stage: before and after arise from the dependence of committed facts, and duration is measured through physical processes within that history. Its technical papers develop this account through mathematical constructions of records, clocks and emergent geometry. This guide explains that account in everyday language.

That is a large claim, and this guide builds it in small steps. The first step seems far removed from the ticking of a clock: the strange way quantum physics treats possibilities. The connection is simple. If time is the order in which things become definite, we must first understand what it means for something to be undecided.

> **The idea in brief**
>
> - Until an outcome is settled, quantum physics describes real possibilities that can reinforce and cancel one another. They are not hidden answers waiting to be read.
> - In VERSF, an outcome becomes a committed fact when a physical record is established irreversibly. A fact cannot be changed. Anything that could still be undone has not become a fact.
> - The dependencies among facts supply the order we call before and after. What cannot be undone accumulates, and that gives the order its direction. Regular processes whose ticks are counted supply clocks.
> - The technical programme develops this picture through explicit results on records, clock relations and emergent geometry. This guide explains those results, the conditions under which they hold and the experiments that can test them.

1 What is superposition?

In everyday life, things seem to have definite properties whether or not anyone knows them. A coin hidden under a cup is already heads or tails. Lifting the cup only reveals what was there all along.

Quantum physics does not always work like that. A quantum system can be in a *superposition*: a state that combines several possible measurement outcomes. What makes this more than ordinary ignorance is that the possibilities can interfere with one another, reinforcing in some places and cancelling in others. A hidden coin cannot do that. Two answers we merely do not know never cancel each other out. [1]

Picture ripples meeting on a pond. Where two crests meet, the water rises higher. Where a crest meets a trough, the surface goes flat. Quantum possibilities combine in a similar way, and experiments detect the pattern this leaves. The analogy is imperfect, because nothing material is rippling, but it captures the essential point: a superposition is not a list of settled answers that we have yet to read.

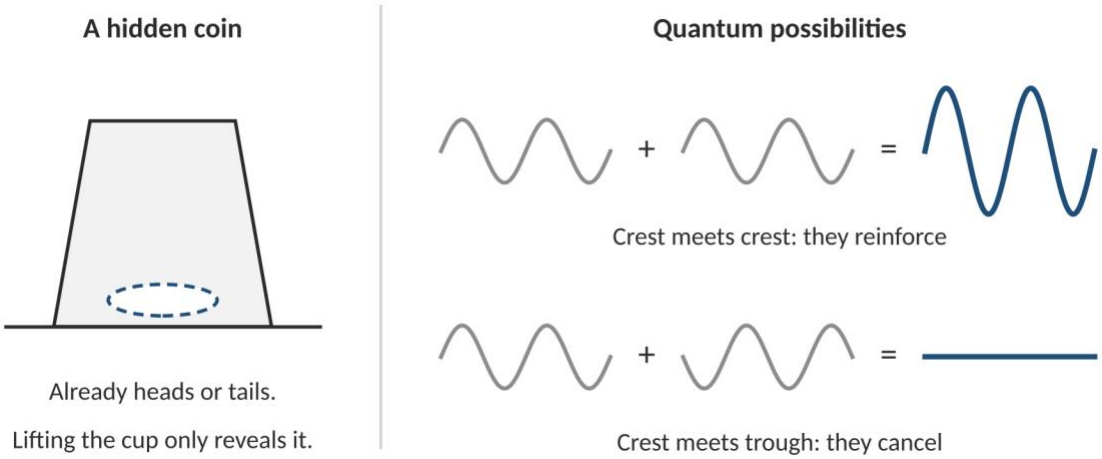


Figure 1. A hidden coin already has its answer. Quantum possibilities behave differently: they can add together or cancel, and experiments detect the pattern this leaves.

A question follows. How does a state made of interfering possibilities give way to one definite result?

2 What does measurement actually mean?

The word “measurement” can suggest that a person has to look. The essential process is physical. A system interacts with a detector, and the state of the detector comes to depend on the state of the system. An electron arriving at a sensor triggers a tiny electrical signal, which is amplified and stored. Someone may read the result afterwards, but their awareness is not what made the sensor respond.

The wider surroundings matter too. Air, light and heat all carry away information about a system, and once that information has spread, the interference described above can no longer be detected in practice. Physicists call this *decoherence*. It explains why the everyday world shows no visible superpositions.

Decoherence leaves one question open. It explains why the possibilities stop interfering. By itself, it does not say why one particular outcome is the one that occurs. The interpretations of quantum physics part company at exactly this point. VERSF’s answer rests on an idea it calls **commitment**.

3 From a possible outcome to a committed fact

In VERSF, a committed fact is an outcome that has been established in a physical record and cannot be un-established. Three features define it.

- **It is recorded.** “Record” here does not mean writing, a photograph or a computer file. It means that a physical difference has been retained: something about an interaction is now carried by the state of the world. A detector that has fired differs physically from one that has not. The smallest possible fact is a single settled yes-or-no difference, which is the “bit” of the framework’s technical papers. [8]
- **It cannot be changed.** This is not an extra property attached to some facts. It is what the word means here: if something can still be undone, it has not become a fact. A history of facts can be added to by further facts. No fact in it can be altered or withdrawn.
- **It has consequences.** Further events can depend on it. A possibility describes what could be recorded. A committed fact belongs to the history that everything following it must take into account.

The second feature draws a sharp line, and laboratory physics shows which side of it things fall on. Reversible traces can sometimes be coherently undone. In carefully isolated experiments, the interaction that left a faint quantum trace of which route a particle took can be run backwards while everything involved is still under control, and the trace is removed. In VERSF's terms nothing was committed there. The trace could be undone, so it was never a fact.

What turns a reversible trace into a fact? VERSF's answer is a physical one. A quantum system left to itself changes reversibly, and nothing is permanently written. That changes when the system couples to something capable of writing permanent records: an apparatus, or simply the surrounding environment. The technical papers call the first situation the pre-entropic regime and the second the entropic regime. These are not two kinds of stuff. They are two ways in which one and the same system can behave. [3, 8]

What decides when record-writing begins? One VERSF measurement model uses a measurable quantity called alignment: how well the internal rhythm of the quantum system matches the reference rhythm supplied by the apparatus, like the fit between a key and one particular lock. When the fit is good, record-forming events happen more often. Alignment governs when a fact forms; the outcome probabilities follow the Born rule. The wider programme also derives that probability rule from explicit geometric and record-consistency premises, rather than only inserting it into the measurement model. [3, 18]

This gives the idea a sharp test. Prepare quantum states with the same odds for each outcome, the same purity and the same amount of coherence, which is the capacity to interfere, but with different phases relative to a fixed apparatus reference. The proposed alignment mechanism predicts a particular variation in the rates at which such states lose their quantum character. The standard model of this kind of decoherence, in which the rate does not depend on that phase, predicts none. The variation has to be separated from ordinary apparatus and noise effects, so the experiment is demanding. A null result would constrain or rule out this mechanism at the sensitivity tested. It would not by itself rule out VERSF as a whole. [3]

Notice what kind of claim this is. VERSF is not saying only that we come to learn an answer. It is saying that an outcome becomes established in reality, whether or not anyone learns of it.

4 How facts build a history

Take an ordinary chain of events. A detector registers an electron. Its signal advances a counter. The counter's display changes. A camera photographs the display.

We would normally say that the detection came first and the rest came later. VERSF asks what gives that statement its meaning, and the answer it offers is dependence. The photograph could not show that reading unless the reading had been produced. The reading could not reflect that detection unless the detection had occurred. Nothing runs the other way: the detection did not need the photograph.

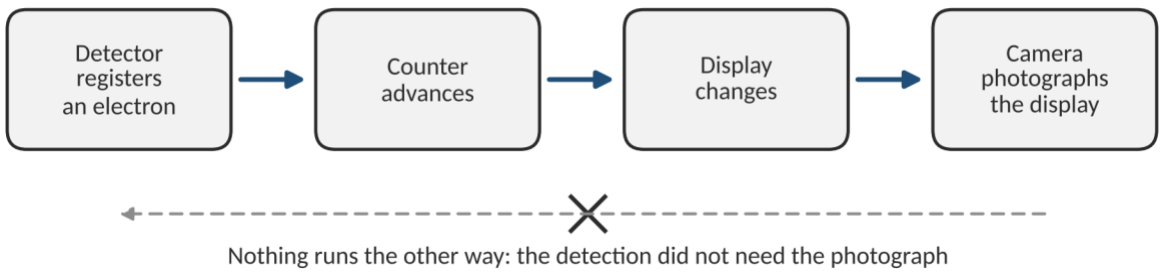


Figure 2. Each fact in the chain is needed by the next. The order was found without a clock, only by asking what each fact required.

So the chain has an order built into it, and we found that order without consulting a clock. We only asked what each fact required.

In VERSF, physical facts form this kind of structure. Reality has a history because established facts support and constrain further facts. The technical programme formalises local record sequences and their relations; the detector example illustrates that structure. [7, 19]

5 How that history becomes time

Here is the central idea.

> **In VERSF, the before and after of time is the order that dependence gives to committed facts.**

Both ingredients are needed. A heap of unrelated facts would have no before and after, however many it contained. The dependencies are what turn a heap into a sequence.

VERSF separates two things that everyday speech runs together. Reversible change has a sequence, like the pages of a book, which can be read in either direction. It has no built-in direction and marks no difference between past and future. Only the formation of facts does that: it separates a past that is written from a future that is not. [3]

Dependence supplies before and after. To measure how much time separates two facts, we also need a physical ruler: a clock. Sections 8 and 9 explain how the programme connects these two parts of the account and obtains the relativistic behaviour of that ruler.

An objection arises naturally here. To say that facts “accumulate”, or that outcomes “become” definite, sounds as though time is already running in the background, with facts being added as it passes. If that were so, the explanation would be circular.

The reply is that the order is not borrowed from a background clock. It is defined by dependence alone. One fact is *before* another when the second depends on it, directly or through a chain of intermediate facts. Nothing more is meant by the word. Everyday language is soaked in time, so words such as “becomes” and “then” are hard to avoid, but in this account they are shorthand for the structure of dependence, not references to a hidden clock outside it.

In VERSF, completed facts are not carried along by time. They are what time is made from.

6 Why time has a direction

Think of a footprint in wet sand. A foot presses down. The sand keeps the impression. Someone photographs it. A wave washes the sand smooth.

The footprint depended on the step, and the photograph depended on the footprint. The wave changed what evidence remains. What the wave did not do is make the step never have happened. Smoothing the sand is a new fact added to the history, not a change to an old one.

Ordinary physics agrees on that much. Wiping away evidence is itself a physical process, and it leaves traces of its own, typically a little heat released into the surroundings. [2] Erasing is not undoing.

In VERSF, the direction of time follows from what a fact is. Because a fact cannot be changed, a history of facts can only be added to. Later facts rest on earlier ones, and earlier facts do not rest on their consequences. The arrow of time is that asymmetry.

Why can a fact not be undone? VERSF's answer starts from a feature of quantum physics. When things interact they become linked, so that the pair can no longer be fully described one member at a time. Physicists call the link *entanglement*. Entanglement is not irreversible in itself. While the systems involved remain under joint control, the interaction that linked them can be run backwards and the link removed. That is the reversible situation of Section 3.

VERSF locates commitment beyond the reversible situation: the record's correlations have entered degrees of freedom that cannot subsequently be brought under the joint control needed to undo the record. From then on a link can be moved but not removed: clearing it from one place means passing it on to another. Think of wiping a whiteboard: the board comes clean, but the ink has moved to the eraser. [4]

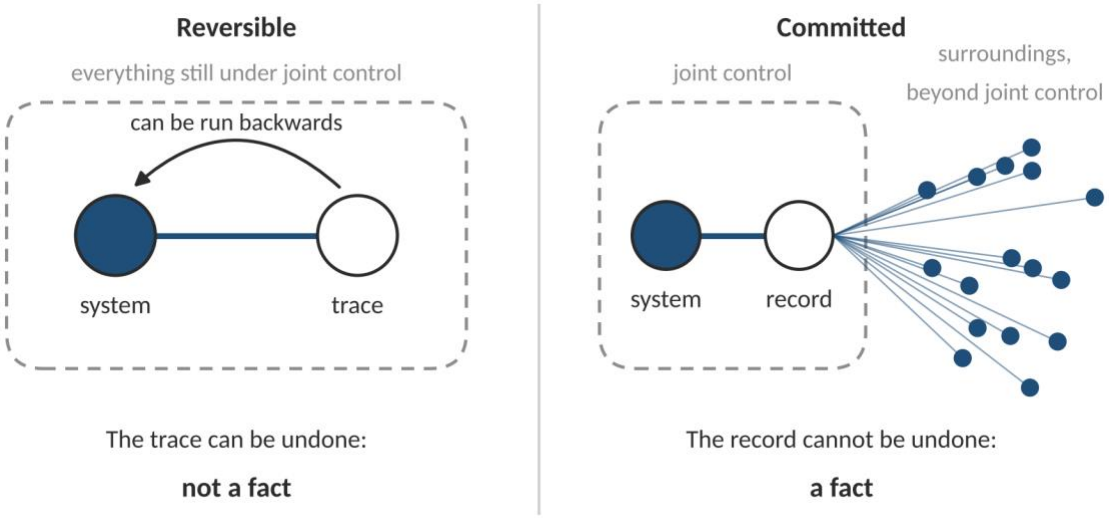


Figure 3. Left: while everything involved stays under joint control, the interaction can be run backwards and the trace removed. Right: once the record's correlations lie beyond joint control, the record cannot be undone. Only the second is a fact.

Each such transfer leaves a residue, and the residue only accumulates. VERSF treats the running total as a ledger to which entries can be added and from which none can be removed. The direction of time is the direction in which that ledger grows. The argument uses established results about quantum information together with one stated principle: no part of the universe can gather up and control all of the universe's connections. [4]

This differs from the usual account, and the difference should be stated fairly. Most of the basic laws of physics work equally well in either direction, so physicists generally trace the arrow of time to the steady growth of disorder from an exceptionally ordered early universe. That account already explains why the world holds footprints of the past and none of the future, so the footprint by itself does not favour VERSF. VERSF's claim concerns what lies underneath. On its account the arrow does not depend on a specially ordered beginning, and the growth of disorder is the footprint the ledger leaves, not the cause of the direction. [4]

The footprint is only an illustration. The claim itself concerns the commitment of physical records at the most basic level.

7 Does every fact remain visible forever?

No. Photographs fade, memories change, footprints vanish, and information can spread so thinly into the surroundings that recovering it is practically impossible.

Two questions need to be kept apart. Can we still find evidence of an event? And did the event belong to the history that produced the present situation? Commitment concerns only the second. Evidence can be lost. The fact cannot be changed.

Nor does VERSF require a cosmic filing cabinet holding a readable copy of everything. The history is carried by physical relationships and consequences, not by an archive. A particular piece of evidence can disappear while the world continues from the history in which it was made. Its disappearance is one more fact in that history, not a change to an earlier one.

8 What does a clock measure?

Order is not yet duration. Knowing that a detector fired before a display changed does not tell us whether a billionth of a second or an hour separated the two.

Nor can duration be found simply by counting facts. A busy room does not age faster than a quiet one, and a million unrelated records say nothing about how many seconds have passed.

What a clock adds is regularity. A clock is a physical process that repeats dependably, such as a swinging pendulum, a vibrating crystal or an oscillating atom, joined to something that counts the repetitions. The oscillation itself may run undisturbed. It is the registered count that enters the history: each counted tick is a committed fact. A working clock is therefore a chain of facts like any other, with one special virtue: its steps are uniform enough to serve as a ruler. Measuring a duration means comparing some other process against that ruler, by counting the ticks registered between one fact and another. No outside timekeeper is needed to certify the ruler, either. Good clocks are simply those that stay in step with one another and with the rest of physics.

Seen this way, a second is not a quantity of some background substance flowing past the clock. It is a count along a standard, regular chain of facts, used to gauge all the others. The official definition of the second already has this form: a fixed number of oscillations associated with one particular atom, caesium. Every measurement of time ever made has been a count or a comparison of physical events. No experiment has reached time in any other way. [6]

Suppose an atom travels undisturbed through an apparatus and is detected at the far end. The laboratory clock records the interval between release and detection. Within the ideal isolated atom, however, no new irreversible record need form during that journey. Its quantum state can nevertheless evolve, and the later detection can reveal effects of that evolution. VERSF distinguishes these two things: reversible quantum evolution and the production of a committed record history. [3]

How does VERSF connect facts to the rates of real clocks? Its technical papers propose that a fact is not completed in a single step. Many smaller underlying steps are needed for each one, and the number needed is not the same everywhere. Where more steps are needed for each completed fact, a clock registers fewer ticks than an identical clock elsewhere. Each clock seems normal to itself. The difference shows only when two clocks are compared. [5, 9]

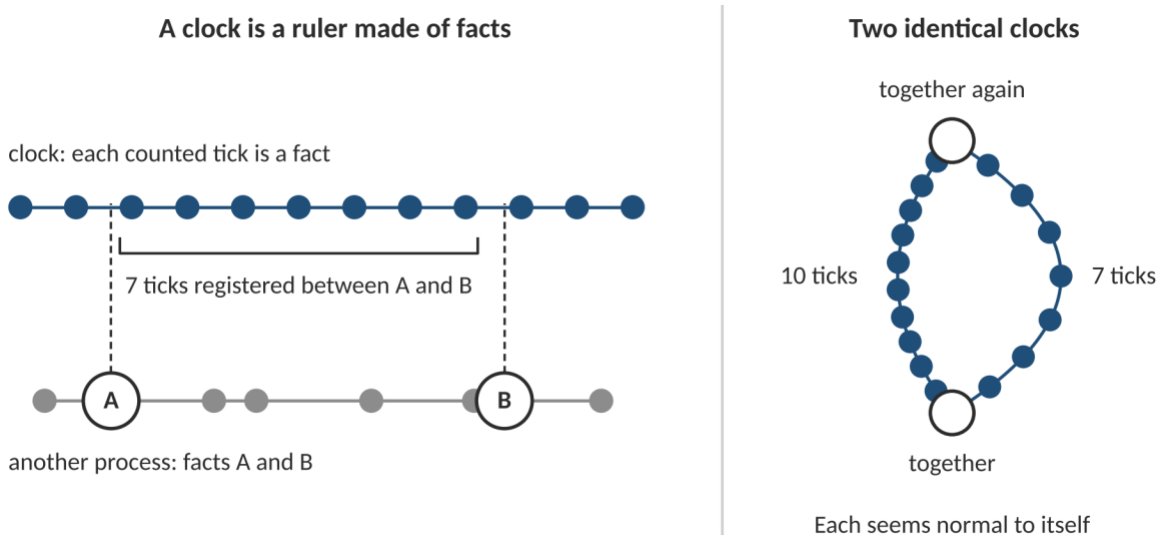


Figure 4. Left: a clock is a regular chain of counted ticks, used as a ruler to gauge other processes. Right: two identical clocks that part and meet again can register different counts.

The programme has derived an explicit bridge. The sequential attaching-map paper proves that, in a locally homogeneous region, the conversion from underlying opportunities to emergent physical time must be proportional: composing opportunities must compose their durations. It then fixes the proportionality using the common temporal and spatial Higgs response. One opportunity corresponds to the model's local spacing divided by its invariant propagation speed. Within the stated class, the conversion is unique. [10]

Expressing that scale in laboratory seconds requires comparison with a specified reference clock. Choosing units is different from deriving the clock relation. The substantive condition still identified in this construction is local homogeneity: whether the microscopic dynamics supplies the same conversion regardless of the event or state within that local region. The paper names that condition explicitly. This is a precise boundary on an existing result, rather than an absence of a bridge from facts to duration. [10]

9 Is there one universal present?

An ordered history need not be a single queue in which every event everywhere receives a unique place. Some facts are linked by dependence. Others arise far apart, with neither required by the other, and for such a pair the structure of dependence does not say which came first.

A better picture than a queue is a growing network: many local chains of facts, joined wherever one depends on another. "Growing" is a convenient word for the addition of facts. It does not imply a second, hidden clock outside the universe that paces the growth.

This feature fits what is already known. Einstein's relativity established more than a century ago that there is no universal "now". Observers in relative motion can disagree about the order of two distant events, but only when neither event could have influenced the other. Whenever one event could have affected another, every observer agrees on their order. A history ordered by dependence has the same shape: a firm order where there is connection, and none imposed where there is not.

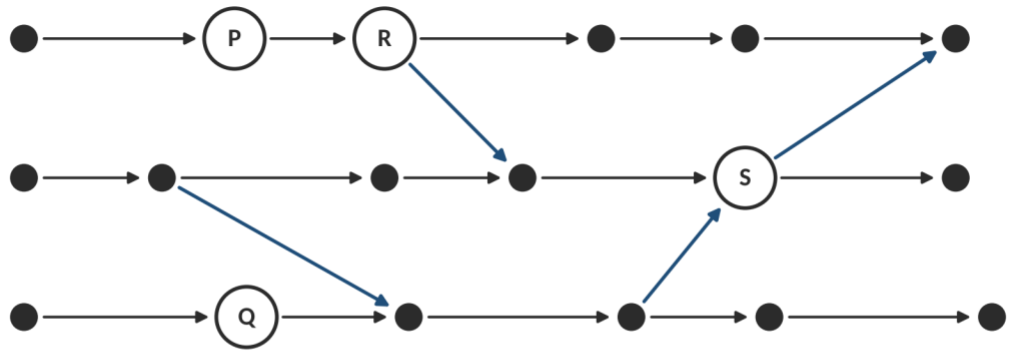


Figure 5. A history pictured as a network of facts. Where dependence connects two facts, their order is fixed. Where it does not, no order is imposed.

Relativity makes exact predictions: clocks in relative motion and at different gravitational potentials can accumulate different durations. VERSF's ticks-per-bit picture interprets these differences through the cost of completing facts. Its geometric papers go further. They construct a Lorentzian metric, the mathematical geometry of relativity, and obtain the usual proper-time relation for motion within its causal cones. In a locally flat region this gives the familiar special-relativistic time-dilation factor. [5, 11, 13]

The wider gravitational programme also contains Einstein-type field equations, a unified covariant action and a derivation of the Einstein–Hilbert action from refinement transport. Follow-on papers construct the transport and address its Lorentz symmetry at substrate level. Within the stated continuum, symmetry and recovery conditions, these papers recover the Einstein form of gravity. The remaining questions concern the physical realisation and quantitative matching of those constructions, including their matter coupling and correction terms. [12, 14–17, 21]

One further case has to be faced. Two particles that have interacted can be sent far apart and measured separately. Neither measurement depends on the other, and neither can be used to send a signal, yet the two outcomes are linked more tightly than any instructions the particles could have carried from their common origin. Here are two facts with no order between them that are nonetheless not independent.

VERSF describes this through a shared quantum state and locally formed records. The shared state is not a set of classical instructions assigning every possible outcome in advance. No ordering of the two distant measurements is needed for their correlations. The alignment model establishes no-signalling at its effective level, while the broader programme supplies additional results on quantum probabilities and on preserving locality when auxiliary mathematical structure is removed. Those results have distinct premises; the outstanding microscopic question for the alignment model is the construction of its underlying local system–controller–environment dynamics. [3, 18, 20]

10 Where do we fit into this?

We are physical systems inside this history, not spectators of it. Our bodies change, our senses register events, and our brains lay down memories. Each memory depends on the physical events that produced it.

This accounts for a familiar asymmetry. We remember the past and not the future because a memory is a record, and a record can depend only on facts already committed. Our expectations concern outcomes for which no record exists.

The feeling of time passing involves more than this. Attention, emotion and memory all shape it, and an account of physical time does not automatically explain that experience. On one point, though, VERSF is definite. Observers do not make time happen by watching. They take part in the same physical history as everything else.

11 What the theory derives and how it can be tested

A fair account distinguishes the physical principles, the results derived from them, and the evidence that tests their application to nature.

- **Established physics.** Superposition and interference, decoherence, entanglement, the reversibility of undisturbed quantum systems, the physical cost of erasing evidence, the growth of disorder, and the absence of a universal present are all part of mainstream physics. None of them is special to VERSF.
- **The physical principles.** VERSF starts from operational distinguishability, finite physical information and irreversible commitment, with the relevant conservation, locality and admissibility conditions stated in its technical constructions. Its operational-finiteness paper argues that the starting constraints are supported by established physics and finite experimental access. The bit–tick papers derive structural consequences from those constraints. A starting principle can be physically well motivated without being a theorem of the theory that starts from it. [6, 7, 19]
- **The derived structure.** The programme supplies mathematical accounts of record order, irreversible correlation export, local clock attachment, Lorentzian geometry and the Einstein gravitational limit. Its newer Born-rule paper also fixes the quadratic probability weight under stated geometric and operational premises. These are substantive derivation results within their respective domains. Each result has a stated domain of validity, which identifies the conditions under which it can be applied. [4, 7, 10–21]

The main conditions and tests relevant to this account of time are:

- **Measurement dynamics.** The phase-alignment experiment in Section 3 tests a particular record-formation mechanism. Its rate law and microscopic implementation require physical justification and experimental testing. A null result constrains that mechanism at the sensitivity tested; it does not erase the separate results on record order, clocks or geometry. [3]
- **Clock attachment.** The unique local homogeneous conversion has been derived. Establishing its local-homogeneity premise from the microscopic dynamics, constructing the relevant physical clock processes and matching the resulting scale to a laboratory reference remain distinct tasks. The attaching-map paper calls the first of these P-ST6 / D-ST11. [10]
- **Relativistic applicability.** The geometric programme contains explicit Lorentzian and gravitational derivations. Their use requires the specified refinement and continuum conditions; the Einstein recovery also requires its stated limiting regime and source matching. Follow-on transport constructions address particular earlier gaps, while quantitative coefficients, general matter coupling and the full interacting completion remain identified research questions. [12, 14–17, 21]

- **Causal dynamics.** The physical-sector quotient theorem proves that locality passes to observable records when a named causal premise, QC-7, holds. It does not itself derive that premise for every microscopic dynamics. Likewise, the Born paper's causal route uses no-signalling to constrain probabilities; that route should not be mistaken for an independent derivation of no-signalling. Each result addresses a particular part of the quantum-causal construction. [18, 20]

Experimental confirmation. The corpus develops a theoretical explanation with explicit mathematical results, conditions and tests. Independent experimental confirmation is a separate standard: the relevant predictions must be compared with measurements, including tests that distinguish VERSF from competing accounts. The programme can therefore be assessed through its specific derivations and physical predictions.

From possibility to history

The route has run from quantum states whose possible outcomes interfere, through measurement, which ties systems to physical records, to commitment, which turns an outcome into a fact that nothing can change. Facts support and constrain further facts. Their dependencies give an order, the ledger of what cannot be undone gives that order a direction, and regular processes whose ticks are counted give clocks.

The central thought is simple enough to carry away:

> **Time is the ordering of reality's becoming definite: one committed fact providing the basis for what can happen next.**

Source notes

[1] IBM Quantum Learning, Quantum mechanics basics. https://quantum.cloud.ibm.com/learning/en/courses/use-a-qc-today/quantum-mechanics-basics

[2] R. Landauer, "Irreversibility and Heat Generation in the Computing Process", *IBM Journal of Research and Development* 5 (3), 183–191 (1961).

The following sources are papers of the VERSF Theoretical Physics Programme. The guide draws on the wider derivation chain as well as the alignment model; a limitation stated for one construction is not automatically a limitation of every other construction.

[3] *The Pre-Entropic and Entropic Domains: An Alignment-Regulated Boundary Framework for Quantum Measurement, Irreversibility and Emergent Gravitational Response.*

[4] *Entanglement, the Void, and the Arrow of Time.*

[5] *Ticks Per Bit: A Complete Framework for Emergent Discrete Time.*

[6] *Empirical Status of the Operational Finiteness Axioms.*

[7] *Uniqueness of the Bit–Tick Ontology.*

[8] *Distinguishability Dynamics Framework: Foundational Structure and Derivations.*

[9] *Change-Density: From Gravitational Time Dilation to Baryon Structure.*

[10] The Sequential Opportunity-to-Lorentzian Commitment-Time Attaching Map in VERSF: Fold-Semigroup Linearity, Endpoint-Incidence Typing, and Closure of the Physical Temporal Higgs Kernel. Sections 5–9 establish the local homogeneous map and proper-time relation; Sections 18–21 retain its scope and P-ST6 / D-ST11.

[11] Structural Necessity of Lorentzian Geometry in VERSF. Theorems 1L, 1G, 2 and 3; local Lorentz structure, the invariant interval and boosts within the stated hypotheses.

[12] Continuum-Limit Regularity and Cone Convergence in VERSF. Theorems 1–8 and Section 14; convergence and regularity results, with the external refinement hypotheses identified.

[13] Lorentzian Completion of Transport-Generated Geometry in VERSF. Sections 3–9, especially Theorem 9.3 on proper commitment time and time dilation.

[14] Einstein-Type Dynamics from Commitment-Generated Stress–Energy in VERSF. Theorems 4.1 and 10.2; leading Einstein-form dynamics and the GR recovery regime, including the matching and boundary conditions.

[15] Unified Covariant Action for Emergent Commitment Geometry in VERSF. The action construction and recovery theorem, with its continuum admissibility conditions.

[16] Substrate Derivation of the Einstein–Hilbert Action in VERSF. Theorems 3.5, 4.1, 5.2, 6.2, 7.1 and 8.2; the connection, curvature, measure and action emergence chain.

[17] Substrate Emergence of the Lorentz Transport Group in VERSF. Theorems 4.1–9.1 and the open-problem crosswalk; transport symmetry, refinement stability and the remaining quantitative questions.

[18] Further VERSF Deliberations on the Born Rule. 7 November 2026, version 7. Sections 3–6: the quadratic-measure theorem, operational reconstruction, causal consistency and conserved total. The causal route assumes causal independence.

[19] Discrete Commitment and the Necessity of Tick–Bit Structure. The record-order construction and its operational-distinguishability premise; read with the operational scope of [7].

[20] The Adjoint-Removal Positivity and Microcausality Theorem in VERSF. Sections 8–11 and 13.3; positive physical extraction, microcausality descent and the explicit QC-7 antecedent.

[21] Microscopic Origin of Refinement Transport in VERSF. Theorems 5.3, 6.2, 9.1 and 11.1; the discrete transport construction and its inherited conditions. Its transport-group question is addressed by [17].