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, a proposed framework for the foundations of physics, starts somewhere else. It suggests that time is not the stage at all. The before and after of time is the order in which the world settles into definite facts, each one resting on facts already settled. Duration, the thing clocks measure, is built on that order.

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.
> - VERSF proposes that an outcome becomes a *committed fact* when a system couples to something able to write a permanent record. 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 framework rests on a few stated principles and offers a direct experimental test. Both are set out here, together with the work that remains open.

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.

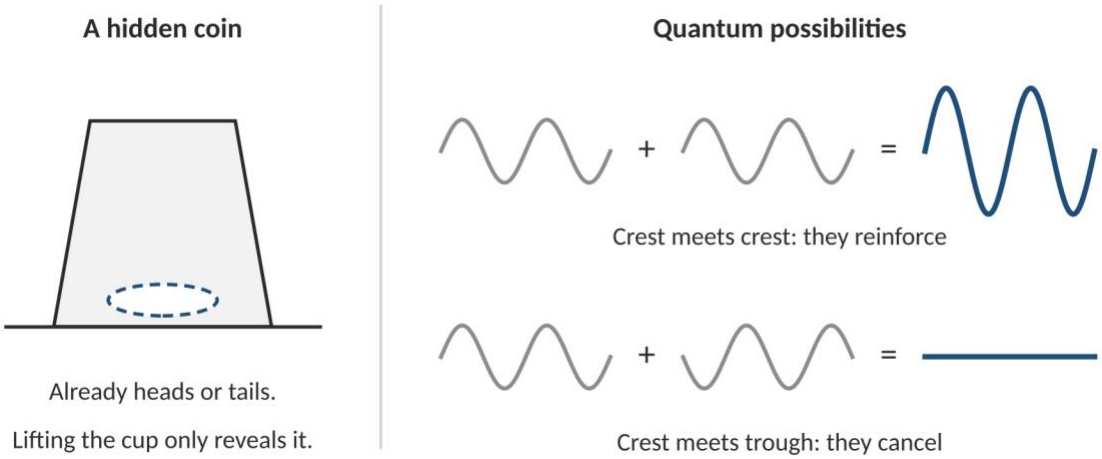


Figure 1. A hidden coin already has its answer. Quantum possibilities behave differently: they can add together or cancel, and experiments detect the pattern this leaves.

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? The framework proposes a measurable quantity it calls *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. Which outcome gets recorded still follows the ordinary rules of quantum physics. Alignment governs when a fact forms. The standard quantum probabilities govern what it is. [3]

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.

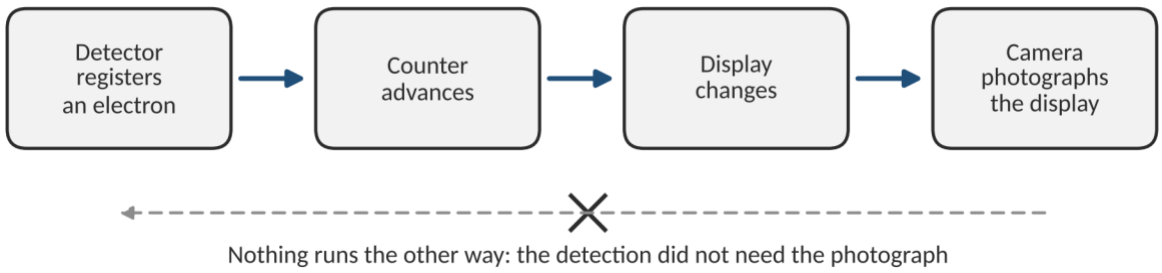


Figure 2. Each fact in the chain is needed by the next. The order was found without a clock, only by asking what each fact required.

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.

VERSF proposes that, at the most basic level, physical facts form exactly this kind of structure. Reality has a history because established facts support and constrain further facts.

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]

It is worth being exact about how much this section delivers. Dependence among facts gives order: which facts come before which. It does not yet give duration, the difference between a second and an hour, and it does not yet give the behaviour of clocks in motion or under gravity. Those are further steps, taken up in Sections 8 and 9.

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]

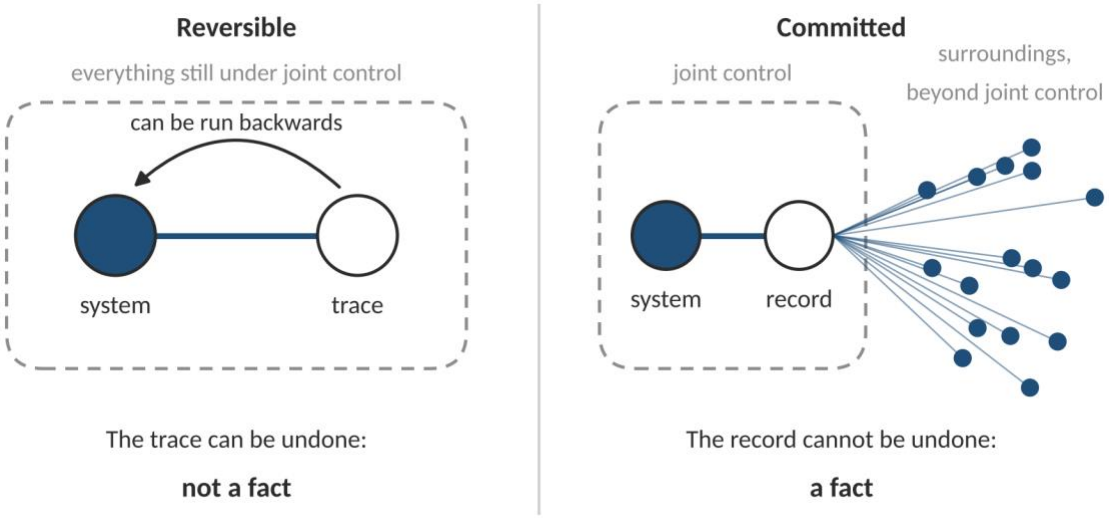


Figure 3. Left: while everything involved stays under joint control, the interaction can be run backwards and the trace removed. Right: once the record's correlations lie beyond joint control, the record cannot be undone. Only the second is a fact.

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]

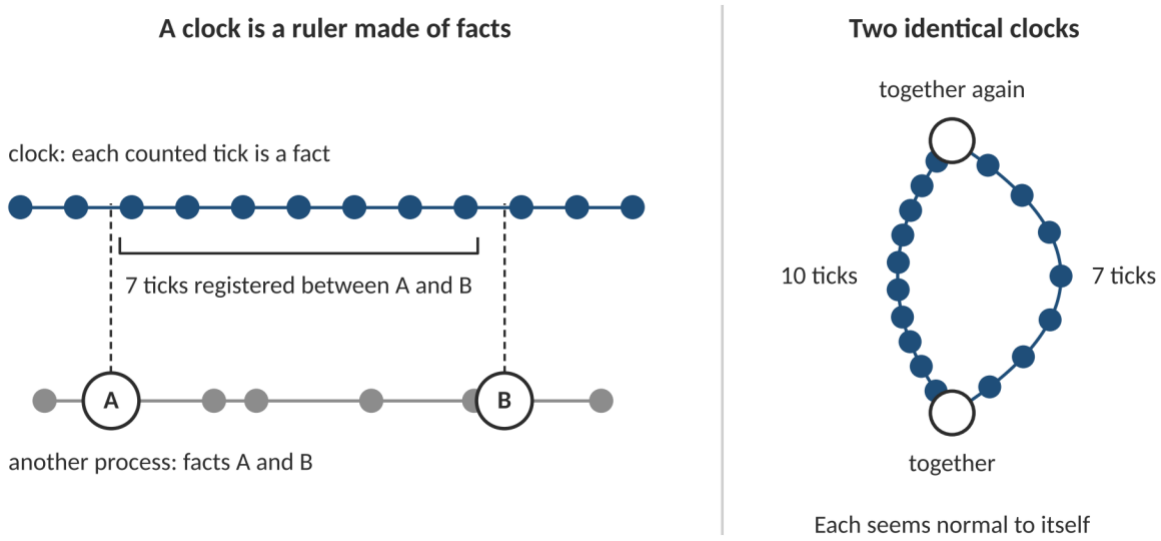


Figure 4. Left: a clock is a regular chain of counted ticks, used as a ruler to gauge other processes. Right: two identical clocks that part and meet again can register different counts.

How far has this been carried through? One of the programme's papers derives a conversion between the count of underlying steps, which it calls opportunities, and the framework's own emergent physical time. The derivation is conditional. Its assumptions are stated, the chief one being that the conversion is the same whichever event occurs, and the paper records the removal of that assumption as work still to be done. What it leaves unresolved is the final translation into laboratory seconds, which needs calibration against a specified reference clock. [10]

So the bridge from facts to duration exists in mathematical form under explicit conditions. Its last span, the match to the readings of real clocks, is still to be completed, and this is the point at which the idea must meet quantitative physics.

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.

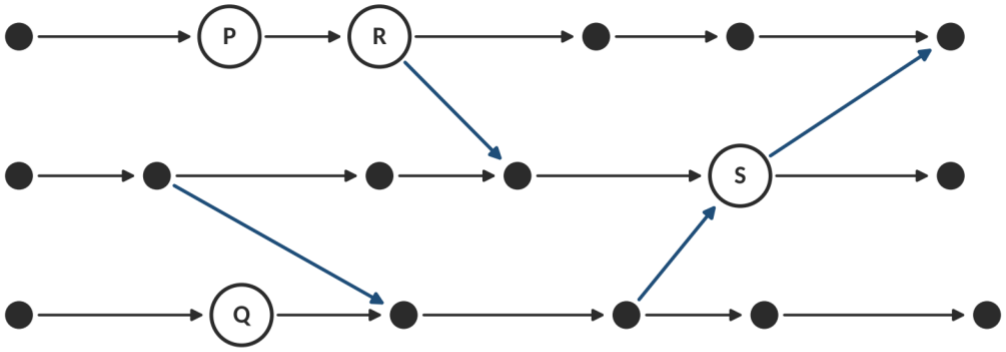


Figure 5. A history pictured as a network of facts. Where dependence connects two facts, their order is fixed. Where it does not, no order is imposed.

A similar shape is not enough, however. Relativity makes exact predictions. Moving clocks run slow, clocks deeper in a gravitational field run slow, and satellite navigation works only because both effects are corrected for. VERSF proposes that the two effects have one source: near a large mass, and for a system in rapid motion, more underlying steps are needed to complete each fact. On this view gravity does not slow a time that was already flowing. A clock deep in a gravitational field is not malfunctioning. It is accurately reporting that fewer facts have been completed there. [5]

That is a proposal about where the effects come from. Reproducing relativity in full quantitative detail is a larger task. It includes the bending of light and gravitational waves, and it includes the way the result for the undisturbed atom of Section 8 depends on the route it took. The framework's own papers describe the full relativistic account as open work. [3]

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's answer is that the link is not a dependence of one outcome on the other. It is the shared connection formed when the particles interacted, of the kind described in Section 6, and both facts depend on that. Each record forms locally, at its own apparatus. The framework's working theory keeps the standard quantum probabilities and shows that nothing done at one end changes the statistics of the records formed at the other. [3] No order between the two facts is needed, and none is imposed. One caution applies. That result holds for the working theory, and the papers state that a deeper construction beneath it has still to be supplied.

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 is established, and what is proposed?

It helps to keep three things apart.

- **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 starting principles.** VERSF builds on a small number of stated principles: that a bounded physical system has only finitely many states that can be told apart; that time means what clocks record; that physics should contain no distinctions which no experiment could detect; and that only a finite amount of information can ever be extracted from a system. To these it adds the principle that no part of the universe can gather up and control all of the universe's connections. Its papers argue that all tested physics behaves as if the first four hold. They remain principles the framework starts from, not results it proves. [4, 6, 7]
- **The VERSF proposal.** An outcome becomes a committed fact when a system couples to something that writes permanent records. Facts cannot be changed. They form a structure of dependence, that structure is the order of time, and the ledger of what cannot be undone gives the order its direction.

The tests the proposal faces, and the work still open, can be collected in one place:

- A direct experiment: matched quantum states that differ only in their phase relative to the apparatus should lose their quantum character at different rates. A null result would constrain or rule out that mechanism at the sensitivity tested, though not VERSF as a whole (Section 3).
- A bridge partly built: a conditional conversion from underlying steps to the framework's emergent time has been derived, and the translation into laboratory seconds remains unresolved (Section 8).
- Open work acknowledged in the framework's own papers: the full reproduction of relativity, and the deeper construction beneath the result that distant records cannot be used to signal (Section 9).

These are where the idea stands or falls. What this guide describes is therefore a proposed explanation of the foundation of time, not an experimentally established replacement for existing physics.

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 remaining sources are papers of the VERSF Theoretical Physics Programme, on which the account in this guide is based.

[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.*