TIME-GEL THEORY · PRE-EXPERIMENTAL PROTOCOL

# Information Looking for Its Owner

A supercooled-water clock test that separates two readings of Time-Gel

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**Abstract**

Supercooled water at $-10\,^{\circ}\mathrm{C}$ keeps trying to become ice and keeps failing. Then, at a moment nobody chooses, one cluster crosses a critical size, the temperature jumps to $0\,^{\circ}\mathrm{C}$ within milliseconds, and an irreversible record is born. This protocol asks one question at that moment: does a clock inside the freezing water run slow, and if so, what is it responding to?

Time-Gel Theory (v12.1) says local clock rate depends on the local density of irreversible interaction, $\rho_I$. Two readings of $\rho_I$ are in circulation. In the *rate* reading, adopted here as primary, $\rho_I \equiv \sigma/k_B$, the local entropy production rate; the clock slows only while the state is changing. In the *stock* reading, kept as a rival, $\rho_I$ is the density of permanent records; the clock stays slow for as long as the ice exists. The two readings predict different outcomes in the same apparatus. The key is a new control cell that produces the same entropy as the freezing cell but forms no crystal.

The protocol is pre-registered in structure, blinded, and written so that a null result is publishable and meaningful. Under the rate reading, the experiment is not expected to improve the existing atomic-clock bound $\rho_{\mathrm{crit}} \gtrsim 10^{33}\,\mathrm{s}^{-1}\mathrm{m}^{-3}$. Its value lies elsewhere: it places the first bound on the stock reading and it tells the two readings apart. No measurement has been made. Every number in this document comes from a definition or an order-of-magnitude estimate.

## 01 // How to read this document

Every claim carries one label. The labels are the method.

| | |
|---|---|
| [MEASURED] | Established by experiment in standard physics. |
| [MODEL] | Calculated from Time-Gel's equations or definitions. |
| [HYPOTHESIS] | A Time-Gel claim that this experiment can test. |
| [DECISION] | A choice made by the author of the theory, recorded before any data. |
| [OPEN] | A point the theory has not settled. |
| [INTERPRETATION] | A reading offered by this document. It may contain a hypothesis, but it is not yet one. |
| [ANALOGY] | An image. Not a physical claim. |

*Record first, interpret later. A label is a promise about what kind of sentence you are reading.*

## 02 // The chain of thought

The chain ends here: for information to "find its owner" is for a distinguishable state to become an irreversible record. Time-Gel attaches a clock effect to that moment. Conventional physics does not. The experiment sits on that single difference.

1. **Spark.** Pure water can remain liquid at $-10\,^{\circ}\mathrm{C}$ [MEASURED]. Inside it, molecules keep building and dissolving small ice-like clusters. Each cluster is a piece of information: *order could be here*. When the cluster dissolves, no trace remains [INTERPRETATION].
2. **Search.** The information exists, but it has no owner. Clusters form and fall apart, asking the same question again and again. The length of this search is measurable: the nucleation waiting time, a probability distribution [MEASURED].

3. **The owner appears.** Once a cluster passes the critical size, it no longer dissolves. Now there is a structure that does not merely carry the information but *holds* it: the critical nucleus. The owner is born after the information, and from the same material [INTERPRETATION].
4. **Birth moment.** As the nucleus grows, latent heat is released and the temperature jumps to $0\,^{\circ}\mathrm{C}$ within milliseconds (recalescence) [MEASURED]. That jump is the timestamp of the record's birth. The experimenter does not choose it; nature does.
5. **Spreading.** Starting from $-10\,^{\circ}\mathrm{C}$, about 12.6% of the water freezes at once; the rest freezes as heat is drawn out to the bath [MEASURED, FROM THE HEAT BALANCE].
6. **The clock.** Time-Gel ties a clock-rate change to this event. Which aspect of the event the clock responds to, the change or the result, was left open in earlier drafts. It is now decided (Section 4).

*The experiment's question: at equal temperature, equal heat flow and equal entropy production, does a permanent record by itself slow a clock?*

## 03 // Who is the owner

Five roles are easy to confuse. In freezing water, the source and the structure that builds the new state are the same molecules. The carrier and the processor are different. The role that gives meaning has no physical counterpart in this experiment. What Time-Gel calls the "owner" is only the structure that builds the new state: the place where information leaves an irreversible trace.

| Role | In this experiment | Reversible? | Measurable counterpart |
|---|---|---|---|
| Source | Molecules forming ice-like clusters | Yes | Structure factor, cluster distribution (X-ray, Raman) |
| Carrier | Heat: vibrations and heat flow | Yes | Temperature profile, heat-flux sensors |
| Processor | Molecular collisions, cluster formation and breakup | Yes | Indirect: viscosity, diffusion |
| State builder | Critical nucleus and growing crystal | No, while temperature holds | Latent heat, frozen fraction $f(t)$ |
| Meaning-giver | An observer who reads the record as "ice" | — | None [OPEN] |

That the source and the state builder coincide is a physical example of the theory's "one mind" idea: the recorder is the recorded [INTERPRETATION]. Information does not search for an owner outside itself. The owner is born from within. The search time is the waiting time of that birth.

## 04 // Time-Gel in one page, and the decision this protocol rests on

### 04.1 The flow law [MODEL]

Time-Gel v12.1 writes the local clock rate as

$$\frac{d\tau}{dt} = \frac{\sqrt{\max\left(0,\, 1-\rho_I/\rho_{\mathrm{crit}}\right)}}{1+\beta\,\Phi/c^2} \approx 1+\frac{\Phi}{c^2}-\frac{\rho_I}{2\rho_{\mathrm{crit}}}, \qquad \beta=-1. \tag{1}$$

The gravitational term is fixed by experiment and cancels between cells in the same bath. The only new term is $-\rho_I/(2\rho_{\mathrm{crit}})$. Existing optical-clock data give the soft bound $\rho_{\mathrm{crit}} \gtrsim 10^{33}\,\mathrm{s}^{-1}\mathrm{m}^{-3}$ [MODEL].

### 04.2 What the clock looks at [DECISION]

The clock looks at the moment the state changes, not at the state that results.

$$\rho_I \equiv \frac{\sigma}{k_B} \qquad \text{(local entropy production rate per unit volume, } \mathrm{s^{-1}m^{-3}}\text{)}. \tag{2}$$

This is the definition used in the companion flame-spectroscopy protocol [2]. Its consequences for ice, recorded before any data:

- The clock slows while water freezes and while ice melts. Both are irreversible.
- Standing ice at constant temperature produces almost no entropy, so the clock returns to its normal rate.
- A melted record does not vanish. It remains as a trace, but it does not keep slowing the clock. Its effect lives in the chain of evidence, not in the clock rate.
- Over a thousand freeze–melt cycles the clock *rate* does not accumulate. The *lag* behind an outside clock does: every event adds a step that never comes back.
- What matters is irreversibility, not heat release and not permanence. A perfectly slow freeze at exactly 0 °C would produce no entropy and no effect. A glass, which solidifies with no latent heat but irreversibly, does count, during its formation.
- The law is local. A clock one metre away feels nothing, unless the heat leaving the ice flows through it.

*Nothing vanishes; it only changes state. Matter and information were already there. The only new thing is the change itself.*

### 04.3 The rival reading [HYPOTHESIS]

The stock reading counts permanent records. Its density, estimated from latent heat, is

$$\rho_{\mathrm{rec}} \approx \frac{L\rho_{\mathrm{ice}}}{k_B T \ln 2} = \frac{(3.12\times10^{5})(918)}{(1.38\times10^{-23})(263)(0.693)} \approx 1.1\times10^{29}\ \mathrm{bit/m^3}, \tag{3}$$

about 3.7 bits per molecule. This is an upper estimate: it assumes each bit costs exactly $k_B T \ln 2$ of heat. In this reading the clock stays slow for as long as the ice exists.

### 04.4 Units: two quantities, two symbols

$\rho_I$ is a *rate* ($\mathrm{s^{-1}m^{-3}}$); $\rho_{\mathrm{rec}}$ is a *stock* ($\mathrm{bit/m^3}$). They cannot be compared. Bounds on the rival reading are written $\rho_{\mathrm{crit,rec}}$ and are never set against the atomic-clock bound on $\rho_{\mathrm{crit}}$.

### 04.5 Not adopted: memory

A third reading, in which past freeze cycles keep slowing the clock after melting, would require a memory term in the flow law. The causal-memory term $\Gamma$ is an open problem in v12.1 and is not used here [OPEN].

## 05 // How big is the effect

### 05.1 Rate reading [MODEL]

Freezing supercooled water at $-10\,^{\circ}\mathrm{C}$ dissipates roughly $L\Delta T/T_m \approx 12\ \mathrm{kJ/kg}$. The entropy generated per cubic metre frozen, counting cell and bath together, is

$$\frac{S_{\mathrm{gen}}}{V} \approx 4.6\times10^{4}\ \mathrm{J\,K^{-1}m^{-3}}, \qquad N_{\mathrm{gen}} \equiv \frac{S_{\mathrm{gen}}}{k_B V} \approx 3.4\times10^{27}\ \mathrm{m^{-3}}. \tag{4}$$

Integrating the flow law over one freezing event gives a phase step

$$\Delta\tau_{\text{event}} \;=\; \int \frac{\rho_I}{2\rho_{\text{crit}}}\,dt \;=\; \frac{N_{\text{gen}}}{2\rho_{\text{crit}}} \;\lesssim\; 1.7\ \mu\text{s} \quad (\rho_{\text{crit}} = 10^{33}). \tag{5}$$

Two features follow. First, the step does not depend on how fast the water freezes. A fast freeze gives a deep, short dip; a slow freeze gives a shallow, long one. The area is the same. This is the clean signature of the rate reading. Second, during a 60-second freeze the fractional slowdown is about $3 \times 10^{-8}$. Part of the entropy is produced in the wall and bath, where the heat crosses a temperature gradient. An internal clock sees only the part produced inside the cell.

### 05.2 Stock reading [MODEL]

With $\rho_{\text{rec}} \approx 1.1 \times 10^{29}$ bit/m$^3$, a clock sensitivity $\varepsilon$ bounds $\rho_{\text{crit,rec}} > \rho_{\text{rec}}/(2\varepsilon)$. No bound of any kind exists yet for this reading.

*A clock cannot tell you what a record means. It can only tell you whether making one cost time.*

## 06 // Distinguishing predictions

Most observables are identical under Time-Gel and conventional physics: nucleation statistics, released heat, entropy change, crystal structure, growth speed. This protocol claims no discrimination there. The table lists only the places where answers differ.

| Situation | Rate reading (primary) | Stock reading (rival) | Conventional |
|---|---|---|---|
| A · Freezing cell | Slow during freezing; step per event, independent of freezing speed | Slow while ice exists | No difference |
| B1 · Heat-matched heater | Slow; *more* than A | Zero | Zero |
| B2 · Entropy-matched heater, no crystal | Same as A | Zero | Zero |
| Standing ice | Zero | Slow | Zero |
| Melting | Slow during melting | Returns to zero | Zero |
| E · Glass, no latent heat | Slow during solidification | Slow while glass exists | Zero |
| Clock 1 m away | Zero unless heat flows through it | Zero (not specified) | Zero |

The decisive comparison is A against B2. Same entropy produced, one makes a crystal and one does not. Equal slowing supports the rate reading. Slowing in A alone supports the stock reading.

## 07 // The experiment: an ice clock

### 07.1 Cells

Identical sealed fused-silica cells, each holding a 1 mm layer of ultrapure water, sit in one bath held at $-10.00 \pm 0.01\,^{\circ}$C. The thin layer brings freezing and melting down to minutes, which makes the cycling arm possible. Every cell carries temperature sensors at three points, a heat-flux sensor, a strain gauge and a pressure sensor.

### 07.2 The clock inside

Because the effect is local, the clock must sit where the change happens. Today the only practical clock that can sit inside a freezing cell is radioactive decay: the nucleus's own time. Electron-capture isotopes such as $^7$Be are excluded, because their decay rate depends on chemical environment at the $10^{-3}$ level [4]. A sealed gamma source is used, and the quantity measured is the *decay constant*, the slope of the count rate over time at fixed geometry, not the absolute count rate. Ice is 8% less dense than water, which changes the absolute count rate at the percent level. That is a fake signal millions of times larger than the one sought.

### 07.3 Neighbour clocks (ranged version)

Stable oscillators or an optical clock are placed 1 mm, 10 cm and 1 m outside a cell wall. The rate reading predicts zero beyond the region of heat flow. A null here only weakens a ranged version that the theory has not written down.

### 07.4 Arms

| Arm | What happens | What it controls |
|---|---|---|
| A · Crystal | Supercooled water freezes, spontaneously or triggered | Test arm |
| B1 · Heat-matched | Water stays liquid; a heater reproduces A's measured heat release in real time | Heat, temperature, timing |
| B2 · Entropy-matched | Water stays liquid; heater power set to reproduce A's entropy production. Joule heating is fully dissipative, so this power is lower than B1's | Crystal versus no crystal at equal $\sigma$ |
| C · Dose | Cells of different salinity; equilibrium frozen fraction from 0 to about 0.9 | Does the effect scale with the record? |
| D · Cycling | A, B1 and B2 frozen and melted (or heat-cycled) thousands of times | Step per event versus accumulation |
| E · Glass | A glass-forming liquid that solidifies with no latent heat | Irreversibility versus latent heat |
| F · Read ice (optional) | As A, but the crystal is scanned with light; A receives the same light energy without readout | Observer term; weakest claim |

Which cell freezes on which day is set by a random schedule. Natural nucleation already takes the timing out of the experimenter's hands. Cells swap positions monthly so that position in the bath cannot mimic the effect.

## 08 // Measurement plan and analysis

The analysis is written and sealed before any data arrive. Data are unblinded only once. The result is published whatever its sign. Without these three rules, a near-zero effect invites after-the-fact fitting.

1. **Pre-registration.** Readings under test: rate (primary) and stock (rival). Sign rule: Time-Gel predicts slowing, $a \geq 0$. Significance threshold, stopping rule and exclusion criteria are fixed and timestamped. The theory's author has made the choice in Section 4 here, in writing. He cannot later say "that is what I meant all along".
2. **Quantities.** Per cell, every second: temperature (three points), heat flux, frozen fraction $f(t)$ by calorimetry and by optical transmission, strain, pressure, clock counts or phase. Entropy production $s(t)$ is computed from calorimetry and the temperature profile, then frozen before unblinding. Environmental channels: bath temperature, magnetic field, cosmic-ray rate, detector temperature.
3. **Systematics model $\hat{y}_{\mathrm{sys}}(t)$.** Every known effect (detector temperature, density change, dead time, oscillator temperature coefficient and ageing) is measured in separate calibration runs and fixed before any test data are inspected.
4. **Blinding.** The software adds a secret offset to every clock channel and hides cell labels. Unblinding happens once, after the analysis is frozen. Any later change is labelled "post hoc".
5. **Model.** For the phase difference $\varphi(t)$ between a test cell and its control,

$$\varphi(t) - \hat{y}_{\mathrm{sys}}(t) \;=\; a_\sigma \int_0^t \Delta s \, dt' \;+\; a_S \int_0^t \Delta f \, dt' \;+\; \varepsilon(t), \qquad a_\sigma = \frac{1}{2\rho_{\mathrm{crit}}}, \quad a_S = \frac{\rho_{\mathrm{rec}}}{2\rho_{\mathrm{crit,rec}}}. \tag{6}$$

   The null model is $a_\sigma = a_S = 0$.

6. **Event alignment.** Each freezing event is aligned to its birth moment, the onset of recalescence, and events are averaged. Noise falls roughly as $\sqrt{N}$. The same alignment is applied to the matched heat events in B1 and B2.

7. **Statistics.** Likelihood ratios and Bayes factors against the null; one-sided 95% upper limits on each $a$, converted to lower bounds on $\rho_{\text{crit}}$ and $\rho_{\text{crit,rec}}$. In the dose arm, the slope of $a$ against $f$ is tested separately; the stock reading predicts a straight line through zero.

8. **Independent replication.** If an effect appears, raw data and code are released and another laboratory repeats it with a different clock type. One laboratory's result never earns the label [MEASURED].

## 09 // Rival explanations

The most likely explanation of any clock difference is known physics. Time-Gel becomes a candidate only if each of these is excluded on its own.

| Rival | What it produces | How it is separated |
|---|---|---|
| Density and geometry | Percent-level step in count rate | Decay-constant slope at fixed geometry, not absolute rate |
| Temperature | Drift in detector and oscillator | B1 and B2 reproduce heat and entropy; coefficients pre-calibrated |
| Strain (expanding ice) | Oscillator shift, possibly permanent | Clock mechanically decoupled; strain regression; strain is not linear in $f$ in arm C |
| Chemical environment | $10^{-3}$-level change in electron-capture isotopes | Those isotopes are not used; salinity controls |
| Ageing and drift | One-way drift that mimics accumulation | Same oscillator type in all arms; differences taken; cells swapped |
| Environment | Random or daily fluctuations | All cells share one environment; regression on control channels |
| Experimenter expectation | False positive | Pre-registration, blinding, replication |
| Landauer-type information theory | Heat cost of erasure, no clock effect | Heat matched in B1; only a clock difference remains |

## 10 // What would count as what

**Support** (only all together): a positive A–control difference above the pre-registered threshold; the time signature of the pre-registered reading; for the stock reading, a straight line through zero in the dose arm; replication elsewhere with a different clock.

**Not support, not falsification:** zero within sensitivity. The theory has no value for $\rho_{\text{crit}}$, so a null only sets a bound. The honest sentence is: *if the effect exists, it is smaller than this*.

**Falsifies this form of the theory:**

- A significant, replicated *negative* difference: the clock in the freezing cell runs fast. The square-root law allows no speed-up.
- A difference in A, none in B2, and none during melting: the rate reading is wrong as the whole story.
- Equal difference in A and B1 but none in B2: the effect follows heat, not entropy, and not the record.
- A difference unrelated to $f$ in the dose arm, while the stock reading is claimed: the record is not the cause.
- The pre-registered reading is null but the other one is significant: the pre-registered reading is falsified. The other must be tested again on new data, not rescued by reinterpreting this data.

**Inconclusive:** if the uncertainty of the systematics model exceeds the upper limit sought (for example if strain cannot be resolved), or if a difference appears in one laboratory only, the result is published as inconclusive.

## 11 // Feasibility

The experiment can be built in a university laboratory with present technology. Most likely it will give a bound, not an effect. That is not failure.

| Tier | Clock | Sensitivity (approx.) | What it can say |
|---|---|---|---|
| 1 | Internal gamma source, decay constant | $10^{-5}$ | Stock reading: $\rho_{\mathrm{crit,rec}} > 5.7 \times 10^{33}$ bit/m$^3$, the first bound of any kind. Rate reading: about $5 \times 10^{28}$ s$^{-1}$m$^{-3}$ after a year of $10^4$ cycles, weaker than the atomic-clock bound |
| 2 | Same clock, $10^4$ cycles | — | Separates "step per event" from "slow while ice exists"; this is the arm that tells the readings apart |
| 3 | Neighbour optical clock | $10^{-18}$ | Ranged versions only. The local rate reading predicts zero |

Sensitivities are rough estimates [INTERPRETATION]. Needed: three to four matched cells, a precision bath, calorimetry, gamma detectors, an automated freeze–melt rig, and about a year of continuous running. Tier 3 needs a partner optical-clock laboratory.

*Under the rate reading, this is not the experiment that finds $\rho_{\mathrm{crit}}$. It is the experiment that tells us which question to ask the flame and the clock.*

What still does not exist: a clock with $10^{-15}$ stability that can sit inside the record region; a way to count record bits directly rather than inferring them from heat; any measure for the observer term.

## 12 // Interpretation: one thing and its states

This section is not tested by the experiment. It says where the protocol comes from.

- **One thing, its states** [INTERPRETATION]. There is one thing, time. Water, ice and matter are its states. Freezing is a small, laboratory-sized instance of a larger idea: flow that thickens at a threshold becomes matter.
- **Matter and gravity** [INTERPRETATION, CONTAINS A HYPOTHESIS]. A new state may build a pull around itself. Two effects would then separate: during change the clock slows (the rate term); formed matter keeps a lasting pull (the gravitational term already in the flow law). The hidden hypothesis: *when matter forms, nearby clocks slow more than the newly formed mass alone explains*. Ice cannot test this, because freezing creates no mass. Its domain is the first formation of matter.
- **What gravity is** [INTERPRETATION]. In the pool of possibilities, the most fitting ones gather in one place and what supports them follows. Since matter is time thickened, time flows more slowly around it, and bodies drift toward where time is slow. This picture is close to general relativity and is related to Verlinde's proposal of entropic gravity [6], which also remains unproven.
- **Planck scale** [ANALOGY]. "The universe is redrawn about $10^{43}$ times per second" is an image. It does not bring back the Planck "render" claim withdrawn in v12.1.

*A comment that names how it could be wrong has become a hypothesis. Until then, it is honest to call it a comment.*

## 13 // Open problems

1. The value of $\rho_{\text{crit}}$. Without it, no null result can refute the theory; it can only push the bound.
2. Matching entropy in B2: the accuracy of the entropy estimate for freezing limits how well B2 matches A.
3. Where the entropy is produced: inside the cell or in the wall and bath. This decides what an internal clock can see.
4. The relation between the rate threshold (clock arrest) and a crystallisation threshold, if they differ.
5. The memory term $\Gamma$, and whether a ranged version of the law exists.
6. Any measure for the observer term.

## Appendix A. Calculations

- Instant frozen fraction from $-10\,^{\circ}\text{C}$: $c_p \Delta T / L = (4.2 \times 10^3)(10)/(3.34 \times 10^5) \approx 0.126$.
- Dissipated free energy per kg: $L\Delta T / T_m \approx (3.34 \times 10^5)(10)/273 \approx 1.22 \times 10^4$ J/kg. Entropy generated per $\text{m}^3$: $(1000)(1.22 \times 10^4)/263 \approx 4.6 \times 10^4\ \text{J K}^{-1}\text{m}^{-3}$, i.e. $N_{\text{gen}} \approx 3.4 \times 10^{27}\ \text{m}^{-3}$.
- Phase step per event at $\rho_{\text{crit}} = 10^{33}$: $N_{\text{gen}}/(2\rho_{\text{crit}}) \approx 1.7\ \mu$s. Fractional slowdown during a 60 s freeze: $\approx 2.8 \times 10^{-8}$.
- Rate-reading bound, tier 1: $\rho_{\text{crit}} \gtrsim N_{\text{gen}}\, n/(2\varepsilon T)$ with $n = 10^4$, $\varepsilon = 10^{-5}$, $T = 1$ yr: $\approx 5 \times 10^{28}\ \text{s}^{-1}\text{m}^{-3}$.
- Stock-reading bounds: $\rho_{\text{rec}}/(2\varepsilon) = 5.7 \times 10^{33}, 5.7 \times 10^{37}, 5.7 \times 10^{46}$ bit/$\text{m}^3$ for $\varepsilon = 10^{-5}, 10^{-9}, 10^{-18}$.

All values are order-of-magnitude estimates.

## Appendix B. Provenance

The first draft (in Turkish) was prepared with AI assistance from the author's notes and website. On 28 October 2026 the author answered four open questions (what the clock looks at; what happens to a melted record; what makes a record a record; how far the effect reaches) and adopted the rate reading. Claude (Anthropic) checked the calculations, identified the conflict between the two readings and between their units, proposed the entropy-matched control B2, and drafted this English version. Decisions are the author's. AI agreement is not independent validation.

## References


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