THE DECISIVE TEST

Proving Time Dilation Arises from Information Density, Not Spacetime Curvature

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A Decorrelation Analysis Using Existing Astrophysical and Precision Metrology Datasets

Dimensional Coherence Theory (DCT)
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Abstract

We present five decisive experimental tests designed to distinguish between General Relativity's geometric account of time dilation and Dimensional Coherence Theory's informational account. The central strategy is **decorrelation**: identifying natural experiments where gravitational potential and information density vary independently, then testing which quantity the observed time dilation tracks. In General Relativity, time dilation depends solely on mass, distance, and velocity through the metric tensor. In DCT, time dilation depends on the coherence function P(N), which encodes the local density of informational handshakes in the BEC fabric substrate. These frameworks make identical predictions for static spherically symmetric masses but **diverge** when information density varies independently of gravitational potential. We identify five such scenarios using existing datasets: (1) Solar Shapiro delay modulation with the 11-year solar activity cycle, (2) neutron star versus black hole gravitational redshift asymmetry, (3) GPS satellite clock residuals correlated with geomagnetic activity, (4) achromatic pulsar timing delays proportional to dispersion measure, and (5) optical lattice clock shifts during solar eclipses. For each test, GR predicts exactly zero signal while DCT predicts a specific, quantifiable correlation. A positive detection at >5 sigma in any test would constitute singular proof that time dilation has an informational component irreducible to spacetime geometry.

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1. The Core Divergence: Where GR and DCT Part Ways

General Relativity and Dimensional Coherence Theory both predict time dilation, but they attribute it to fundamentally different causes. Understanding exactly where they diverge is the key to designing a decisive test.

1.1 Time Dilation in General Relativity

In GR, time dilation arises from the geometry of spacetime. For a static, spherically symmetric mass, the Schwarzschild metric gives the gravitational time dilation factor:

$$dt/dt_{inf} = sqrt(1 - 2GM / rc^2)$$

For an object in motion, special relativistic time dilation adds:

$$dt/dt_0 = sqrt(1 - v^2/c^2)$$

The critical feature: these expressions depend **only** on mass M, distance r, and velocity v. The internal composition of the gravitating body, its temperature, its electromagnetic environment, the density of particle interactions in the surrounding medium -- none of these enter the GR prediction. A 1.4 solar-mass neutron star and a 1.4 solar-mass cloud of cold hydrogen produce identical time dilation at the same distance. This is a direct consequence of the Strong Equivalence Principle.

1.2 Time Dilation in DCT

In Dimensional Coherence Theory, time dilation arises from the informational processing load on the BEC fabric substrate. The Parrott Metric replaces the standard metric with a coherence-weighted version:

$$ds^2_{RDC} = P(N) * g_{mu,nu} dx^{mu} dx^{nu}$$

where the Coherence Function P(N) = 1 - exp(-N/Lambda) encodes the local density of informational handshakes. The time dilation factor becomes:

$$dt/dt_{inf} = sqrt(P(N))$$

The handshake count N receives contributions from **all** sources of information exchange in the local region:

$$\mathbf{N_{total} = N_{gravitational} + N_{electromagnetic} + N_{thermal} + N_{quantum}}$$

The gravitational contribution N_{grav} scales with GM/rc^2, recovering the GR prediction for static masses. But the electromagnetic, thermal, and quantum contributions introduce terms that vary **independently** of gravitational potential. This is the wedge that allows decisive testing.

1.3 The Equivalence and the Divergence

Scenario	GR Prediction	DCT Prediction	Distinguishable?
Static mass, vacuum	dt = f(M, r)	dt = f(N_grav) ~ f(M, r)	No -- identical
Moving object, vacuum	dt = f(v)	dt = f(v) via render lag	No -- identical
Static mass + EM activity	dt = f(M, r) only	dt = f(M, r) + f(N_em)	YES

Scenario	GR Prediction	DCT Prediction	Distinguishable?
Same M/r, different composition	Identical	Different (N_int differs)	YES
Varying information, constant M	Zero variation	Non-zero variation	YES

Table 1. Scenarios where GR and DCT predictions converge or diverge.

The bottom three rows of this table define the experimental program. In each case, we seek a natural experiment where information density varies while gravitational potential remains fixed. Any detected correlation between time dilation and information density -- in a regime where GR predicts zero effect -- constitutes proof of the informational mechanism.

2. The Decorrelation Principle

The entire strategy rests on a single logical principle: **decorrelation**. In typical gravitational environments, information density N and gravitational potential Phi are strongly correlated -- more mass means more particles means more interactions. This correlation is why GR and DCT have been observationally indistinguishable to date.

To break the degeneracy, we must find scenarios satisfying:

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dN/dt != 0 while d(Phi)/dt = 0
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That is: information density changes while gravitational potential stays fixed. Nature provides several such experiments:

Natural Experiment	What Varies (N)	What Stays Fixed (Phi)	Timescale
Solar activity cycle	Coronal particle density, photon flux, B-field energy	Solar mass (constant to 10^-10)	11 years
NS vs BH at same M/r	10^80 internal interactions/s vs ~20 Hawking photons/s	Same M, same r (by selection)	Steady-state
Geomagnetic storms	Ionospheric electron density (factor 10-1000x)	Earth's mass (unchanged)	Hours to days
ISM density variation	Free electron column density along pulsar sightline	Pulsar mass, distance (unchanged)	Weeks to months
Solar eclipse	Local photon flux (drops by 10^6)	Local gravitational potential (unchanged)	Minutes

Table 2. Natural experiments where information density and gravitational potential are decorrelated.

The logic is airtight: if time dilation correlates with the varying quantity (N) when the supposedly controlling quantity (Phi) is fixed, then Phi alone cannot be the cause. The informational component is real, and GR's purely geometric account is incomplete.

3. Test 1 -- Solar Shapiro Delay vs. Solar Activity Cycle

3.1 Background

The Shapiro delay is the additional time required for an electromagnetic signal to traverse the curved spacetime near a massive body. For a signal passing the Sun at closest approach distance b, with source at distance r_1 and receiver at r_2:

$$\text{Delta\_t} = (4GM_{sun}/c^3) * \ln(4\ r_1\ r_2\ /\ b^2)$$

The Cassini spacecraft measured this delay with extraordinary precision during its 2002 solar conjunction, confirming GR to $|\text{gamma} - 1| < 2.3 \times 10^{-5}$. At closest approach of ~3 solar radii, the delay is approximately 240 microseconds.

3.2 The DCT Prediction

The Sun's mass is constant to better than one part in 10^{10} over the solar cycle. GR therefore predicts **exactly zero** variation in the Shapiro delay correlated with solar activity (for identical geometry).

DCT predicts otherwise. The solar corona is a region of intense informational activity:

Information Proxy	Solar Minimum	Solar Maximum	Variation Factor
Coronal electron density (2 R_sun)	~1 x 10^14 m^-3	~3 x 10^14 m^-3	3x
Coronal temperature	~1.5 MK	~3 MK	2x
Solar wind flux (1 AU)	~2 x 10^12 m^-2 s^-1	~8 x 10^12 m^-2 s^-1	4x
Magnetic field energy	Baseline	10-100x baseline	10-100x
Total soft X-ray luminosity	~10^20 W	~10^22 W	100x

Table 3. Solar information density proxies over the 11-year activity cycle.

In DCT, this variation in information density modifies P(N) along the signal path. The Shapiro delay acquires an additional modulation:

$$\text{Delta\_t}_{DCT} = \text{Delta\_t}_{GR} \times [1 + \text{alpha}_I * (I(t) - I_0) / I_0]$$

where I(t) is a suitable information density proxy (e.g., the F10.7 solar radio flux index, measured daily) and alpha_I is the information-metric coupling constant. The coupling alpha_I encodes how strongly the non-gravitational component of N affects the Parrott Metric.

3.3 Datasets and Methodology

Existing datasets span multiple solar cycles: Cassini ranging (2003-2017), Mars Express ranging, Juno ranging, Viking lander ranging (1976-1982), and pulsar timing through solar conjunction. The F10.7 index is continuously recorded at Penticton, Canada since 1947. The analysis proceeds as follows:

(a) Extract Shapiro delay residuals from spacecraft ranging after fitting for all known GR effects, orbital mechanics, and instrumental systematics. (b) Compute the cross-correlation function between Shapiro residuals and the F10.7 index. (c) Test the null hypothesis H_0: correlation coefficient r = 0 against the DCT alternative H_1: r > 0 with the specific prediction that the correlation follows the 11-year cycle.

3.4 Decisive Criterion

If the Shapiro delay residuals show a statistically significant correlation (>3 sigma) with the F10.7 index at the 11-year period, GR is excluded as the sole mechanism for time dilation near the Sun. GR provides **no mechanism whatsoever** for the Shapiro delay to vary with solar activity -- the mass is constant, and the metric depends only on mass.

4. Test 2 -- Neutron Star vs. Black Hole Redshift Asymmetry

4.1 The Physical Setup

Consider two compact objects viewed via X-ray spectroscopy: a neutron star and a black hole, both in binary systems. We select pairs where the gravitational redshift $z_{grav} = GM/(rc^2)$ is comparable. In GR, the Fe K-alpha emission line at 6.4 keV is gravitationally redshifted by the same formula regardless of whether the central object is a neutron star or a black hole.

4.2 The Information Asymmetry

In DCT, these two objects have **vastly different** information densities:

Property	Neutron Star (1.4 M_sun)	Black Hole (5 M_sun)
Internal baryons	~10^57	N/A (no internal structure in GR)
Strong force interactions/s	~10^80	0
EM interaction rate	~10^57 (surface photons)	~20 (Hawking radiation)
Dynamic information exchange	Enormous	Negligible
DCT coherence state	P < 1 (actively crystallizing)	P -> 1 (fully saturated)

Table 4. Information density comparison between neutron stars and black holes.

A neutron star is an **information furnace** -- 10^{57} baryons interacting via the strong force at 10^{23} interactions per baryon per second, producing a dynamic handshake rate of $\sim 10^{80}\ s^{-1}$. A black hole of comparable mass is informationally **saturated** -- it has achieved P = 1 (maximum crystallization) and its only dynamic information exchange is the trickle of Hawking radiation (~20 photons/s for a stellar-mass black hole).

4.3 The DCT Prediction

Because the neutron star has enormously higher dynamic information density, DCT predicts that the effective P(N) near a neutron star surface includes a correction term:

$$P_{NS} = P_{grav} + \text{delta\_}P_{info}$$

where $\text{delta\_}P_{info}$ arises from the non-gravitational handshakes. This makes P_{NS} slightly **higher** than P_{BH} at equivalent M/r, meaning neutron star clocks run slightly **faster** than GR predicts relative to a black hole at the same gravitational potential. The predicted offset is:

$$\text{Delta\_z} / z \sim 10^{-4}$$

4.4 Datasets and Decisive Criterion

X-ray observatories Chandra and XMM-Newton have accumulated extensive Fe K-alpha line profiles from both neutron star LMXBs (4U 1820-30, EXO 0748-676, Serpens X-1) and black hole XRBs (GRS 1915+105, Cyg X-1, GX 339-4). After fitting relativistic line profiles and controlling for inclination, spin, and accretion geometry, compare the population-level residuals. If neutron stars show a systematic positive offset in redshift residuals relative to GR predictions, while black holes do not, this is a direct signature of the information density mechanism.

5. Test 3 -- GPS Clock Residuals vs. Geomagnetic Activity

5.1 Background

The Global Positioning System provides the largest operational demonstration of GR's time dilation predictions. Each GPS satellite carries atomic clocks that are pre-corrected for the combined gravitational blueshift (+45.9 microseconds/day) and kinematic redshift (-7.2 microseconds/day), yielding a net correction of +38.6 microseconds/day. After this correction, residuals at the nanosecond level are tracked continuously by the International GNSS Service (IGS).

5.2 The DCT Signal

During geomagnetic storms, the Earth's magnetosphere is dramatically perturbed. Charged particle precipitation increases by factors of 10 to 1000, ionospheric electron density increases by factors of 2 to 10, and the ring current energy budget increases by factors of 10 to 100. In GR, **none of this affects time dilation** -- the Earth's mass and the satellite's orbital parameters are unchanged.

In DCT, the increased particle density represents a massive increase in local information density N_{em}. The ionosphere becomes a region of heightened handshake activity, and signals traversing this region experience a modified P(N). The prediction:

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GPS clock residuals should show a SYSTEMATIC correlation with the Kp
geomagnetic index.
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Kp Index	Storm Level	Ionospheric Enhancement	GR Prediction	DCT Prediction
0	Quiet	Baseline	No effect	Baseline
3	Unsettled	~4x	No effect	Detectable shift
5	Moderate storm	~10x	No effect	Clear correlation
7	Strong storm	~30x	No effect	Strong correlation
9	Extreme storm	~1000x	No effect	Maximum signal

Table 5. GPS clock predictions under geomagnetic activity.

5.3 Datasets and Methodology

The IGS provides precise clock solutions for all GPS satellites at 5-minute intervals, spanning 2000 to present -- over 25 years of continuous data. NOAA provides the Kp index at 3-hour intervals and the Dst index at 1-hour intervals. The analysis: (a) extract GPS clock residuals after removing all modeled effects (GR, tidal, thermal), (b) compute cross-correlation with Kp and Dst indices, (c) test for significance using bootstrapping to account for temporal autocorrelation. With 25 years of data covering multiple solar cycles and thousands of geomagnetic events, the statistical power is enormous.

5.4 Decisive Criterion

A Pearson or Spearman correlation coefficient $r > 0.2$ between GPS residuals and the Kp index, with $p < 10^{-6}$, would exclude GR as the complete description of time dilation. GR provides absolutely no pathway for geomagnetic activity to affect satellite clock rates -- the gravitational potential at GPS altitude (20,200 km) is unchanged by ionospheric storms.

6. Test 4 -- Pulsar Timing Residuals vs. Dispersion Measure

6.1 The Key Distinction: Dispersive vs. Achromatic Delay

Pulsar timing arrays achieve timing precision of ~100 nanoseconds over decades. The interstellar medium introduces a well-understood dispersive delay proportional to nu^{-2} and to the Dispersion Measure DM = integral(n_e dl). This dispersive delay is routinely removed using multi-frequency observations.

The critical test: after removing the dispersive (frequency-dependent) DM delay, does any **achromatic** (frequency-independent) residual remain that correlates with DM?

GR: **No.** The DM delay is purely electromagnetic dispersion. Once removed, no residual should correlate with DM. Gravitational time dilation along the line of sight depends on mass distribution, not free electron density.

DCT: **Yes.** The free electrons along the line of sight represent information density. Each electron-photon interaction is a handshake that modifies the local P(N). This produces an achromatic delay proportional to DM -- a fundamentally different physical effect from electromagnetic dispersion.

6.2 The DCT Achromatic Delay

The predicted achromatic delay scales as:

$$\text{delta\_t}_{\text{achromatic}} = \text{alpha}_{\text{DM}} * \text{DM}$$

where alpha_{DM} is the information-time coupling coefficient. The signal should be visible as a correlation between post-fit timing residuals and DM across the pulsar population: pulsars with higher DM (longer lines of sight through denser ISM) should show systematically larger achromatic residuals.

6.3 Datasets

The NANOGrav 15-year dataset, the European Pulsar Timing Array (EPTA), the Parkes Pulsar Timing Array (PPTA), and the combined International Pulsar Timing Array (IPTA) provide timing residuals for dozens of millisecond pulsars spanning DM values from ~3 to ~120 pc cm^{-3}. The test is a simple regression of achromatic residual magnitude against DM.

6.4 Decisive Criterion

A positive slope in the achromatic residual vs. DM relation, significant at >3 sigma, would be unexplainable by GR. Gravitational delays along pulsar lines of sight depend on mass concentrations (galaxies, clusters), not on free electron density. A correlation with DM specifically is a signature of the information density mechanism.

7. Test 5 -- Optical Lattice Clock Shift During Solar Eclipse

7.1 The Experiment

Modern optical lattice clocks achieve fractional frequency stability of 10^{-18}, sufficient to detect gravitational redshift from a height difference of 1 centimeter. During a total solar eclipse, the local photon flux drops by approximately six orders of magnitude over a period of 2 to 7 minutes.

7.2 GR Prediction

Exactly zero effect. The Sun's gravitational influence on a ground-based clock does not change during an eclipse (the Moon's mass is insufficient to produce a detectable tidal effect at clock precision, and in any case the Moon's position is already accounted for in the tidal model). The eclipse changes the **light** environment but not the gravitational environment.

7.3 DCT Prediction

In DCT, the dramatic reduction in local photon flux represents a sudden decrease in information density. Fewer photons means fewer handshakes, which means lower N, which means lower P(N), which means the clock should run **measurably slower** during totality. The predicted fractional frequency shift is:

$$\text{Delta\_f} / f \sim \text{alpha}_{\text{photon}} * \text{Delta}(n_{\text{photon}}) / n_{\text{photon}}$$

The magnitude depends on the coupling constant $\text{alpha}_{\text{photon}}$, which connects photon density to the coherence function. Even at the most conservative estimates, the signal may be within reach of next-generation transportable optical clocks, and the qualitative prediction (clock slows during eclipse) is unambiguous.

7.4 Decisive Criterion

Deploy an optical lattice clock on the path of totality and monitor its frequency relative to a reference clock outside the eclipse path (connected via optical fiber). Any achromatic frequency shift correlated with the eclipse shadow, absent in the reference clock, would be unexplainable by GR and would constitute direct evidence for information-density time dilation.

8. Bayesian Model Comparison Framework

For each of the five tests, we compute the Bayes factor comparing the DCT model to the GR null:

$$B = P(\text{data} \mid H_{DCT}) / P(\text{data} \mid H_{GR})$$

8.1 Null Hypothesis (GR)

H_{GR}: Time dilation residuals are statistically independent of all information density proxies. Residuals follow N(0, sigma^2) after removing known GR effects. The cross-correlation with F10.7, Kp, DM, n_{photon}, and eclipse timing is consistent with zero.

8.2 Alternative Hypothesis (DCT)

H_{DCT}: Residuals contain a component proportional to the information density proxy: residual(t) = alpha * I(t) + noise, where alpha is the information-metric coupling constant and I(t) is the measured information proxy.

8.3 Interpretation Scale

Bayes Factor B	Interpretation
B > 100	Decisive evidence for DCT -- information density controls time dilation
B > 10	Strong evidence for DCT
B > 3	Substantial evidence for DCT
1/3 < B < 3	Inconclusive
B < 1/3	Evidence against DCT (GR sufficient)

Table 6. Jeffreys scale for Bayes factor interpretation.

The combined Bayes factor across all five independent tests is the product: $B_{combined} = B_1 \times B_2 \times B_3 \times B_4 \times B_5$. Even modest individual evidence ($B_i \sim 3$) yields decisive combined evidence ($B_{combined} \sim 243$).

9. The Exclusion Argument: Why GR Cannot Produce These Signals

This section establishes why a positive detection in any of the five tests would be **singularly** attributable to the information density mechanism, ruling out GR and all known alternative gravitational theories.

9.1 The Structural Limitation of GR

In General Relativity, the spacetime metric is determined by the Einstein Field Equations: $G_{mu,nu}$ + Lambda $g_{mu,nu}$ = (8 pi G / c^4) $T_{mu,nu}$. The stress-energy tensor $T_{mu,nu}$ contains mass-energy density, momentum flux, pressure, and stress. It does **not** contain a term for information density, interaction count, photon number density independent of energy density, or any quantity that tracks the *number* of interactions rather than their *energy content*.

This is not a contingent limitation that could be fixed by adding terms to $T_{mu,nu}$. It is a **structural feature** of the theory: GR couples geometry to energy-momentum, not to information. Adding an information-dependent term to the field equations would transform GR into a different theory -- one that, we argue, would necessarily resemble DCT.

9.2 Why Each Signal Excludes GR

Test	Why GR Cannot Produce This Signal
1. Shapiro-Solar	Solar mass is constant. GR's Shapiro delay depends only on mass. No coupling exists between coronal activity and the metric.
2. NS-BH Asymmetry	GR's gravitational redshift z = GM/rc^2 is composition-independent. The Strong Equivalence Principle forbids internal-structure corrections.
3. GPS-Kp	Earth's mass and GPS orbital radius are unchanged during storms. GR provides no mechanism for ionospheric electrons to affect clock rates.
4. Pulsar-DM	GR's gravitational delays depend on mass, not electron density. DM's effect in GR is purely dispersive (frequency-dependent), not achromatic.
5. Eclipse-Clock	Solar gravity at Earth's surface is unchanged during eclipse. GR predicts zero achromatic effect from changes in illumination.

Table 7. GR exclusion logic for each test.

9.3 Ruling Out Alternative Explanations

For each test, we must also rule out mundane (non-gravitational, non-informational) explanations for any observed correlation:

Thermal effects: Temperature changes can affect atomic clocks via blackbody radiation shifts. These are well-characterized and can be independently measured and subtracted. Crucially, thermal effects on GPS clocks are modeled and removed before computing residuals.

Electromagnetic interference: Direct EM coupling to clock electronics could mimic a signal. This is controlled by comparing multiple satellite clocks (which see different EM environments) and by using magnetically shielded laboratory clocks.

Ionospheric propagation effects: The ionosphere affects signal propagation (delay and scintillation), not clock rates. Dual-frequency observations remove ionospheric propagation delays. The test specifically looks for *clock rate* changes, not signal delays.

10. The BEC Fabric Connection

The five tests above are grounded in DCT's foundational claim: spacetime is a Bose-Einstein Condensate (BEC) fabric -- a crystallizing information substrate where the local rate of crystallization determines the local flow of time.

10.1 The Mechanism

In the BEC fabric model, the ground state corresponds to P = 0 (the Indefinite Core). Observational interactions -- handshakes between the Core and the outer layers of the Onion topology -- cause local crystallization, driving P toward 1 (the Definite Skin). Time, in this framework, is not a dimension through which objects move but the **rendering rate** of the crystallization front. More interactions means faster crystallization means faster local time.

10.2 Why Mass Slows Time

A massive object is a region where the BEC fabric has been written with extraordinary density. The information content per unit volume is so high that the rendering pipeline -- the crystallization front -- becomes saturated. This saturation manifests as gravitational time dilation: clocks near massive objects tick slowly because the local processing queue is backed up.

This recovers GR's predictions because, for static masses, information density and gravitational potential are proportional. But DCT goes further: it predicts that **any** source of information density -- not just mass -- can affect the local processing rate. Electromagnetic interactions, thermal photon exchanges, particle collisions -- all contribute to N, and all affect P(N), and therefore all affect the local flow of time.

10.3 The Parrott Stress Tensor

Mathematically, the informational contribution enters through the Parrott Stress Tensor $Xi_{mu,nu}$, which appears in the Modified Einstein Field Equations:

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G_mu,nu + Xi_mu,nu = (8 pi G / c^4) T_mu,nu
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where $Xi_{mu,nu}$ is proportional to the gradient of coherence: Xi ~ grad(P) * grad(P). This tensor captures the **pressure of information density on the geometry of spacetime**. It is this term that produces the non-GR signals predicted in the five tests above.

11. Summary and Verdict

#	Test	GR Predicts	DCT Predicts	Dataset	Sensitivity
1	Shapiro Delay vs Solar Cycle	Zero correlation	r ~ 0.3-0.5 with F10.7	Cassini, Viking	~0.1-1 ns residuals
2	NS vs BH Redshift	Same formula	NS offset ~ 10^-4	Chandra, XMM-Newton	Fe K-alpha line fits
3	GPS Residuals vs Kp Index	Zero correlation	r ~ 0.2-0.4 with Kp	IGS + NOAA	~ns clock residuals
4	Pulsar Timing vs DM	Zero achromatic	delta_t ~ alpha * DM	NANOGrav, IPTA	~100 ns timing
5	Clock During Eclipse	Zero effect	Clock slows during totality	NIST, PTB	~10^-18 fractional

Table 8. Summary of all five decisive tests.

The logic of this test program is as follows:

Premise 1: GR says time dilation depends only on gravitational potential and velocity. Information density, electromagnetic environment, and interaction count are irrelevant.

Premise 2: DCT says time dilation depends on the total information density N, which includes gravitational, electromagnetic, thermal, and quantum contributions.

Premise 3: We identify five natural experiments where information density varies while gravitational potential is held fixed.

Conclusion: If time dilation correlates with information density in these decorrelated regimes, then GR's geometric account is incomplete and DCT's informational account is validated. If no correlation is found, DCT's information-time coupling is bounded below the experimental sensitivity.

These five tests are not matters of interpretation or theoretical preference. They produce binary outcomes: either time dilation correlates with information density when gravitational potential is fixed, or it does not. GR and DCT make opposite predictions. The data will choose one. This is what a decisive test looks like.