

The Clock

Artist’s Proof 42

Dark Energy

The 68/27/5 partition — the universe knows what time it is

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Artist’s Note

This is Artist’s Proof 42 of The 420 Code, a chapter of Notebook VI — Cosmology. The observed energy budget of the universe is roughly 68% dark energy, 27% dark matter, 5% visible matter (Planck 2018). The body of work already derives the total dark fraction — 20/21 ≈ 95.24% — from the channel count (AP10, AP28, AP41). What it did not derive was the internal split between dark matter and dark energy. That was Debt D44, the most important open quantitative gap in the cosmological sector. This paper addresses it.

The claim: the 68/27 split is not a partition of channels and not a constant of nature. It is a clock reading. Dark matter is not a substance — it is a process: the ongoing defragmentation of structured records inside black holes (AP09’s forgetful functor), still carrying mass-energy, still clustering, no longer radiating. Dark energy is not a force — it is the reservoir: substrate content that has completed defragmentation and returned to the symmetric 1:1 state, the condensate at rest. The split measures how far the universe has progressed through its current defragmentation cycle.

One timescale governs it, derived from the axiom system: $\tau = (6/21) \times t_H \approx 3.9$ Gyr — the six faces of ε (AP24) over the twenty-one coupling channels (AP28), applied to the Hubble time. With a constant-feeding approximation this yields dark energy 68.85% (Planck 68.89%), dark matter 26.39% (26.07%), visible 4.76% (4.86%) — the two dark fractions within 1.3% of measurement, the visible within ≈2%, with zero free parameters. The same counting logic that gives AP28 the gravitational constant gives this paper the dark sector. The central prediction is that the split is epoch-dependent, which dissolves the cosmological coincidence problem and is observationally testable. Nothing is imported; every number traces to a derived result.

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Orientation

Where this paper fits in the 420 Code

AP42 is a chapter of Notebook VI (Cosmology). It takes the channel count from AP10/AP28 and the visible-channel identification and dark-sector reading from AP41, and supplies the internal dark-sector split AP41 owes (D44). It uses AP09 (defragmentation as the forgetful functor), AP24 (the six faces of ε), AP04/AP41 (the loop — black holes as doors), AP03 (the condensate and substrate stiffness), AP20 (the substrate clock), AP21 (filamentary structure feeding black holes), and AP30 (geometric resistance).

How to read this paper

The spine is one derivation: a single timescale $\tau = (6/21) \times t_H$, fed through a rate equation, yields the three fractions. The structural identifications — dark matter as process, dark energy as reservoir — carry the reading; the formal blocks (the timescale ratio, the rate equation and its convolution solution, the result, the epoch table) are preserved verbatim. The central prediction is the epoch dependence, and the sharpest kill switch is empirical: find a dark-matter particle and the mechanism is dead.

0 — Dependency and Scope

0.1 — What this paper does

The observed late-universe energy budget is approximately 68% dark energy, 27% dark matter, 5% visible matter (Planck 2018; the remaining ~0.2% radiation and relativistic neutrinos is not part of the late-universe budget addressed here). The axioms derive the total dark fraction (20/21 ≈ 95.24%, AP10/AP28/AP41) but not the internal split — that is Debt D44. This paper addresses D44. The 68/27 split is not a partition of channels but a clock reading: dark matter is the ongoing defragmentation of records inside black holes; dark energy is the reservoir of content that has completed defragmentation and returned to the 1:1 state. One derived timescale, $\tau = (6/21) \times t_H \approx 3.9$ Gyr, fixes the two dark fractions to within 1.3% of Planck and the visible channel to ≈2%, with no free parameters, and predicts its epoch dependence.

0.2 — Dependencies

AP04 (the loop — black holes as doors to new cycles), AP06 (α, the leakage constant), AP09 (defragmentation — the forgetful functor U: Mon → Set), AP10 (twenty-one channels, three dimensions), AP20 (axioms unconditional — the substrate clock), AP21 (filamentary structure — how matter reaches black holes), AP24 (the six faces of ε), AP28 (the twenty-one-channel geometry; coupling independence), AP41 (fusion as ongoing break; the visible-channel identification). It does not depend on AP30/AP30a (the proton mass, an independent result) or on AP31–AP39 (the ethics chain; no ethical claims are made).

0.3 — Axiom mapping

Axiom S (Symmetry — the involution σ). The fully-defragmented state is the symmetric 1:1 — the unbroken mirror, the condensate at rest. Dark energy is the substrate returned to σ-symmetry; it does not cluster because it has no residual structure.

Axiom B (Break — the unique break ε). Defragmentation reverses the break: structured records (carrying 1×ε structure) dissolve back toward 1:1. The visible channel is the +1×ε; the dark sector is the symmetric remainder.

Axiom R (Record — monotone accumulation). Records persist (the information survives the forgetful functor) but their causal order dissolves. The Hubble time is the total actualisation budget of the substrate (AP20) — the clock against which defragmentation is timed.

Axiom C (Constraint — locality; finite propagation speed c). The σ-boundary (the event horizon) closes the electromagnetic channel for in-transit content, which is why dark matter responds to gravity but not to light.

0.4 — Epistemic status per section

1 (Three components). STRUCTURAL IDENTIFICATION. Visible = 1/21 (derived); dark energy = completed reservoir; dark matter = in-transit process.

2 (Mechanism). STRUCTURAL. Defragmentation (AP09) and the two populations; the cosmological-constant and dark-matter property lists follow from the 1:1 rest state and the residual-structure transit state.

3 (Derivation). DERIVED. The timescale ratio τ/t_H = 6/21, the rate equation, the constant-feeding result (the two dark fractions to within 1.3% of Planck, the visible to ≈2%).

4 (Epoch dependence). PREDICTION. The split as a function of epoch; the dissolution of the coincidence problem; the DESI DR2 confrontation and the effective equation of state w_eff(z) (4.3); the ΛCDM comparison (KS-42.2).

5 (Derivation of τ). DERIVED. Why 6/21 (six faces / twenty-one channels); the same counting logic as AP28; the meaning of 3.9 Gyr.

6 (Dark-matter particles). EMPIRICAL. The sharpest test (KS-42.1).

7 (What this does not do). SCOPE. The formation-history convolution (D48), the equation of state (KS-42.4), substructure, and the full closure of D44.

0.5 — Kill switch summary

KS-42.1 (Dark-matter particle detection). LIVE — EMPIRICAL. A detected particle at the right abundance falsifies the mechanism.

KS-42.2 (Epoch dependence). LIVE — EMPIRICAL. The predicted dark-sector composition at each epoch must match (the key observable is the growth rate $\sigma_8(z)$).

KS-42.3 (Defragmentation timescale derivation). LIVE — STRUCTURAL. The $\tau = (6/21) \times t_H$ derivation rests on one face-erasure as the atomic unit of defragmentation work.

KS-42.4 (Equation of state). LIVE — EMPIRICAL. Dark energy's intrinsic equation of state is $w = -1$ (the substrate at rest); the effective $w_{eff}(z)$ inferred under a non-interacting analysis is predicted to be phantom ($w_{eff} \leq -1$) in the past, relaxing toward -1 today ($w_a < 0$). The model is under tension if w_0 settles firmly above -1, and killed outright only if w is non-evolving or evolves the wrong way (4.3).

KS-42.5 (Constant feeding rate). LIVE — STRUCTURAL. The section-3 derivation assumes a constant black-hole feeding rate.

KS-42.6 (Timescale ratio derivation). LIVE — EMPIRICAL. The dark-sector timescale ratio $\tau/t_H = 6/21$ (six faces over twenty-one channels); if the ratio that fits the observed split departs from 6/21 beyond the formation-history correction, the ratio derivation fails.

0.6 — Structural debts owed

D44 (Dark-sector partition) — ADDRESSED. The mechanism is proposed, the timescale derived, the epoch dependence predicted, the two dark fractions fixed to within 1.3% of Planck, the visible to ≈2%. Fully closing D44 requires the formation-history convolution (D48) and observational confirmation of the epoch dependence (KS-42.2).

D47 (Defragmentation timescale) — CLOSED (conditional on KS-42.3). $\tau = (6/21) \times t_H$, derived from the ratio of faces (AP24) to channels (AP28). If face-erasure is not the correct atomic unit (KS-42.3), the derivation fails and D47 reopens.

D48 (Formation-history convolution) — OPENED. The constant-feeding model is a first approximation; the exact prediction requires convolution with the observed cosmic black-hole formation history (an astrophysical computation using AP21 plus empirical star-formation data). The 1.2% dark-matter error is attributed to this approximation. The same convolution sets the feeding-rate history that governs the late-time behaviour of the effective equation of state $w_{eff}(z)$ (section 4.3): the constant-feeding model gives a phantom $w_{eff} \leq -1$ asymptoting to -1, and only a declining feeding rate at late times would let w_{eff} cross to the $w_0 > -1$ side DESI's central value prefers. Deriving that history is what would turn AP42's phantom-past sign match into a quantitative w_0w_a contour fit — or confirm the tension.

0.7 — Items held open without claiming debt status

The equation of state $w = -1$ (KS-42.4) follows from the rest-state reading but is not formally derived from the axioms. Dark-matter substructure (halos, density profiles) requires the detailed defragmentation dynamics, not computed here. These are scope boundaries, named for honesty.

0.8 — Structural relationships

AP41 (The Loop). Identifies the visible channel and reads the dark sector as unbroken symmetry; owes the internal split (D44). AP42 supplies it. The dark-sector partition is read consistently across AP29, AP41, and AP42 — one partition under different ordering and rounding (5/26/69, 1/21 + 20/21, 68/27/5).

AP09 (The Forgetful Functor). Defragmentation as U: Mon → Set — the underlying elements survive while the monoid composition dissolves. The mechanism of the dark sector.

AP24 (The Residual). The six faces of ε — the numerator of the timescale ratio. Defragmentation erases six independent readings.

AP28 (The Constant). The twenty-one independent channels — the denominator. The same counting logic that gives $\alpha_G = \alpha_{em}^{21}$ (up to the geometric factor $1 + 1/\pi$; AP28) gives $\tau/t_H = 6/21$.

AP03 (The Ratio). The condensate and why the rest state exerts negative pressure and does not dilute. The substrate stiffness itself — $\lambda \approx 2.15 \times 10^{46}$, the unique constant with dimensions of energy per length — is established in AP15 (see AP21).

AP20 (The Proof). The Hubble time as the total actualisation budget of the substrate — the clock against which defragmentation is timed.

AP21 (The Web). Filamentary structure — how matter reaches black holes; the input to the formation-history convolution (D48).

1 — The Three Components

You already know the total dark fraction: 20/21 ≈ 95.24%. You have watched it derived. But what is inside that 95%? What splits it into 68 and 27?

1.1 — Visible matter: the open channel

1/21 of the total energy budget — the single electromagnetic channel where records are actively being written. Matter that interacts with light. The crack still cracking. Predicted: 4.76%. Observed: 4.86% (Planck 2018). Derived: AP10 gives twenty-one channels, AP28 proves their independence, AP41 identifies one as the visible channel. The match to observation is structural.

1.2 — Dark energy: the completed reservoir

Substrate content in the twenty dark channels that has fully returned to the 1:1 symmetric state. No residual structure. No clustering. No interaction except gravitational, through the background metric. Pure potential. The unbroken mirror. Dark energy is Mode 0 at rest — the condensate (AP03) in its equilibrium configuration. It exerts negative pressure because the 1:1 state resists disturbance (the substrate is extraordinarily stiff, $\lambda \approx 2.15 \times 10^{46}$; AP15). It does not dilute with expansion because it is a property of the substrate itself, not of the matter on it.

1.3 — Dark matter: the process

Substrate content in the twenty dark channels that is still defragmenting — still losing structure, still transitioning from broken (1×ε) back toward symmetric (1:1). The content gravitates because it still carries mass-energy. It clusters because it retains geometric structure during the transition. It does not interact electromagnetically because the electromagnetic channel has already closed for this content — the coupling to the visible channel was severed when the content crossed a σ-boundary (an event horizon). Dark matter is not a particle. It is matter in transit. The 27% is not a noun. It is a verb. And once you see it as a verb, the question changes: you stop asking what dark matter is made of and start asking how far along the processing is.

2 — The Mechanism

Here is the claim. Read it slowly, because if it holds, the most expensive particle search in human history is looking for something that does not exist.

2.1 — What is defragmentation?

AP09 establishes defragmentation: at the loop point (the black-hole interior), records are stripped of their causal order. The forgetful functor U: Mon → Set preserves the underlying elements while dissolving the monoid composition. The information content survives but the structure — the relationships, the ordering, the causal web — dissolves. AP04 and AP41 establish the loop: matter enters a black hole, crosses the Planck surface, and re-emerges as the seed of a new expansion. But the crossing is not instantaneous. The dissolution of structure takes time. A bound state with 1836 units of geometric resistance (AP30) does not defragment in a Planck time. The more structured the record, the longer the processing.

2.2 — The two populations

At any given cosmic epoch, the twenty dark channels contain two populations. Still processing: records that entered black holes recently enough that defragmentation is not complete — these retain residual structure, they cluster, they appear as dark matter. Fully processed: records that entered long enough ago that defragmentation is complete — these have returned to the 1:1 state, they do not cluster, they appear as dark energy. The boundary between the two is not sharp; it is a continuous exponential process. But the characteristic timescale τ divides the populations: content that entered more than ~τ ago is mostly processed; content that entered less than ~τ ago is mostly still in transit.

2.3 — Why the processed content behaves as dark energy

Once defragmentation is complete, the content is in the 1:1 symmetric state — the unbroken vacuum. This state has the properties of a cosmological constant: it is spatially uniform (the 1:1 has no preferred direction), it does not dilute with expansion (it is a property of the substrate, not of objects on it — AP03), it exerts negative pressure (the substrate resists deformation — λ is large), and it

does not cluster (no residual structure to source gravitational attraction). The dark energy is not a mysterious force. It is the substrate in its rest state. It grows over cosmic time because more and more content completes defragmentation. If you have followed the 1:1 through the 420 Code — the unbroken mirror, the symmetric ground state — you already know what this rest state is. It is where the substrate wants to be.

2.4 — Why the in-transit content behaves as dark matter

During defragmentation, the content retains partial structure: it has mass-energy (the geometric resistance is not yet fully dissolved), it clusters gravitationally (residual structure sources gravitational attraction through Mode 0), it does not emit or absorb light (the electromagnetic channel is closed — the content is behind a σ-boundary), and it responds to gravity but not to electromagnetism. These are exactly the observed properties of dark matter. The axioms produce them from one mechanism — incomplete defragmentation — without introducing new particles, new forces, or new fields. You are not being asked to believe in a new substance. You are being asked to recognise a process you have already seen: the break dissolving back into the mirror.

3 — The Derivation

3.1 — The defragmentation timescale from {S, B, R, C}

The defragmentation timescale is not a free parameter. It is derived from the axiom system. Step 1: AP24 establishes that the break ε has exactly six independent scalar readings — six faces: G (geometry), c (propagation), α_em (coupling), m_e (mass), the stiffness ratio (fabric), and time (direction). No seventh face exists (KS-R.8a). To fully defragment a record is to dissolve all six face-structures; each face is an independent reading of ε, so each must be independently erased. Step 2: AP28 establishes that the arena has twenty-one independent coupling channels: six faces × three spatial dimensions = eighteen face-projections, plus three actualisation couplings. The channels are independent (AP28 Proposition 2). Step 3: the atomic unit of defragmentation work is the erasure of one face — not one face-projection (face × dimension), and not one face × one actualisation coupling. One face. The face is the structural unit because defragmentation reverses the break, and the break has six independent readings (AP24 Proposition 1), not eighteen projections. Step 4: there are six faces to erase; the arena offers twenty-one simultaneous processing channels. The fraction of the total actualisation budget consumed by defragmentation is therefore:

$$\tau / t_H = 6 / 21 = 2 / 7.$$

Six faces. Twenty-one channels. The ratio writes itself. No free parameters. You can trace every number back to a derived result: 6 comes from AP24, 21 comes from AP28, both derived. A note on why the Hubble time appears: the Hubble time is not merely the age of the universe — it is the total actualisation budget of the substrate (AP20). Defragmentation occurs within the substrate, not within the black hole as a separate system; inside and outside the event horizon are the same substrate, measured by the same clock. t_H is the only available measure of total elapsed actualisation.

3.2 — The rate equation

Let $\rho_{DM}(t)$ be the record density still defragmenting at cosmic time t, and $\dot{R}(t)$ the rate at which new record density enters black holes. Content enters the

defragmenting population at rate Ṙ(t) and exits into the fully-processed reservoir at rate ρ_DM/τ:

dρ_DM/dt = Ṙ(t) − ρ_DM/τ.

This is a standard linear ODE. The solution is a convolution: ρ_DM(t) = $\int_0^t$ Ṙ(t′) × e^(−(t−t′)/τ) dt′. Each parcel of record density that entered at time t′ has been defragmenting for duration (t − t′); the exponential kernel gives the fraction still in process after that duration.

3.3 — Constant feeding rate approximation

First approximation: Ṙ(t) = Ṙ₀ (constant) — black holes have been ingesting matter at a roughly constant rate over cosmic history. Then ρ_DM(t) = Ṙ₀ τ (1 − e^(−t/τ)). The total dark density created over time t is ρ_dark = Ṙ₀ t. The dark-matter fraction of the dark sector is f_DM = (τ/t)(1 − e^(−t/τ)), and the ratio R = f_DE / f_DM is R(t) = [1 − (τ/t)(1 − e^(−t/τ))] / [(τ/t)(1 − e^(−t/τ))].

3.4 — The result

At the present epoch (t = t_H), with τ/t_H = 6/21: e^(−21/6) = e^(−3.5) ≈ 0.03020. f_DM = (6/21)(1 − 0.03020) = (6/21)(0.96980) = 0.27709. The dark-matter fraction of the dark sector is 27.71%; the dark-energy fraction is 72.29%. Applied to the total budget (dark sector = 20/21):

Dark energy: 0.7229 × 20/21 = 68.85%. Observed (Planck 2018): 68.89%. Error: −0.06%.

Dark matter: 0.2771 × 20/21 = 26.39%. Observed (Planck 2018): 26.07%. Error: +1.22%.

Visible: 1/21 = 4.76%. Observed (Planck 2018): 4.86%. Error: −2.02%.

DE/DM ratio: Model: 2.609. Planck 2018: 2.643. Discrepancy: 1.27%.

The two dark fractions within 1.3% of Planck 2018, the visible channel within ≈2%. The comparison value 4.86 is the Planck 2018 late-universe budget net of radiation and relativistic neutrinos (100 − 68.89 − 26.07 − 0.18 ≈ 4.86). Zero free parameters. The only inputs are 6 (faces, AP24), 21 (channels, AP28), and the exponential decay model (AP09) — all three derived. Sit with that. Three

numbers that cosmologists have spent decades measuring with billion-dollar satellites, predicted from a ratio of two integers — six faces divided by twenty-one channels — and an exponential. No fitting, no tuning. The clock reads itself. For comparison, AP28 derives the gravitational constant G to 0.69%; this paper derives the dark-sector partition to 1.2%. Same axioms. Same ε.

4 — The Epoch Dependence

This is the central prediction of the paper. If you take nothing else from AP42, take this: the 68/27 split is not a constant. It is a snapshot. At different cosmic epochs the ratio is different — because the universe has been defragmenting for a different amount of time. The model predicts the dark-sector composition at every epoch:

z ≈ 5 (1.2 Gyr): DE 13.1%, DM 82.1%, Vis 4.8%, DE/DM 0.16.

z ≈ 2 (3.3 Gyr): DE 30.7%, DM 64.5%, Vis 4.8%, DE/DM 0.48.

z ≈ 1 (5.9 Gyr): DE 45.8%, DM 49.4%, Vis 4.8%, DE/DM 0.93.

z ≈ 0.5 (8.6 Gyr): DE 56.5%, DM 38.7%, Vis 4.8%, DE/DM 1.46.

z = 0, now (13.8 Gyr): DE 68.85%, DM 26.39%, Vis 4.76%, DE/DM 2.609.

The crossover — the epoch at which dark energy first exceeds dark matter — occurs at t ≈ 6.3 Gyr, corresponding to z ≈ 0.9.

4.1 — The coincidence problem dissolves

A persistent puzzle in cosmology: why are we living at the epoch where dark energy has only recently come to dominate? In ΛCDM this is a coincidence — there is no structural reason why the cosmological constant should be comparable to the matter density at this particular moment. In the defragmentation model there is no coincidence. The ratio changes continuously as defragmentation proceeds: dark matter dominated early (most content was still in process), dark energy dominates late (most content has completed processing). You are living at an unremarkable point on a monotonic curve. There is nothing special about z = 0 except that this is when you happen to be reading the clock.

4.2 — Comparison with ΛCDM

In standard ΛCDM, dark matter dilutes as $(1+z)^3$ while dark energy density is constant; the DE = DM crossover occurs at z ≈ 0.38. In the defragmentation model, dark matter is being actively converted into dark energy through defragmentation; the crossover occurs at z ≈ 0.9 in the constant-feeding

approximation. These differ. The defragmentation model predicts more dark matter at high redshift than ΛCDM, because it has a conversion mechanism ΛCDM lacks. This is observationally testable: precision measurements of the dark-matter fraction at $z > 1$ (weak lensing, BAO, CMB lensing) can distinguish the two models. This is flagged as KS-42.2.

ΛCDM is itself now under observational strain, and in a direction this model predicted. DESI DR2 (2025), combining three years of BAO with CMB and Type Ia supernovae, disfavours a constant Λ against an evolving dark energy (the w_0w_aCDM parameterisation) at 2.8–4.2σ depending on the supernova sample (2.8σ Pantheon+, 3.8σ Union3, 4.2σ DESY5; a principled combination of BAO and CMB alone gives 3.1σ), with the data preferring $w_0 > -1$ and $w_a < 0$ — the quintom-B region, in which the equation of state was phantom ($w < -1$) in the past and quintessence-like ($w > -1$) today, with a phantom crossing near $z \approx 0.4$–0.5. The best-fit point for the DESI+CMB+Pantheon+ combination sits near $w_0 \approx -0.84$, $w_a \approx -0.62$. At least one analysis additionally reports a hint of a late-time interaction between dark energy and matter.

This cuts both ways for AP42, and honesty requires naming both. In support: an evolving dark sector with a late-time matter–dark-energy interaction is precisely this paper's mechanism — dark matter (defragmentation in progress) is continuously converted into dark energy (the completed 1:1 reservoir). The coincidence-problem dissolution of section 4.1 lands in a far friendlier observational climate than "Planck 2018, ΛCDM" implies; the data have moved toward the kind of universe the defragmentation clock describes. In tension: the model's effective equation of state is phantom in the past relaxing toward −1 (section 4.3), which matches DESI's phantom-anchored early constraint and the $w_a < 0$ trend but not, in the constant-feeding approximation, the present-day $w_0 > -1$ the late-universe data prefer. Whether that present-day crossing can be reached is owed to the feeding-rate history (D48), and is a live tension meanwhile. That confrontation is section 4.3 and the sharpened KS-42.2 and KS-42.4.

4.3 — The effective equation of state

DESI measures an effective equation of state under a non-interacting analysis: it fits w_0w_aCDM, in which the dark-energy density is assumed to evolve only through its own equation of state, with no source term. The defragmentation model is not that model — it is an interacting one, in which the dark-energy

reservoir is continuously sourced by completed defragmentation. The two equations of state must therefore be distinguished, and the distinction is the prediction.

Intrinsically, each completed unit of reservoir is the substrate at rest: spatially uniform, non-diluting, negative-pressure — a cosmological-constant element with $w = -1$. But the reservoir as a whole is sourced. Its density does not merely fail to dilute; it grows, because content is continuously injected as defragmentation completes (section 1.2). An observer who fits a non-interacting model to a growing reservoir omits the source term, and the omission has a definite sign. From the continuity equation $\dot{\rho} = -3H(1 + w)\rho$, the inferred equation of state is $1 + w_{eff} = -\dot{\rho}_{DE} / (3H\rho_{DE})$. With the reservoir growing, $\dot{\rho}_{DE} > 0$, so $1 + w_{eff} < 0$: the inferred w_{eff} is below -1. A sourced, growing reservoir whose intrinsic state is $w = -1$ is read by the standard analysis as phantom.

This is not a defect; it is the section-4 epoch dependence written in the w-parameterisation, and it must be stated with its real limit. At early times the conversion rate is high relative to the small reservoir, $\dot{\rho}_{DE}/\rho_{DE}$ is large, and w_{eff} sits well below -1 — the phantom regime DESI's CMB-anchored early-universe constraint prefers. As conversion saturates toward the present — most of the dark-sector content already completed — $\dot{\rho}_{DE}/\rho_{DE}$ shrinks and w_{eff} rises back toward -1 from below. The model therefore robustly predicts a phantom past (w_{eff} well below -1) relaxing toward -1 today, which matches DESI's phantom-anchored early constraint and the rising trend $w_a < 0$.

What the model does not do, in the constant-feeding approximation, is deliver a present-day crossing to $w_0 > -1$. A growing, non-diluting reservoir keeps $\dot{\rho}_{DE} > 0$, so $1 + w_{eff} = -\dot{\rho}_{DE}/(3H\rho_{DE}) < 0$ at all times: w_{eff} stays ≤ -1 throughout, asymptoting to -1 rather than crossing it. Reaching the quintessence side that DESI's central value ($w_0 \approx -0.84$) prefers would require the reservoir density to decline at late times — the feeding rate falling faster than replenishment — which is exactly the feeding-rate history the constant-feeding model omits (D48). The match is therefore directional and bounded: the phantom past and the sign of w_a are predicted from the same $\tau = (6/21) \times t_H$ that fixes the partition; the present-day w_0, and whether it crosses -1 at all, are owed to D48. If the data settle firmly at $w_0 > -1$, that is a live tension for the constant-feeding model, not a confirmation of it — and the kill switch (KS-42.4) is written to say so. This is a sign-structure match on the phantom-past half, not a contour fit, and the paper claims no more.

5 — The Derivation of τ

The defragmentation timescale is τ = (6/21) × t_H = (6/21) × 13.8 Gyr ≈ 3.9 Gyr. Here t_H denotes the present cosmic age ≈ 13.8 Gyr (numerically ≈ $1/H_0$ at $H_0 \approx 71$); the partition at the present epoch depends only on the ratio t/τ = 21/6 and is unchanged under either reading.

5.1 — Why 6/21?

Matter entering a black hole must have all six face-structures of ε erased. Each face is an independent reading of the break (AP24 Proposition 1); defragmentation is the dissolution of all six readings. The unit of defragmentation work is one face, not one face-projection. A face-projection is one face read through one spatial dimension; there are eighteen of them (6 × 3). But the three projections of a single face are not independent defragmentation targets — they are three views of the same structural reading. When the G-face is erased, it is erased across all three spatial dimensions simultaneously. The face is the indivisible unit because the break has six independent readings (AP24), and defragmentation reverses the break. The arena processes through twenty-one channels simultaneously (AP28); the channels are independent (AP28 Proposition 2). Each face-erasure takes 1/21 of the total actualisation budget — one channel-share of the total processing time. Six faces, twenty-one channels; the defragmentation time is the ratio τ/t_H = 6/21. This is 1:1 + 1×ε applied to time: the Hubble time is the full clock (the 1); the defragmentation timescale is the 6/21 fraction of it that erasing six faces through twenty-one channels consumes.

5.2 — Why this is the same logic as AP28

You have seen this before. AP28 asks why the gravitational coupling sits $\sim 10^{45}$ below the electromagnetic, and answers: gravity couples through all twenty-one channels simultaneously, so $\alpha_G = \alpha_{em}^{21}$. The hierarchy is a count. This paper asks why the dark sector splits 68/27, and answers: defragmentation erases six faces through twenty-one channels, so τ/t_H = 6/21. The partition is a count. Same structure. Same ε. Different question.

5.3 — What 3.9 Gyr means

The derived defragmentation timescale $\tau \approx 3.9$ Gyr is comparable to the age of the solar system (4.57 Gyr) and to the cosmic age at the peak of star formation ($z \approx 2$, ~3.3 Gyr after the Big Bang). This is not a coincidence: the defragmentation timescale is set by the same structural constants that govern the formation of the structures that produce black holes. Matter that entered black holes in the early universe has had time to fully defragment; matter that entered within the last 3.9 billion years is still in process.

6 — What Dark Matter Particles Would Mean

If dark-matter particles are discovered — WIMPs, axions, sterile neutrinos, or any other species that accounts for the observed 27% — the defragmentation mechanism is dead. KS-42.1 fires. The argument hands you the weapon: find the particle. Conversely, if dark-matter particles are not found despite increasingly sensitive searches, the mechanism gains confidence. The search has been running for approximately forty years with no confirmed detection. The axioms predict there will not be one, because there is no particle to find — the 27% is not a thing, it is a process. This is the sharpest empirical test, and it requires no new experiments, only the continuation of those already running (LZ, XENONnT, PandaX, ADMX, CASPEr, and successors). Every null result is evidence. Every non-detection narrows the space for alternatives. If you want to kill this paper, find the particle.

7 — What This Does Not Do

Model the actual black-hole formation history. The constant-feeding approximation is a first step; the real history (peaked at z ≈ 2, declining since) would modify the predicted epoch dependence and tighten the result. The 1.2% dark-matter error likely comes from this approximation. D48 covers it.

Derive the equation of state. Dark energy's intrinsic state is w = −1 (cosmological-constant behaviour) because the fully-defragmented state is the substrate at rest; the effective w_eff(z) departs from −1 because the reservoir is sourced (section 4.3). The intrinsic value has not been formally derived from the axiom system, and the crossing redshift of w_eff awaits the feeding-rate history (D48). KS-42.4 carries the test.

Explain dark-matter substructure. Whether defragmenting substrate forms halos, and with what density profile, requires the detailed dynamics of the defragmentation process, not computed here.

Close D44 fully. This paper addresses D44 by deriving the timescale and predicting the epoch dependence. Closing it completely requires the full formation-history convolution (D48) and observational confirmation of the epoch dependence (KS-42.2).

8 — Kill Switches

8.1 — KS-42.1 — Dark-matter particle detection

Claim. The 27% is a process (incomplete defragmentation), not a substance; no particle is needed.

Test. Direct detection (LZ, XENONnT, successors), collider searches, indirect detection (Fermi-LAT, CTA). One confirmed detection at the right abundance to explain the observed 27% falsifies the mechanism.

Status. LIVE — EMPIRICAL. Every null result strengthens the mechanism.

Recovery. A confirmed particle kills the defragmentation reading of dark matter; the dark-energy-as-reservoir reading and the channel count would have to be re-examined separately.

8.2 — KS-42.2 — Epoch dependence

Claim. The dark-sector composition varies with epoch along the defragmentation curve (the central prediction, section 4).

Test. Two handles. (i) The DE/DM ratio at $z > 1$: if the ratio at $z \approx 2$ differs from DE/DM ≈ 0.48 by more than the formation-history correction can accommodate, the mechanism fails. (ii) The effective equation of state: the predicted $w_{eff}(z)$ is phantom in the past relaxing toward −1 ($w_a < 0$), so the model matches the phantom-anchored and trend halves of the DESI w_0w_a contour; a measured $w_a > 0$ or a non-evolving w kills it, while a present-day w_0 firmly above −1 is a live tension on the constant-feeding model (section 4.3, KS-42.4). Probes: BAO (DESI), weak lensing (Euclid, Rubin LSST), CMB lensing (Simons Observatory, CMB-S4); the key observables are the growth rate $\sigma_8(z)$ and the w_0w_a constraint.

Status. LIVE — EMPIRICAL.

Recovery. A measured epoch dependence off the curve but still monotonic would point to the feeding-rate history (KS-42.5, D48) rather than to the mechanism.

8.3 — KS-42.3 — Defragmentation timescale derivation

Claim. $\tau = (6/21) \times t_H$, resting on one face-erasure as the atomic unit of defragmentation work.

Test. A formal derivation of defragmentation dynamics from AP09 and AP41 that contradicts the face-by-face dissolution model — e.g. if defragmentation dissolves all faces simultaneously, or if the correct unit is the face-projection (giving $\tau = 18/21 \times t_H$, which fails).

Status. LIVE — STRUCTURAL.

Recovery. If face-erasure is not the atomic unit, the 6/21 ratio fails and the timescale must be rederived; the mechanism survives (dark matter is still a process) but the specific prediction changes, and D47 reopens.

8.4 — KS-42.4 — Equation of state

Claim. Dark energy's intrinsic equation of state is $w = -1$ (the substrate at rest). Because the reservoir is sourced and non-diluting, its density grows ($\dot{\rho}_{DE} > 0$), so the effective $w_{eff}(z)$ inferred under a non-interacting (w_0w_aCDM) analysis is phantom ($w_{eff} \leq -1$) at all times, deepest in the past and asymptoting to -1 today — a phantom past with $w_a < 0$. The constant-feeding model predicts the phantom-past sign and the $w_a < 0$ trend; it does not deliver a present-day crossing to $w_0 > -1$.

Test. Precision w_0w_a measurements (DESI BAO; Type Ia supernovae — Rubin LSST; CMB — Planck successors). Two outcomes: a strictly non-evolving $w = -1$ to high precision, or an evolution in the wrong sense ($w_a > 0$, or a quintom-A signature), kills the rest-state reading outright. A present-day value firmly at $w_0 > -1$ (DESI DR2 currently centres near $w_0 \approx -0.84$) is a live tension for the constant-feeding model, since that model gives $w_0 \leq -1$.

Status. LIVE — EMPIRICAL.

Recovery. A measured $w_0 > -1$ with $w_a < 0$ does not kill the mechanism but does kill the constant-feeding approximation: reaching the quintessence side requires a declining reservoir density at late times, i.e. a feeding rate that falls faster than replenishment — the feeding-rate history owed to D48. The

mechanism survives; the simple feeding model is replaced. Only a wrong-sign or non-evolving w kills the rest-state reading itself.

8.5 — KS-42.5 — Constant feeding rate

Claim. The section-3 derivation uses a constant black-hole feeding rate $\dot{R}_0$.

Test. Compute the convolution using the observed cosmic star-formation history and black-hole mass-function evolution; if the convolved DE/DM ratio at the present epoch differs significantly from 2.609, the constant-rate approximation fails.

Status. LIVE — STRUCTURAL.

Recovery. Failure here kills the simple model, not the mechanism: it requires the detailed formation-history computation (D48), not abandonment of defragmentation.

8.6 — KS-42.6 — Timescale ratio derivation

Claim. The dark-sector timescale ratio is $\tau/t_H = 6/21$ — six faces (AP24) over twenty-one channels (AP28) — the same counting logic as AP28's hierarchy.

Test. If the timescale ratio that fits the observed dark-sector split, after the formation-history correction, departs from 6/21, the ratio derivation fails.

Status. LIVE — EMPIRICAL.

Recovery. A ratio away from 6/21 that had to be imposed by hand would localise the gap to the face-count or channel-count inputs (AP24, AP28) rather than to the defragmentation mechanism itself.

9 — What This Establishes and What Remains Open

9.1 — What this paper closes

It addresses D44, the dark-sector partition, by deriving a single timescale $\tau = (6/21) \times t_H \approx 3.9$ Gyr from the six faces (AP24) and twenty-one channels (AP28), and from it the three fractions — dark energy 68.85%, dark matter 26.39%, visible 4.76% — the two dark fractions within 1.3% of Planck 2018 and the visible within ≈2%, with zero free parameters. It closes D47 (the defragmentation timescale) conditional on KS-42.3. It supplies the structural identification of dark matter as process and dark energy as reservoir.

9.2 — What this paper does not close

It does not fully close D44: the full closure needs the formation-history convolution (D48) and observational confirmation of the epoch dependence (KS-42.2). It does not formally derive the equation of state $w = -1$ (KS-42.4) or dark-matter substructure. It does not model the actual black-hole formation history (the constant-feeding approximation; the 1.2% dark-matter error is attributed to it).

9.3 — Items held open without claiming debt status

The equation of state (a rest-state reading, not an axiom derivation) and dark-matter substructure (needs the detailed defragmentation dynamics). Named for honesty about scope.

9.4 — Where the philosophical-register implementations live

The expository-register companion for the dark-sector reading — dark matter as process, the universe as a clock — lives in Ø Predictions (its dark-sector chapters; the timescale-ratio prediction is registered there as well). AP42 is the formal-register origin of the defragmentation timescale and the dark-sector split.

9.5 — Structural relationships to subsequent work

AP42 supplies the internal split AP41 owes (D44). It feeds the cosmological dark-sector claims, the prediction that dark-matter particles will not be found, the dissolution of the coincidence problem, and the epoch dependence. Its formation-history convolution (D48) takes AP21 as input.

9.6 — The 420 Code placement

AP42 is a chapter of Notebook VI (Cosmology), the dark-energy chapter, completing the dark-sector account that AP41 opens.

9.7 — How the body of work reads now

With AP41 and AP42 in place, the 420 Code reads the entire energy budget as a count and a clock: the visible 5% as one channel of twenty-one, the dark sector as the twenty unbroken channels, and the 68/27 split within them as a reading of how far the current defragmentation cycle has run. The hardest open work is empirical — the epoch dependence and the particle search — plus the formation-history convolution (D48).

9.8 — The closing

The dark-sector partition 68/27/5 is not a mystery. It is a clock. And now you can read it. Visible matter (4.76%, observed 4.86%): the one channel of twenty-one where the crack is still open and records are still being written. Dark matter (26.39%, observed 26.07%): the fraction of the twenty dark channels where defragmentation is still in progress — substrate content that entered black holes within the last ~4 billion years, still structured enough to cluster. Dark energy (68.85%, observed 68.89%): the substrate that has completed defragmentation and returned to the symmetric 1:1 rest state. One timescale, $\tau = (6/21) \times t_H$, derived from six faces and twenty-one channels. The clock reads itself.

Claim Summary

DERIVED. The defragmentation timescale $\tau = (6/21) \times t_H \approx 3.9$ Gyr (sections 3.1, 5). The three fractions — dark energy 68.85%, dark matter 26.39%, visible 4.76% — the two dark within 1.3% of Planck 2018, the visible within ≈2%, zero free parameters (section 3.4). The rate equation and its convolution solution (section 3.2).

STRUCTURAL IDENTIFICATION. Dark matter as the in-transit defragmentation process; dark energy as the completed-reservoir rest state; visible matter as the open channel (sections 1–2).

PREDICTION. The epoch dependence of the split, dissolving the coincidence problem; the ΛCDM-distinguishing crossover at $z \approx 0.9$ (section 4).

ADDRESSED / CLOSED. D44 (dark-sector partition) ADDRESSED; D47 (defragmentation timescale) CLOSED conditional on KS-42.3; D48 (formation-history convolution) OPENED.

FALSIFICATION REGISTER. KS-42.1 (dark-matter particle detection, EMPIRICAL), KS-42.2 (epoch dependence, EMPIRICAL), KS-42.3 (defragmentation timescale derivation, STRUCTURAL), KS-42.4 (equation of state, EMPIRICAL), KS-42.5 (constant feeding rate, STRUCTURAL), KS-42.6 (timescale ratio derivation, EMPIRICAL).

Conditionality Footer

Dependencies

AP04 (the loop), AP06 (α), AP09 (defragmentation, the forgetful functor), AP10 (twenty-one channels, three dimensions), AP20 (the substrate clock), AP21 (filamentary structure), AP24 (the six faces), AP28 (the twenty-one channels, coupling independence), AP41 (the visible-channel identification). Independent of AP30/AP30a and the ethics chain (AP31–AP39).

Dependents

The body of work's cosmological dark-sector claims; the prediction that dark-matter particles will not be found; the resolution of the coincidence problem; the epoch dependence of the partition.

Kill switches closed by this paper

None outright. D47 is CLOSED conditional on KS-42.3. KS-42.1–KS-42.6 are introduced or carried as live (KS-42.6 newly added).

Kill switches that remain live

KS-42.1 (EMPIRICAL), KS-42.2 (EMPIRICAL), KS-42.3 (STRUCTURAL), KS-42.4 (EMPIRICAL), KS-42.5 (STRUCTURAL), KS-42.6 (EMPIRICAL).

Structural debts owed

D44 (ADDRESSED — full closure needs D48 and KS-42.2), D47 (CLOSED conditional on KS-42.3), D48 (OPENED — the formation-history convolution).

Items held open without claiming debt status

The equation of state $w = -1$ (KS-42.4, not formally derived); dark-matter substructure; the actual black-hole formation history (the constant-feeding approximation).

Notation Reference

τ — the defragmentation timescale. τ = (6/21) × t_H ≈ 3.9 Gyr.

t_H — the Hubble time; the total actualisation budget of the substrate (AP20).

6/21 — the timescale ratio: six faces of ε (AP24) over twenty-one coupling channels (AP28). Equivalently 2/7.

ρ_DM, Ṙ(t), Ṙ₀ — the defragmenting record density; the rate new record density enters black holes; the constant-feeding approximation Ṙ(t) = Ṙ₀.

f_DM, f_DE — the dark-matter and dark-energy fractions of the dark sector; f_DM = (τ/t)(1 − e^(−t/τ)).

20/21, 1/21 — the total dark fraction (≈ 95.24%) and the visible fraction (≈ 4.76%) from the channel count (AP10, AP28, AP41).

w — the dark-energy equation-of-state parameter; the model predicts w = −1 (the substrate at rest).

U: Mon → Set — the forgetful functor (AP09): defragmentation preserves the underlying elements while dissolving the monoid composition.

σ-boundary — the event horizon; crossing it closes the electromagnetic channel for the content (Axiom S, Axiom C).

λ — the substrate stiffness, λ ≈ 2.15 × 10^{46} (the dimensionful constant with units of energy per length; established in AP15, used in AP21). Distinct from AP17's dimensionless stiffness ratio Λ_sub, which shares the magnitude but not the dimensions. Why the rest state exerts negative pressure and does not dilute.

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STUDIO 6