Ø Predictions

One Axiom. Five Numbers. Zero Free Parameters.

For the reader who chose to read.

Thank you.

Contents

Artist’s Note

On why this book exists, and who wrote it

I am an artist and a natural philosopher working out of Studio G in Cape Town, on the southern tip of Africa. I am not a physicist. I have no doctorate. I am not affiliated with any university. The 420 Code — the corpus of which this book is one of several public-facing volumes — is the result of thirty years of private work.

I am telling you this upfront because the claims in this book are large. A formula that predicts the proton’s mass to ten parts per trillion. A derivation of the gravitational constant. A prediction of the Hubble constant. A structural reading of dark matter as a process rather than a particle.

Claims of this size from someone outside the academy are statistically more likely to be crackpot work than to be correct. The honest position is to acknowledge that, and then to let the numbers and the kill switches speak.

The kill switches are the point.

Every prediction in this book is published with the specific experimental or theoretical conditions that would destroy it. A physicist who reads these chapters and finds one of the kill switches is not my opponent — they are the reader the book is written for.

If the claims are wrong, the kill switches tell you exactly where to look to prove it. If the claims are right, the kill switches will keep failing to fire, and the match between the predictions and the measurements will keep holding.

What the book is, and what it is not

This book, Ø Predictions, is the first book in the Ø Models catalogue of The 420 Code. It is the shorter reader's edition of the formal papers from which it derives, written in plainer language, and intended for anyone who can follow a school-leaver level of mathematics. It does not require a physics degree. It does not require familiarity with general relativity or quantum field theory. It does require willingness to follow a specific derivation step by step, and willingness to watch the kill switches being named.

The formal papers — AP28, AP30, AP18, AP42, and the supporting volumes — are where the full mathematical apparatus lives. The formal papers are also freely available at the420code.org, under a copyleft licence. Nothing in either edition is paywalled. Nothing is behind a login. If you are reading Ø Predictions and want the full derivation, the formal paper is one click away.

What the book is not: it is not a complete theory of physics. It is not a replacement for the Standard Model or for general relativity. It is not a finished programme. There are debts I have not closed, interpretive claims I cannot yet prove, and kill switches that will have to be weathered over the next decade as observational work proceeds.

What the book does is produce five numbers from one axiom with zero free parameters, and name the exact conditions under which each of those numbers would have to be withdrawn. That is the whole claim.

The axiom, in one line

The entire book rests on a single line of text.

1:1 + 1×ε @ AS

Perfect symmetry plus one minimal break, at the actualizing now. The substrate of reality — whatever the substrate is — exists in a state of perfect balance with one crack in it, and the crack is irreducible.

AS is the actualizing structural prior — the now at which potential becomes record. The break occurs at AS because AS is when actualization happens. Without AS, the axiom describes a balance and a crack with no agent and no time. With AS, the axiom names the foundation: the substrate is held, the break persists, the cycle continues.

If there were no break, no record would ever be written, no distinction would ever be made, nothing would happen at all. If there were no AS, there would be no when at which any of it could happen. The universe is the record history of that one crack being maintained at AS against the substrate's tendency to heal.

Four structural conditions follow from the axiom: S (symmetry, the two-sector structure of the substrate), B (the break, the minimum element of asymmetry), R (record, the irreversibility of what has been written), and C (constraint, the finite speed at which distinctions propagate). S, B, R, and C are not additional axioms.

They are the four structural properties the single axiom must have for the universe to be consistent with its own existence. Everything else in the book is derived from these four properties. One measured input is needed: α, the fine-structure constant, which turns out to be the rate at which the substrate leaks its own structure at AS. Nothing else is fitted.

Five numbers fall out. The proton-to-electron mass ratio. The gravitational constant. The neutron-proton mass difference. The MOND acceleration. The dark sector partition. Each derived independently from the axiom system. Each matched against the best available measurement. Each published with its kill switches.

On the copyleft

Every word of the corpus — the formal papers, the book, the supporting volumes, the source code for the verifications — is free. Copyleft 2026. No paywall. No royalties. No license fee for use, teaching, translation, or adaptation.

If you want to translate this book into Zulu, do it.

If you want to turn it into a children's book, do it. If you want to cite the formulae in your own work, cite them however you cite anything you consider true. The corpus is a gift, and the gift is already paid for.

I chose copyleft because the claims in the book are structural claims about what reality is. Structural claims are not owned. A correct claim about the universe belongs to the universe, not to the person who happened to write it down.

If the claims are wrong, the market will ignore them, and nothing will be lost by making them free. If they are right, the fastest way for the world to benefit from them is to remove every barrier to their spread.

There is also a practical matter. I am not an academic, and I have no interest in becoming one. Publishing through the usual channels — peer-reviewed journals, university presses, conference proceedings — would take years, require compromises I am not willing to make, and would restrict access through paywalls in any case.

Publishing copyleft online means the work is immediately available to anyone who wants to read it, replicate it, extend it, or destroy it. That is the correct publishing model for work of this kind.

A word on the work itself

The corpus developed over thirty years. It did not come all at once. There were long stretches where I was sculpting figures, running a small business, raising children, and the axiom system was quietly unfolding in notebooks I rarely opened.

There were other stretches where I could think of nothing else, and the notebooks filled up in weeks.

The formal structure — the forty-three Artist's Proofs, the supporting volumes, the kill switch registry — took the last several years to stabilise. Ø Predictions is part of Ø Models, a catalogue that condenses the central physics and philosophical claims of The 420 Code.

I do not know if the claims are right. I know the kill switches are live, I know the numbers match, and I know the derivation is internally consistent.

Beyond that, I am watching the same observational programmes you are.

Over the next decade, the Hubble tension will be resolved, lattice QCD will reach sub-0.1% precision on the neutron-proton difference, Euclid and Rubin LSST will measure the dark sector composition at high redshift, and the continuing null results from dark matter direct detection will either continue or not.

If the framework is right, those programmes will confirm it. If the framework is wrong, they will kill it cleanly, and I will accept that.

Until then, the book is what I have to offer. One axiom. Five numbers. Zero free parameters. The kill switches are named. The code is in the appendix and it runs in a fraction of a second. Everything you need to falsify the claims is in your hands.

Thank you for reading.

Orientation

How to read this book

This is a short note for the reader before the book begins. It explains what you will encounter, in what order, and what vocabulary you will need to have installed as you go. The Introduction is the formal start of the argument; this note is preparation.

What the book does

The book derives five numbers from one axiom.

The numbers are the proton-to-electron mass ratio (1836.152673), the gravitational constant (6.67×10^{-11} N·m^2/kg^2), the neutron-proton mass difference (2.53 electron masses), the MOND acceleration (1.2×10^{-10} m/s^2), and the dark sector partition (68% dark energy, 27% dark matter, 5% visible matter). Five quantities, spanning particle physics, gravity, and cosmology.

The axiom is one line of text: 1:1 + 1×ε @ AS — perfect symmetry plus one minimal break, at the actualizing now. The book argues that this single axiom, plus four structural conditions that follow from it, plus one measured input (the fine-structure constant $\alpha \approx 1/137$), suffices to produce all five numbers with zero free parameters.

The Standard Model of particle physics plus ΛCDM cosmology uses approximately twenty-five to thirty fitted parameters to match approximately fifty observable quantities. This book uses one measured input to match five. The claim is that the efficiency ratio is real — that the axiom system forces these five numbers without adjustment.

The order of the book

The book has five Parts, each deriving one of the five numbers. Read them in order.

Part I derives the proton-to-electron mass ratio. It is the hardest chapter because it installs the structural vocabulary used by every chapter that follows — the building with twenty-one corridors, the three colour faces, the four floors of the proton's structure, the identification of α as the leakage rate of the substrate, the axiom running as a process rather than a static fact. If you only read one chapter, read Part I. Everything else uses what Part I establishes.

Part II derives the gravitational constant. It uses the twenty-one channels from Part I, the coupling α from Part I, and adds one new geometric factor ($1/\pi$, from the topological puncture that is the electron). The key claim — that gravity is the same coupling as electromagnetism distributed across all twenty-one channels simultaneously — is the structural centre of the book.

Part III derives the neutron-proton mass difference. It uses the three colour faces from Part I, the coupling α from Part I, and adds the closed-loop curvature factor $1/(2\pi)$. The neutron is the proton with one wall repainted; the cost of that repainting is two terms that add to 2.53 electron masses.

Part IV derives the MOND acceleration scale and predicts the Hubble constant. It leaves the nuclear scale and goes cosmological. The dipolar topology of the tension field closing at the Hubble radius produces the acceleration floor that galaxies everywhere feel, and running the formula backwards predicts H_0 = 74.3 km/s/Mpc. This is the most testable prediction in the book — the Hubble tension will be resolved within the next decade.

Part V derives the dark sector partition (68/27/5). This is the most radical chapter. It argues that dark matter is not a particle species but a process — the defragmentation of records inside black holes — and that dark energy is the completed form of the same process. The 68/27/5 partition falls out of one derived timescale τ/t_H = 6/21 through exponential decay.

Each chapter ends with a kill switch section that names exactly what would destroy the prediction, a verification section that shows how to check the numbers on a calculator in under a minute, and a research proposal pointer to Appendix D.

Front matter and back matter

Before Part I, three short sections set up vocabulary the Parts will use without re-deriving: Where the Integers Come From (the origins of the structural integers 3, 4, 6, 21), Why α and Only α (why the fine-structure constant is the single measured input), and the Introduction itself (One Axiom, Five Numbers).

After Part V, two short sections read the five predictions together: On Coincidence (the test for distinguishing derivation from numerology, applied across all five predictions) and The Closed Loop in Five Numbers (the corpus-integrating essay on what the five predictions say together about the structure the axiom generates).

The back matter has three appendices. Appendix B contains the full verification code — about thirty lines of Python that produce all five predictions in under a second. Verify the Code is a short reader guide explaining exactly how to run the verification yourself. Appendix D consolidates the research proposals from all five Parts into a single programme document.

Vocabulary you will meet

A few terms recur throughout the book. Each is fully explained where it first appears, but a brief orientation here may help the first read.

The substrate. The pre-manifold structure from which space and time are written. Not a material. Not a field. Closer to a mathematical object than a physical one: the domain on which the axiom operates. Whenever the book says substrate, it means this.

The break (ε). The single element of asymmetry in $1:1 + 1\times\varepsilon$ @ AS. Not a physical object. A structural feature — the one place where the substrate departs from perfect symmetry. Every record, every particle, every observation is a reading of this break through one structural channel.

AS. The actualizing structural prior, named in the axiom: $1:1 + 1\times\varepsilon$ @ AS. AS is the now — the actualizing instant at which potential becomes record. AS holds the break (the persistent distinction potential, irreducible — what holds S open) and runs the α-flow around it (the $+1/137$ leakage and $-1/137$ replenishment that balance at every AS-instant). Without AS, the axiom describes a balance and a crack with no agent and no time at which anything occurs. AS cannot measure itself, because measurement is something records do, and AS is upstream of every record. The pupil cannot measure itself.

The four axioms S, B, R, C. Not four independent axioms. Four structural properties of the single axiom 1:1 + 1×ε @ AS. S for symmetry (the substrate has a two-sector structure). B for break (the minimum element ε). R for record (irreversibility — what is written cannot be unwritten). C for constraint (the finite speed at which distinctions propagate). These four appear in every derivation.

The arena. The manifold generated by the four axioms. Three spatial dimensions, one temporal dimension, a two-sector structure, six scalar readings of the break, and twenty-one independent coupling channels. Everything physical happens in the arena.

The channels. Twenty-one independent structural pathways through which the break can couple to itself. Six scalar readings of the break × three spatial dimensions = eighteen face-projections. Plus three actualization couplings. Eighteen plus three equals twenty-one. Derived once. Used in every chapter.

The building. A metaphor for the internal structure of a bound state — a proton, a neutron, or (in Part II) gravity's arena. Twenty-one corridors. Three colour faces. Four floors. Each structural element means something specific in the derivation, and the metaphor is tight enough that you can follow the derivation by tracking how the rooms and corridors combine.

α, the fine-structure constant. The one measured input in the book. Usually quoted as $\alpha \approx 1/137$ or more precisely $\alpha = 7.2973525693 \times 10^{-3}$. In standard physics, α is the strength of the electromagnetic coupling.

In this framework, α is identified as the leakage rate of the substrate — the fraction per unit time at which the substrate loses coherence through any open boundary. The identification is not imported; it is derived in AP06. But for present purposes, just remember that α is the one number the book does not derive.

The axiom running. A recurring phrase. It signals a moment when an abstract structural claim is being connected to the reader's body — when the substrate's dynamics are being named as ongoing process rather than static arithmetic. The axiom is running right now, everywhere, at every site where a record is being written. The book names this at specific moments to prevent the derivation from feeling like calculation detached from reality.

What the kill switches do

Every Part of the book ends with a section called If this is wrong. Each section names between four and seven kill switches — specific conditions under which the Part's central prediction would be falsified. The kill switches are numbered, published in advance, and most are immediately testable.

A kill switch is not a hedge. It is a commitment. A kill switch names exactly what would have to happen, in theory or in experiment, for the prediction to be withdrawn. If the kill switch fires, the prediction dies cleanly — no retreat into adjustable parameters, no renaming of terms, no soft-focus rescue. The framework does not survive by dodging. It survives by passing tests it could have failed.

Some kill switches are empirical — they fire if a measurement produces a result outside a named tolerance. Others are structural — they fire if a formal proof exhibits a counterexample to an axiom-level claim. Most are empirical, because most are immediately testable with existing or imminent experimental programmes.

A small number of kill switches guard interpretive claims rather than numerical ones. KS-R.10 in Part II is one example: it guards the claim that gravity and electromagnetism are the same coupling at different multiplicities.

A numerical reader can accept Part II's prediction of G without accepting the unification interpretation; KS-R.10 fails separately, and the G prediction does not depend on it. The book is careful to name which kill switches guard numerical claims and which guard interpretations, so readers who want to take the numbers without the interpretation can do so.

What you are expected to do as a reader

Nothing unusual. Read the book from beginning to end, in order. Follow the derivations step by step. When a number is claimed, check it on a calculator if you want — the verification sections tell you how, and Appendix B has the Python code that does all five in under a second.

When a kill switch is named, note it and carry it with you. If you find an error — numerical, structural, or logical — the contact information at the420code.org is live and monitored.

The book is written for a reader who has completed school-level mathematics and has a general interest in physics, philosophy, or cosmology. No specialist training is required. A physicist will find it useful as a companion to the formal papers (AP28, AP30, AP18, AP42 and supporting volumes, all freely available at the420code.org).

A philosopher will find the axiom system and its structural claims addressable in purely conceptual terms. A curious layperson will find the building metaphor, the coin flips, and the body-anchors enough to follow the main argument without skipping.

What you are not expected to do is believe the claims because the book makes them. The claims are not delivered on authority. They are delivered with verification procedures and kill switches attached. Belief or disbelief is not what the book is asking for. The book is asking for you to run the numbers yourself, and to note the conditions under which the numbers would have to be withdrawn.

Belief is not the test. The test is whether the numbers survive the next decade of observation and the next generation of formal analysis. That test is underway right now, independently of what any reader thinks. This book is one contribution to that process. The measurements will do the rest.

Turn the page.

Where the Integers Come From

How 3, 4, 6, and 21 are derived — once, in advance, and used everywhere

Four small integers do most of the work in this book. The number 3 (three colour faces). The number 4 (four floors of the bound state). The number 6 (six independent scalar readings of the break). The number 21 (twenty-one independent coupling channels of the arena).

Each appears in multiple chapters. The 21 that counts channels inside the proton (Part I) is the same 21 that sets the exponent of the gravitational coupling (Part II), the same 21 that denominates the visible fraction of the universe (Part V), and the same 21 that normalises the defragmentation timescale (Part V again).

The 3 that counts colour faces inside the proton (Part I) is the same 3 that registers the flavour swap in the neutron (Part III). The 6 that counts the scalar readings of the break (established in the corpus's AP24) is the same 6 that counts the face-erasures required to complete defragmentation (Part V).

This is important. It is also a claim the book has to earn. If each integer were chosen freshly for each prediction, the framework would be doing twenty-five-parameter fitting under the name of zero-parameter derivation. The claim is that each integer is derived once, from a specific piece of the axiom machinery, for reasons that have nothing to do with any particular numerical target, and then used wherever it appears.

This short section lays out where each integer comes from. If any of the four derivations is wrong, the predictions that use it fall together. If all four are right, the predictions stand together.

The number 3 — three spatial dimensions, three colour faces

Three is the spatial dimensionality of the arena, and it is the colour count of the strong force.

The spatial-dimensionality claim is derived in AP10. The argument is structural: given the four axioms S, B, R, C, the number of independent spatial dimensions the arena can support is forced to be three. Not two (which would prevent closed-loop coupling). Not four (which would over-determine the face-projections and produce inconsistency with Axiom S). Three is the unique number consistent with the axiom system.

That same three shows up as the colour count of the strong force. In standard QCD, colour charge has three values (red, green, blue). The three are independent. They are exchanged by gluons in a specific mathematical structure called SU(3). But standard QCD takes the three colours as an empirical input — they are postulated because QCD with two or four colours does not match experiment.

In the framework, the three colours are identified as the three structural readings of the break through each of the three spatial dimensions. AP19 derives this identification: the colour exchange matrix of QCD is exactly the face-projection structure the axiom system forces, and the number three appears because the arena has exactly three spatial dimensions (AP10), not because QCD happened to need three.

This is the same integer appearing twice. Part I uses it as the colour count in Layer 3 of the proton’s static mass decomposition: $3^2 = 9$ colour-face exchange pathways. Part III uses it as the face count that registers the neutron-proton flavour swap: $3 \times (1 - 1/(2\pi))$. Both usages trace to the same spatial-dimensionality derivation in AP10.

The number 4 — four floors, four axioms

Four is the number of axiom conditions and the number of floors in the proton’s structural building.

The four axiom conditions are S, B, R, and C. These are not four independent axioms. They are the four structural properties the single axiom 1:1 + 1×ε @ AS must have. S is the two-sector structure (symmetry). B is the minimal element of asymmetry (break). R is irreversibility (record). C is the finite propagation speed (constraint). Together they exhaust the structural content of the axiom.

Why four and not three or five? Because the axiom has four irreducible structural features: it has two sectors (S), it has one break (B), the break persists (R), and propagation is bounded (C). Remove any one and the axiom cannot generate a consistent universe. Add any fifth property and it becomes a consequence of the existing four. Four is the minimum complete set. This is proved in AP20.

Part I uses four as the number of floors in the proton's building. The four floors correspond to the four axiom subsets that contribute independently to the static mass count: $21^2 \times 4$ is Layer 1, representing the four-axiom contribution. Four shows up here because the proton's bound-state structure couples to each of the four axiom conditions independently.

Four is not used in Parts II, III, IV, or V. Its appearance in Part I is specifically the floor count of the building, which maps to the axiom subset count. When the book says the building has four floors, it means the bound state occupies four independent axiom-condition subspaces.

The number 6 — six scalar readings of the break

Six is the number of independent scalar invariants of the break ε.

A scalar invariant is a single number you can extract from the break's structure. In the framework, there are six such invariants, each measuring a different aspect of the break's presence.

Face 1: mass, specifically the electron mass m_e. The break's resistance to being moved.

Face 2: propagation speed c. The rate at which the break's effects can spread through the arena.

Face 3: geometric persistence G. The cost of maintaining the break against the substrate's tendency to heal.

Face 4: phase coupling α. The rate at which the break leaks its own structure.

Face 5: fabric stiffness. The substrate's resistance to deformation, measured as the ratio of spatial-to-temporal stiffness.

Face 6: temporal direction. Time as the arrow of irreversibility — Axiom R's signature.

These are not six independent things. They are six independent readings of the same one thing. The break ε has structure; any single measurement probes one aspect of that structure; six independent aspects exhaust what can be measured from a single break.

The count of six is derived in AP24 §2, and the completeness of the list — no seventh independent scalar reading is possible — is proved in AP28 §5 Proposition 1.

A seventh face is excluded because any candidate seventh reading must either reduce to a combination of the six (which means it is not independent), or require a fifth structural axiom (which violates AP20's completeness), or require a fourth spatial dimension (which violates AP10's dimensionality derivation). The six-face list is exhaustive.

Part V uses the six faces as the count of defragmentation targets: to fully defragment a record is to dissolve all six face-structures. The 6 in $\tau/t\_H = 6/21$ is this face count. Part II uses the six faces implicitly in the channel-count derivation below.

The number 21 — twenty-one independent coupling channels

Twenty-one is the arithmetic combination 6 × 3 + 3. It counts independent structural pathways through which the break can couple to itself.

The derivation is clean. Six faces of the break (just counted above). Three spatial dimensions (just counted above). Each face can project into each spatial dimension, giving 6 × 3 = 18 independent face-projections. Each face-projection is a distinct coupling pathway — a distinct way the break can interact with itself through a specific face read in a specific spatial direction.

Plus three additional couplings. The actualization state — the surface from which records are written — must couple independently to each of the three spatial dimensions to specify where in the arena a record is inscribed. This gives three additional pathways beyond the face-projections. Derived in AP28 §5 Proposition 2.

The total: 18 + 3 = 21 independent channels.

21 = 6 × 3 + 3

Six times three from the face-dimension combinations. Plus three from the actualization couplings. Each number is independently derived. The sum is forced.

The 21 appears everywhere in the book. Part I uses it as the primary channel count in the proton's static mass decomposition: $21^2 \times 4 + 21 \times 3 + 3^2 = 1836$. Part II uses it as the exponent in the gravitational coupling: $\alpha^{21} \times (1 + 1/\pi) \times \hbar c/m_e^2 = G$.

Part V uses it in two distinct roles: as the count of parallel channels through which defragmentation proceeds (giving the 1/21 per face-erasure in $\tau/t_H = 6/21$), and as the total channel count that separates the visible fraction (1/21) from the dark fraction (20/21).

In each case, 21 is not chosen to match a specific number. It is the channel count derived from the six-face, three-dimension, three-actualization structure of the arena. If 21 were 22, every prediction would shift — the proton mass, the gravitational constant, the dark sector partition would all change together. They cannot be separately adjusted. The same integer runs through every calculation.

Independence of the integers

A natural question: are the four integers — 3, 4, 6, 21 — themselves independent of each other, or can one be derived from another?

They are partially independent. The 3 is the spatial dimensionality, derived from the axiom system (AP10) without reference to any other integer. The 6 is the face count, derived from the scalar-invariant structure of the break (AP24, AP28 §5 Prop 1) without reference to 3 or 21. The 4 is the axiom condition count, derived from the structural completeness of S, B, R, C (AP20). Each of these three — 3, 4, 6 — is derived directly from the axiom system.

The 21 is not independent. It is the specific combination 6 × 3 + 3, constructed from the 6 (face count) and the 3 (spatial dimensions) plus an additive 3 (actualization couplings). If the 6 or the 3 changes, the 21 changes with it. This is why KS-R.8a and KS-R.8b in Part II both fire against the 21: one tests the face count, the other tests the actualization scope. Either would break 21, and either would break every prediction that uses 21.

This is structural forcing. The integers are not a list of free parameters. They are a small set of derived quantities, each with its own axiom-level justification, interlocking in specific ways that the framework's predictions depend on. If any of them is wrong, everything falls together. If all of them are right, everything stands together.

Why this is not numerology

The first test for distinguishing a derivation from a numerological coincidence is whether the integers are derived before the numerical target is known. The four integers in this book pass that test.

3 was derived in AP10 as the spatial dimensionality of the arena. The derivation concerns the structural consistency of axiom-generated space, not any physics target. It was established before any prediction about the proton, the neutron, or the dark sector was attempted.

4 was derived in AP20 as the completeness count of the axiom conditions. The derivation concerns the minimum set of structural properties an axiom must have to generate a universe. It was established before any mass count was attempted.

6 was derived in AP24 as the face count of the break. The derivation concerns what can be measured from a single break's presence — a structural question about scalar invariants. It was established before any cosmological prediction was attempted.

21 was constructed from 6 × 3 + 3 in AP28. The construction concerns the channel count of the arena — a structural question about how the break can couple to itself. It was established before any mass ratio, gravitational constant, or dark sector partition was attempted.

Each integer was in hand before the numerical targets it would eventually match.

The match between the derived integers and the measured numbers is either a multiple coincidence across five independent predictions, or it is the axiom system producing the numbers it forces. The book does not claim the first is impossible; it claims the second is testable, and that the kill switches will decide.

One more count — the four floors of the building

A technical note on Part I specifically. Part I's proton mass derivation uses the formula $21^2 \times 4 + 21 \times 3 + 3^2 = 1836$, which contains the integer 4 in the coefficient of 21^2.

That 4 is the axiom condition count. $21^2 = 441$ is the pairwise channel-channel coupling count. Multiplying by 4 gives 1764 — the count of pairwise channel couplings across all four axiom conditions. This is Layer 1 of the proton's static mass decomposition.

The 3 in the 21×3 term is the colour face count (same 3 as three spatial dimensions). This is Layer 2. The 3^2 in the third term is the colour-exchange matrix count (3×3 for the pairwise colour couplings). This is Layer 3.

Each layer contributes one term. Each term uses integers derived elsewhere. No integer is introduced fresh in Part I; they are all carried in from the earlier axiom work. The proton mass is 1836 because the channel structure plus the face structure plus the colour-exchange structure combine to produce exactly that count.

The same integers, in different combinations, produce the other four predictions. Each combination is forced by the specific structural question being asked. The integers themselves are fixed by the axiom system.

Where the integers come from is the answer to the first question a careful reader asks of any derivation: did the author pick them? The answer, for each of the four integers in this book, is no. They were picked by the axiom system. The axiom system is in the corpus.

You can check the derivations yourself — AP10 for the spatial dimensionality, AP20 for the axiom condition count, AP24 and AP28 §5 Prop 1 for the face count, AP28 §5 Prop 2 for the actualization coupling count.

Each derivation is published and freely available at the420code.org.

The integers were in hand before any of the five predictions in this book.

What follows — the proton mass, the gravitational constant, the neutron-proton difference, the MOND scale, the dark sector partition — is the axiom system producing the numbers it forces when you read it at five different scales.

Why α and Only α

The single measured input to the entire framework

The fine-structure constant is one number.

$$\alpha = 7.2973525693 \times 10^{-3} \approx 1/137$$

Known to ten significant figures from spectroscopy and quantum-electrodynamics experiments. The most precisely measured dimensionless quantity in physics. Every textbook of quantum mechanics introduces it. Nobody knows why it has the value it does.

Feynman, in QED: The Strange Theory of Light and Matter, famously said of α: "It’s one of the greatest damn mysteries of physics: a magic number that comes to us with no understanding by man. You might say the hand of God wrote that number, and we don’t know how He pushed His pencil." That quote is from 1985. The mystery has not been resolved since.

This book does not derive α. It takes α as the one measured input. Everything else — the five predictions, the integers, the kill switches — is derived from the axiom system plus this one number.

This short section explains why one measured input is needed at all, why it must be α specifically, and why no other constant of physics enters the derivations as an independent free parameter.

Why one measured input is needed

A natural question: if the axiom system is consistent, why does it need any measured input?

The axiom system produces structural relationships. It tells you how quantities depend on each other. It does not tell you the overall scale. The relationship between the proton mass and the electron mass is structural. The relationship between the gravitational constant and the electromagnetic coupling is structural. The relationship between the neutron and the proton is structural. All of these are dimensionless ratios, and all are forced by the axiom system.

But to produce a specific number — a ratio like 1836.152 — you need to know what the scale is. In the framework, the scale is set by the rate at which the substrate leaks its own structure. That rate is α. One number, measured once, sets the absolute scale, and then every structural relationship produces a specific number.

Compare this to the Standard Model, which requires approximately twenty-five to thirty separately measured parameters: nine quark and charged-lepton masses, three neutrino mass differences, four CKM quark-mixing parameters, three PMNS neutrino-mixing parameters, three gauge couplings, the Higgs mass, the Higgs self-coupling, and several more in cosmology (the cosmological constant, the dark matter density, the primordial perturbation amplitude, the tilt, the optical depth).

Each is measured independently. None is derived from any other. The Standard Model's predictions are powerful once all twenty-five are plugged in, but the model itself does not generate any of them.

This framework uses one. Zero of the other twenty-four free parameters of the Standard Model + ΛCDM are free in this framework. They are either derived or not used. That is the efficiency ratio the book is claiming — one input to five outputs, across a range of physics from particle masses to cosmology.

What α is, inside the framework

In standard physics, α is the strength of the electromagnetic coupling. A photon interacts with an electron with probability proportional to α. The small value ($\alpha \approx 1/137$) is why electromagnetic interactions are tractable in perturbation theory: higher-order diagrams are suppressed by higher powers of α, and the series converges.

In this framework, α has a specific structural identification. It is the leakage rate of the substrate.

What does that mean? The substrate maintains the break ε against its own tendency to heal. The maintenance is not perfect. At every moment, a small fraction of the substrate's coupling escapes through open boundaries — the surfaces where one structural region meets another.

This escape rate is α. It is a pure number because it is a rate per unit coupling event: of every coupling event the break undergoes, a fraction α leaks out into the surrounding substrate rather than being retained in the bound state.

The identification is derived in AP06 (The Leakage Constant). The argument rests on two axiom-level claims: no boundary in the substrate can be perfectly tight (a consequence of Axiom R's irreversibility applied to coupling surfaces), and the leakage rate must be dimensionless (a consequence of the scale-invariance required by Axiom S). These two constraints force the leakage rate to be a pure number, and the number is what we measure experimentally as α.

This identification does two things. First, it explains what α is — not a property of light-matter coupling specifically, but a property of the substrate's own self-maintenance. Second, it explains why α appears in every derivation in the book. Wherever the framework's calculation involves the rate at which structure is maintained against leakage, α appears.

Wherever the calculation is purely geometric (integer counts, manifold curvature, dimensional bridges), α does not appear.

Why the other constants are not inputs

Three other constants appear throughout the book: the speed of light c, Planck's constant ħ, and the gravitational constant G. The electron mass m_e appears in the dimensional bridge of Part II. A careful reader might ask: are these additional inputs?

They are not. Each has its specific status within the framework.

The speed of light c is the constraint C of the axiom system — the finite propagation speed at which distinctions spread. In the framework, c is not an independent measured quantity; it is the unit in which speed is measured. Every speed in physics is some fraction of c. Setting c is a choice of unit, not a free parameter. Derived in AP03 from the substrate's stiffness ratio.

Planck's constant ħ is the minimum break — the smallest possible record. It is the quantum of action. Again, not an independent measured quantity: it is the unit in which action is measured. Derived in AP12 from Stone's theorem applied to the axiom-derived Hilbert space.

The gravitational constant G is the cost of persisting the break across the arena geometry. It is derived in Part II of this book from α, the 21 channels, and the puncture factor 1/π. G is not an input to any Part. It is an output of Part II.

The electron mass m_e is where the subtlety lives. The book uses m_e/m_p (the electron-to-proton mass ratio, derived in Part I) and m_e^2 (in the dimensional bridge of Part II). These usages do not require m_e as a separate input, because the ratios and bridges are set by the unit system.

In SI units, m_e has a specific numerical value; in natural units where ħ = c = 1, m_e sets the length scale. Neither is a free parameter of the framework — m_e is the mass of the break's topological puncture, and its value is fixed by the same structural physics that produces all the other masses.

So: c sets the speed unit. ħ sets the action unit. m_e is the break's puncture mass, fixed structurally. G is derived. α is the one free parameter. That is the full list.

What α does, chapter by chapter

α appears in four of the five chapters of this book. Part IV is the exception — it uses only geometric quantities and the cosmological constants c and H_0, with no α dependence. (The C_S^2 factor in Part IV is a pure geometric number from the S^2 tension profile; the name similarity to α is an accident of the original AP18 paper, and the symbol was explicitly renamed to prevent confusion.)

Part I uses α in the first-order and second-order dynamic corrections to the proton mass. The static mass comes from integer geometry alone ($21^2 \times 4 + 21 \times 3 + 3^2 = 1836$).

The dynamic corrections $\alpha \times 21 \times (1 - 1/(84\pi))$ and $\alpha^2 \times 21 \times 16/1836$ refine the static count against the substrate's leakage. Without α, the static count stands alone — but only matches the measured proton mass to a residual of about 5 ppb. With α, the match sharpens to 0.010 ppb — inside the experimental error bar.

Part II uses α at the twenty-first power. The gravitational coupling $\alpha^{21} = 1.338 \times 10^{-45}$ is the result of α coupling through all 21 channels of the arena simultaneously. A single channel couples at rate $\alpha \approx 1/137$. Twenty-one channels coupling simultaneously compound multiplicatively (independent events), producing the vast hierarchy between gravity and electromagnetism. One input, twenty-one factors, one output.

Part III uses α in the dynamic correction to the neutron-proton mass difference. The static count — three colour faces, each registering the flavour swap, reduced by closed-loop curvature — gives 2.5225 electron masses. The dynamic correction $\alpha \times (1 + 1/(2\pi))$ adds 0.00846 electron masses. The total, 2.531 electron masses, matches the measured difference to 2 ppm.

Part V uses α implicitly in the channel count (21, derived from the leakage-rate-induced channel structure) but does not take α as an explicit input to the defragmentation timescale. $\tau/t_H = 6/21$ is a ratio of integers, and the integers come from the channel structure that α's existence establishes, but the timescale itself is α-independent in its explicit form.

Across all five chapters: one measured input (α), five predictions, each matched to within its stated tolerance. The book's central efficiency claim — five outputs from one input — rests on α's identification as the single leakage rate of the substrate and on the integers derived independently from the axiom system.

What would happen if α were a different number

A useful way to see the framework's structure is to ask what would happen if α had a different value.

If α were, say, 1/100 instead of 1/137, every prediction in the book would shift together. The proton mass would change because the dynamic correction changes. The gravitational constant would change at the twenty-first power — a factor of $(137/100)^{21} \approx 10^{-2}$ change in G. The neutron-proton difference would change in its dynamic term. The dark sector prediction, which depends on the channel count (21) but not directly on α, would be unaffected in its central formula.

The predictions are not independent. They move together as α is varied. This is a feature of the framework, not a bug. It means that a precision re-measurement of α would not trigger recalibration of twenty-five free parameters.

It would trigger a proportional shift in five predictions simultaneously, each by an amount the framework specifies. If future precision measurements of α move its value by 1 part in 10^{10}, the framework's predictions move correspondingly — and the match between predictions and observed values either continues to hold or does not. Either outcome is informative.

This is also why the framework is potentially falsifiable in a way that multi-parameter models are not. A ΛCDM fit absorbs small parameter variations by re-fitting. The framework cannot re-fit because there is nothing to fit. If α moves and the predictions stop matching, the framework is wrong. If α moves and the predictions continue to match within their stated tolerances, the framework survives a test it could have failed.

Why no other constants appear

Closing the argument: the Standard Model takes nine quark and charged-lepton masses as inputs. It takes three neutrino mass differences as inputs. It takes the CKM matrix parameters, the PMNS matrix parameters, the Higgs mass, the Higgs self-coupling, and the strong-force coupling constant α_s as inputs. ΛCDM adds the cosmological constant, the dark matter density, the primordial amplitude, the tilt, and other parameters. None of these appears in this book as an input.

Some of them appear as derived outputs (the neutron-proton mass difference, the dark matter fraction). Others do not appear at all because the book does not attempt to derive them. The book does not derive the quark masses individually, the CKM matrix, the neutrino masses, the Higgs self-coupling, or the full structure of the weak-force. These are either present implicitly (quark masses enter through the neutron-proton difference) or absent entirely (the weak-force structure is not addressed).

The claim is not that the framework derives every constant of physics. The claim is that the framework derives five specific constants from one measured input, and that these five are structurally related — they all use the same small integer set, the same leakage rate α, the same axiom system. Extending the framework to the other twenty or so constants is future work. The five derived here are the first instalment.

One measured input. Five derived numbers. Zero free parameters.

This is the book's central efficiency claim.

Measure α once to ten significant figures. Do not measure anything else. The axiom system then forces, without adjustment, the proton-to-electron mass ratio, the gravitational constant, the neutron-proton mass difference, the MOND acceleration scale, and the dark sector partition. Each is matched against independent experimental measurement. Each is within its stated tolerance.

If the match is a coincidence — if five structurally related integers happen to produce five numbers that happen to match five measurements — then the book is numerology. The kill switches in each chapter specify the conditions under which this interpretation would be confirmed.

Most of those kill switches involve either specific experimental results (measuring dark energy's equation of state, resolving the Hubble tension, precision lattice QCD calculations) or specific theoretical discoveries (a seventh face of the break, a counterexample to the additivity of the mass layers, a formal derivation of the timescale ratio from a different starting point).

If the match is not a coincidence — if the axiom system actually produces these five numbers because the structure forces them — then α is doing the work one measured number should do: set the scale for everything structurally related to substrate leakage, and let the structural relationships produce the rest.

The test is underway. Over the next decade, the kill switches will either fire or not. Either result is informative. The book is betting that the framework is right; the measurements will do the deciding.

α is the one number. Everything else is structure.

Introduction

One Axiom, Five Numbers

Physics has three kinds of numbers.

Some you measure. The speed of light. Planck's constant. The fine structure constant $\alpha \approx 1/137$. These are numbers you put onto the page by reading an instrument carefully, writing down what the instrument said, and tabulating the result. Nobody knows why the universe picked the values it did. The measurements are all we have.

Some you derive. The impedance of free space follows from the vacuum permittivity and the speed of light. The Bohr radius follows from $\hbar$, me, and α. These are not independent numbers — if you already have the measured ones, the derived ones come out of arithmetic. No new measurement required.

And some you fit. A fitted number is one the theory does not produce, so the modeller adjusts the value until the theory matches observation. The quark masses in the Standard Model are fitted. The Cabibbo-Kobayashi-Maskawa mixing angles are fitted. The Higgs self-coupling is fitted. The cosmological constant Λ is fitted. The dark matter density ΩDM is fitted. Count the fitted parameters in fundamental physics today — around twenty-five to thirty across the Standard Model and ΛCDM cosmology.

Every fitted parameter is a question that has not been answered.

A framework with twenty-five fitted parameters has enormous descriptive power. It can accommodate almost any data you give it. But its explanatory power is correspondingly low. It tells you what is. It does not tell you why.

You are carrying around twenty-five to thirty numbers that no one has been able to derive. They are in every atom of you, in the gravity that holds your weight to the floor, in the rate at which the universe is expanding around you. They are not optional. They are also not explained.

This book reduces the count.

It starts from one axiom — *1:1 + 1×ε @ AS*, perfect symmetry plus one minimal break at the actualizing now — and derives five fundamental quantities. Zero free parameters. One measured input: α. Everything else structural.

The five predictions span a range of physics: particle masses (proton, neutron), gravity (the gravitational constant, the MOND acceleration scale), and cosmology (the dark sector partition). They use the same small set of integers — 21, 6, 3, 4 — each of which is derived independently from the axiom structure before any constant is computed.

They use the same coupling α, identified within the framework as the leakage rate of the substrate. They use the same perturbative structure: static geometry dominates, with O(α) dynamic corrections and smaller higher-order terms below that.

A note on the count. The book calls these five predictions because the structural derivation groups them into five Parts. The empirical count is higher. Part I predicts the proton-electron mass ratio. Part II predicts the gravitational constant. Part III predicts the neutron-proton mass difference.

Part IV predicts both the MOND acceleration scale and, by inversion, the Hubble constant. Part V predicts three dark-sector partition fractions — dark energy, dark matter, visible matter. Eight independent observables from five derivations. The book uses "five predictions" throughout as shorthand for the chapter count. Where precision matters, the number is eight.

The specific claim of this book, stated directly:

If the derivations are correct, then what were previously twenty-five to thirty fitted parameters in fundamental physics are consequences of one axiom system. The mass ratio, the gravitational strength, the MOND scale, the dark sector composition — these are not independent tunable quantities of nature. They are readings of the same underlying structure, taken at different scales.

This is a strong claim. It deserves strong scrutiny.

Every Part includes a kill switch section naming exactly what would falsify the claim. Every Part ends with a research proposal naming specific experiments or calculations that could confirm or destroy the prediction. None of the kill switches is currently fired. All are live.

If the framework is right, the next decade of precision physics will provide decisive tests. Improved measurements of G. Precision neutron-mass experiments. High-redshift cosmological surveys from Euclid, Rubin LSST, DESI. The continuing non-detection of dark matter particles. The predictions are sharp. They cannot hide behind parameter adjustments, because there are no parameters to adjust.

If the framework is wrong, the same experiments will show where. The failure modes are specified in advance. The kill switches are public.

That is the structure. Five chapters. Five numbers. One axiom.

The book is written to be read straight through. Each Part is self-contained if you prefer to read them selectively. Part I is the flagship. It establishes the structural vocabulary the other four Parts use — channels, faces, leakage rate, the integer count that carries through every chapter.

If you are going to read only one Part, read Part I. If you are going to skim, focus on the kill switch sections and the research proposals. That is where the work meets the world.

Part I – The Proton's Weight

The proton-electron mass ratio, derived to 0.010 ppb

Predicted: 1836.1526734444

Measured: 1836.152673426 (CODATA 2022)

Residual: 0.010 ppb — within CODATA 2022 uncertainty (0.017 ppb) at 0.6σ

One measured input: α ≈ 1/137. Zero free parameters.

You are reading this sentence with eyes that exist, in a body that exists, on a planet made of atoms that hold together. None of this would be happening if the proton were 1,835 times heavier than the electron. Or 1,837 times. The number that makes all of it possible — the ratio every atom in your body is built around — is 1836.152673426.

That number is how many times heavier a proton is than an electron. It is one of the most precisely measured quantities in all of physics, known to eleven significant figures. For over a century, physicists have refined it in quieter and quieter laboratories, with colder traps and steadier clocks, and each refinement has added another digit of certainty.

The proton sits at the nucleus, nearly two thousand times heavier than the electron that orbits it. This mass asymmetry is what makes an atom look the way it does. The electron, being light, has room to move — it spreads into a probability cloud around the nucleus, and that cloud is what chemistry actually is.

Chemical bonds form when clouds overlap. Molecules hold together because clouds share space. DNA exists because specific clouds settle into specific shapes. Every protein in your body, every signal in your brain, every drop of water on Earth — all of it is downstream of this ratio.

Change the ratio by one percent, and none of this works.

If the proton were only a hundred times heavier than the electron instead of 1,836 times heavier, the proton itself would jiggle more. Nuclei would be less stable. The energy levels inside atoms would shift. Chemistry would still exist but it would be different chemistry — different bond strengths, different molecular shapes, different reactions.

Proteins would fold differently, or not at all. DNA might be unable to stabilise. The conditions for life as we know it would change, and probably vanish.

If the proton were ten thousand times heavier, atoms would be tiny and rigid. Electrons would be locked into fixed positions. Chemistry would freeze. No reactions, no biology.

The actual ratio, 1,836, sits in a narrow band where atoms are stable but reactive, where chemistry is possible but not locked, where biology has room to happen. This is not a coincidence physicists comment on and move past. It is one of the most precisely measured numbers in science. And in all of physics, in over a century of theoretical effort, no framework has ever derived it.

The formula uses one measured input — the fine structure constant $\alpha \approx 1/137$ — and three integers: 21, 3, and 4. These integers are not chosen. They are not fitted. They are outputs of the axiom system, derived in earlier work. 21 is the number of independent geometric channels in the arena. 3 is the number of spatial dimensions and the number of colour charges in the strong force. 4 is the number of spacetime dimensions. Each is derived, not assumed.

The prediction matches measurement to 0.010 parts per billion. This is within the CODATA 2022 experimental uncertainty of 0.017 parts per billion — 0.6 standard deviations from the central value. The prediction lies inside the error bar of one of the most precisely determined quantities in all of physics, with no free parameter to tune.

Nothing adjustable. Nothing tuned. It either matches or it does not.

It matches.

This chapter walks you through the derivation, step by step, in language a school leaver can follow. It names the assumptions. It names the kill switches — the conditions under which the derivation is wrong. And it proposes the specific experiments that would confirm or destroy the claim.

The first question to answer is why the formula works at all. Why should a handful of integers and one measured constant give the mass of the proton to eleven decimal places? The answer is that mass is not what you think it is.

The ratio that built the universe

You are made of protons. About 10^{28} of them — ten billion billion billion. Each one has been stable since roughly the first microseconds after the Big Bang. The proton is the oldest compound object in the universe.

Every atom in your body was assembled from protons and neutrons and electrons, and the protons at the centre of those atoms have been protons, unchanged, for fourteen billion years. The particle that gives your body its weight has survived longer than any star that ever existed.

The neutron, which is also inside your atomic nuclei, is not stable outside of nuclei. A free neutron decays in about 880 seconds — fifteen minutes — into a proton, an electron, and a neutrino.

But a proton, as far as any experiment has ever been able to detect, does not decay at all. The current experimental lower bound on the proton lifetime is over 10^{34} years — nearly a trillion trillion times the age of the universe. Protons are, as far as anyone can measure, forever.

The mass of this permanent particle, measured against the electron, is 1836.152673426. This is the structural constant of matter. It is the ratio on which the architecture of atoms depends. And it is the ratio the Standard Model cannot derive.

The measurement

Ernest Rutherford discovered the proton in 1919. By 1932, physicists had measured the ratio of its mass to the electron's to about three significant figures. Over the following ninety years, that number sharpened through successive generations of Penning trap experiments — devices that confine single charged particles in precisely controlled electric and magnetic fields.

By 2022, CODATA reported mp/me = 1836.152673426(32), where the number in parentheses is the uncertainty in the last two digits — a relative uncertainty of 1.7×10^{-11}, or 0.017 parts per billion. The measurement is not controversial. It is one of the most reliable numbers in experimental physics.

Four ways the question has not closed

If 1,836 has been measured for over a century, something should have explained it by now. Four programmes have tried. Each deserves naming, and each has a specific site at which it has not closed.

The first response is to inherit the number via quark masses. The Standard Model of particle physics — whose predictions agree with experiment to better than one part in 10^{12} for the electron magnetic moment — takes the quark masses as input. Tell it the masses, and it computes the proton's mass.

But the quark masses themselves are not derived. Each quark's mass comes from its interaction strength with the Higgs field, and the Higgs mechanism does not determine which interaction strength each quark should have. The interaction strengths are free parameters, dialled in to match observation. The ratio has been inherited, not explained.

The second response is computational: lattice QCD. Lattice QCD simulates the strong force on a supercomputer grid, and computes the proton mass from the quark masses and the strong coupling. The proton's mass, it turns out, is not the sum of its quarks' masses. The up quark has a mass of about 2.2 MeV/c^2.

The down quark about 4.7 MeV/c^2. Two ups and one down add up to about 9. The proton's mass is 938. The quark masses account for about one percent of the proton's mass; the other 99% is the energy of the strong-force binding.

The BMW collaboration's 2008 paper in Science demonstrated that the light hadron spectrum can be computed from the Standard Model with no free parameters beyond those of the theory itself. This is a magnificent achievement. But lattice QCD takes the quark masses as inputs. It confirms the Standard Model is self-consistent. It does not explain why 1,836 and not some other number.

The third response is unification. Grand unified theories propose mass relations between different particles — the electron and the tau, the proton and the neutron — derived from larger gauge groups that embed the Standard Model. Each proposal has its own appeal. None has derived the proton-electron mass ratio from first principles.

The fourth response is quantum gravity. String theory has not produced a number. Loop quantum gravity has not produced a number. Supersymmetry, in the versions meant to explain hadron masses, has not produced a number either. The programmes that promised to go deeper than the Standard Model have, after half a century of effort, not produced one of the most precisely measured ratios in physics.

Four responses. Four ways to fail. The ratio has been inherited, computed, speculated about, and postponed — but not derived.

This chapter derives it.

What a derivation would mean

A formula that derives the proton-electron mass ratio from structural integers and one measured coupling constant, without any quark masses as input, would mean the proton's mass is not arbitrary. It would mean the proton's mass is geometry. A count of something. A feature of the spacetime manifold itself, not a property of specific particle inputs.

If that is true, the consequences ripple outward. The quark masses, which in the Standard Model look like independent adjustable parameters, would themselves be consequences of a deeper geometric structure.

The hierarchy of particle masses — why the muon is 207 times heavier than the electron, why the tau is 3,477 times heavier — might be derivable from the same principles. The proton's mass, the gravitational constant (Part II), the MOND scale (Part IV), and the dark sector composition (Part V) would all be expressions of the same underlying manifold.

A single formula matching measurement to 0.010 ppb would be remarkable. But it would be the opening move in a much larger argument. The formula is significant not only because it works, but because it suggests that a unified structural derivation of fundamental constants is possible at all. That is the stake.

Mass is not substance

Before the derivation begins, a note on quarks — the name most readers bring to this chapter.

The framework does not deny quarks. It reinterprets them. The three quarks are the three colour faces of the manifold, read through the strong force. The gluons are the exchange pathways between them.

Both descriptions produce the same physical object. Both agree on every observable. What this chapter adds is an answer to the question QCD cannot ask: where do the quark masses come from? Answer: the channel geometry itself. The proton has quarks. The quarks are the manifold's colour faces.

With that in hand — the line that matters now.

Mass is not substance. Mass is resistance.

That sentence sounds strange. Here it is a different way. When you push something heavy, you are not fighting against the stuff it is made of. You are fighting against the structure.

Think of dragging a tangled knot of rope through a narrow gap in a fence. The knot catches. The more tangled it is, the more it catches. A straight piece of rope slides through easily. A complex knot jams against the gap. The catching is the resistance. The resistance is what you feel when you pull.

Now suppose both ropes are made of the same material and weigh exactly the same. On a scale, both read the same number. But if you try to move them through the gap, the tangled one is harder to push. It resists more.

That extra resistance is mass — and the weight on the scale is only one way of measuring it. Mass shows up wherever structure has to move, whether through a gap, through space, or against an accelerating force.

The electron is the simplest possible knot. One break in the substrate. One channel. One unit of resistance. It is the minimum viable structure that can exist and persist — the smallest thing that satisfies all four axioms simultaneously. It is the minimal break. Its mass, me, is the unit against which every other mass is measured. Every particle is some number of me. For the proton, that number is 1,836.

So the question is: why is the proton 1,836 times more tangled than the electron?

The building and its rooms

The proton is the most complex stable knot the substrate can make. To count its complexity, you need to know what the substrate has to offer — how many distinct ways structure can exist.

Imagine a building. It has 21 corridors, each leading to a different room. It has 4 floors. Each corridor exists on every floor. Each room can connect to every other room.

The electron lives in one room. It uses one corridor, on one floor. One channel. Its resistance is 1.

The proton lives in the whole building. It uses all 21 corridors on all 4 floors, and every room connects to every other room. That is why the proton is more complex. Not because it has more substance, but because it has more structure.

Where do these numbers — 21, 3, 4 — come from? They are derived from the axiom system.

21 channels. The break ε has six independent ways it can be read — six faces. These are: mass (me), propagation speed (c), geometric persistence (G), phase coupling (α), fabric stiffness, and temporal direction. Each is a different scalar measurement of the same break, like six photographs of the same mountain taken from six different valleys.

AP24 identifies the six faces and proves their completeness — no seventh independent face exists. Each face projects across three spatial dimensions, giving 6 × 3 = 18 face-projections. Three additional degrees of freedom couple the 'now' — the actualization state — to each spatial direction. Total: 18 + 3 = 21.

Phase coupling is α — the same fine structure constant that appears as the one measured input in this chapter's formula. α is one of the six scalar readings of the break, and it is also the leakage rate of the substrate (AP06) — the probability the break couples to itself through one channel.

The two readings are the same quantity at different structural levels. When α appears below as the coupling rate of dynamic maintenance, it is the same α identified here as one of the six faces of ε.

3 spatial dimensions. The axiom system produces four independent degrees of freedom, one per axiom. One becomes the temporal direction (from Axiom R, irreversibility). Three become spatial. These three correspond to the three faces of the strong force — the three colours of quantum chromodynamics — and to three structural roles played by the break: propagation, exchange, and break itself. Derived in AP10.

4 spacetime dimensions. Three spatial plus one temporal. Same derivation.

With the vocabulary established, the count begins.

Layer 1 — The manifold capacity: $21^2 \times 4 = 1{,}764$

The first and largest layer counts the proton's total geometric footprint.

The proton integrates all 21 channels across all 4 spacetime dimensions. Each channel has an expression on each floor of the building. Twenty-one corridors on four floors: 21 × 4 = 84 dimensional expressions. That is the first count.

But these 84 expressions do not exist in isolation. Each expression couples back to each of the 21 channels. Every corridor on every floor connects to every other corridor. A visiting particle that enters via channel 7 on floor 2 has to consider its interaction with all 21 channels. The full resistance network is $84 \times 21 = 1{,}764$. Or, written compactly: $21^2 \times 4$.

$21^2 \times 4 = 1{,}764$

This is the dominant term. It accounts for about 96% of the mass ratio. The proton resists 1,764 times more than the bare electron because it fills the entire channel network across all spacetime dimensions.

Layer 2 — The face projection: 21 × 3 = 63

The second layer counts the cost of anchoring.

The proton is not just any 21-channel object. It is specifically a strong-force object — made of quarks bound by gluons. The strong force is described by SU(3), the mathematical group of three colour charges. Physicists call them red, green, and blue. These are not actual colours. They are labels. The three colours correspond to the three faces of the manifold — the three spatial dimensions read as structural roles.

So the 21 channels have to anchor to these three specific faces. Each channel has to decide which face it belongs to, and then commit to that face. A structural commitment costs resistance. Each channel anchored to each face:

21 × 3 = 63

Think of it as painting a building. The 21 corridors are already there, but each must be painted in one of three colours — red, green, or blue — and the colour pattern must be consistent throughout the building. The painting is extra work, extra structural detail, extra resistance. The work of deciding which corridor gets which colour, and keeping the scheme consistent across all four floors, is 63 units of additional structural commitment.

Notice that Layer 2 uses fewer corpus numbers than Layer 1. Layer 1 used {21, 4}. Layer 2 uses {21, 3}. The number 4 has dropped out, because the colour scheme is the same across all four floors — it does not add another factor. This is the beginning of the hierarchical nesting that makes 1,836 a clean decomposition.

Layer 3 — The static exchange matrix: $3^2 = 9$

The third and smallest layer counts the communication overhead.

The three colour faces cannot just sit quietly next to each other. The strong force is confining: you cannot pull a quark out of a proton.

If you try, the energy required to separate a red quark from a green quark becomes so large that, at some point, it is cheaper for the universe to create a new pair of quarks — one red, one anti-red — and break the separation that way. Confinement is not a bug. It is a feature of the strong force.

Confinement requires continuous exchange. The three faces must continuously swap colour charges among themselves, via gluons, to keep the overall state colour-neutral. The full exchange matrix — every face communicating with every face, including itself — is 3 × 3 = 9 pathways.

$3^2 = 9$

In the Standard Model, the exchange of colour charge is mediated by 8 gluons — the 8 generators of the group SU(3). The 8 gluons are measured experimentally. Jet production at particle colliders depends on them. Where does the ninth count come from?

The 8 gluons are the pathways. The 9th is the structural requirement that the bound state be colour-neutral. Confinement is exactly this requirement — any isolated coloured state is forbidden, because colour-singlet is the only stable configuration. The 8 gluons do the exchange. The colour-singlet condition is the closure constraint that keeps the exchange inside the proton rather than leaking out. Eight pathways plus one closure condition: nine elements of the exchange matrix.

Layer 3 uses only {3}. The number 21 has dropped out — this layer counts pathways between the three faces only, not within the channel structure. The nesting tightens: {21, 4}, then {21, 3}, then {3}. Each layer answers a more specific question, using fewer of the structural primitives.

Static resistance total:

1,764 + 63 + 9 = 1,836

This is the axiom running. *{S, B, R, C}* produces the manifold; the manifold produces 21 channels across 4 floors with 3 colour faces; the proton integrates all of it — right now, at every site where a proton exists. The integer 1,836 is not a number the proton happens to have. It is the count the axiom forces, at AS, when the break fills every room the manifold offers.

Three terms. Three layers. Each uses fewer corpus numbers than the previous. Each answers a structurally distinct question about the proton. This is not a factorisation of 1,836 — 1,836 has many factorisations. It is a hierarchical reading of 1,836 in the language of the manifold, using only the derived integers {21, 3, 4}.

Why the layers add

But wait. Why do the layers add? Why not multiply? Why not combine in some more complex way?

Because the axioms are independent.

The four axioms *{S, B, R, C}* are independent. No axiom can be derived from the other three. This is proved in AP20.

Each of the three layers in the decomposition traces to a different subset of these axioms.

Layer 1 — the manifold capacity — depends on all four axioms acting together, through the full channel structure.

Layer 2 — the face projection — depends specifically on the spatial structure from *{S, C}*: three spatial dimensions projected onto three colour faces via AP19.

Layer 3 — the static exchange matrix — depends on the confinement condition from *{S, R}*: the three faces must maintain continuous exchange for the bound state to persist as a closed record.

Three layers. Three axiom subsets. Three independent structural constraints acting on three independent degrees of freedom.

Independent constraints acting on independent degrees of freedom contribute additively. This is the same principle that governs energy in statistical mechanics. If a system's state space is the Cartesian product of independent subspaces, the total energy is the sum of the contributions from each subspace. No cross-terms. No surprises. Just addition.

Three builders, each working on a different aspect of a foundation. One pours the concrete. One lays the steel reinforcement. One installs the drainage. They do not interfere with each other. The total work is the sum of their contributions, not the product. Independent causes produce additive effects.

This is the weakest formal point in the derivation, and it is named as such.

Two distinct kinds of independence are at stake here, and it matters not to slide between them. Axiom independence — proved in AP20 — is the claim that no axiom in *{S, B, R, C}* can be derived from the other three. Layer independence is a different claim: that the three terms of the proton mass decomposition live on three genuinely orthogonal subspaces of the proton's state space, so the total resistance factorises as a sum rather than a product.

Axiom independence is an input to the layer-independence argument, not the argument itself. Each layer depends on a different subset of the axioms, so the subspaces must factorise. This is suggestive but not a theorem. A careful reader will notice that axiom S appears in all three layer subsets — Layer 1 on all four, Layer 2 on *{S, C}*, Layer 3 on *{S, R}*.

S is shared. Kill switch KS-30.1 is this question, formalised: can the shared axiom S produce a non-negligible cross-term between layers that the additive decomposition ignores? If it can, the combination is not additive and the integer 1,836 is no longer pure arithmetic.

The Cartesian product structure of the proton's state space is argued here, not exhibited as a theorem. KS-30.1 remains the single most vulnerable formal point in the derivation. Closing it will require either an explicit proof of layer orthogonality on the shared axiom S, or a demonstration that any cross-terms vanish at the precision relevant to the prediction.

The kill switch coda below gives the firing condition. The corpus lists this as Debt D19 — an obligation declared but not yet discharged.

The decomposition is unique

A sceptic will now ask: is this the only way to write 1,836 from these integers? The full enumeration closes the question within a well-specified family.

Three conditions pin the family down. The three terms must sum to 1,836. Each term must be a product of non-negative integer powers of {21, 3, 4}. And the exponent of 21 must strictly decrease across the three terms — Layer 1 carries two copies of the channel count, Layer 2 carries one, Layer 3 carries zero. That progressive shedding of arenas is what makes the decomposition structurally meaningful rather than an arithmetic match.

The enumeration has been carried out computationally. Under the first two conditions alone, eleven three-term sums reach 1,836. Under all three together, exactly one decomposition survives: the one derived above. Uniqueness within this family is established by enumeration, not asserted. The full list is reproduced in Appendix C.

Kill switch KS-30.4 is not closed by this enumeration. KS-30.4 asks a broader question: does any alternative formula, using different structural integers or a different structural condition entirely, also match the proton-electron mass ratio to comparable precision? The within-family uniqueness is closed. The between-family openness remains. KS-30.4 guards the broader claim, now sharpened to its precise scope.

The proton breathes — dynamic maintenance

The integer 1,836 is the static geometry. The resistance of the structure at rest, counting only the architecture. But the proton is not static internally. It is a seething dynamic object. Three quarks continuously exchange gluons, maintain confinement, sustain the bound state. This activity costs energy, and the cost shows up as additional mass.

The proton has to sustain itself against the substrate's tendency to close the break that created the proton in the first place. The substrate does not want to be cracked. It constantly tries to heal. The proton exists because it holds the crack open across all 21 channels simultaneously — and this holding requires continuous effort.

The rate at which the substrate pushes back is α. That is what the face-identification in the previous section was preparing for: α is one of the six scalar readings of ε, and it is also, by AP06, the leakage rate of the substrate — the probability that any given interaction between the break and itself actualises. The substrate's fundamental coupling rate is α.

A natural question: why α and not the strong coupling αs? The strong coupling is what holds the quarks together inside the proton. Surely that is what sets the proton's dynamic cost?

Different jobs, different couplings. The strong coupling αs holds the quarks to each other. α holds the proton to existence. αs describes how quarks interact with each other inside the proton. The dynamic maintenance cost is the proton's coupling to the substrate — the rate at which the crack leaks. That rate is α. All other coupling constants — αs, αG (the gravitational coupling) — are derived from α through the channel geometry. The fundamental rate of the substrate is α.

The coupling has to span all 21 channels, because the proton integrates all 21. Each channel contributes one unit of α to the total dynamic coupling:

$\alpha \times 21 = 0.15324$

The leakage correction: $1 - 1/(84\pi)$

But not all of that 0.15324 stays within the bound state. Some of it radiates outward as the proton leaks into its environment.

The leakage correction is the factor 1/(84π), which reduces the first-order dynamic term. Two independent geometric elements combine to produce this factor.

The 1/84. The dynamic coupling has 84 dimensional expressions: 21 channels × 4 spacetime dimensions. The leakage distributes uniformly across all 84 expressions — each leaks an equal share. The factor 1/84 is the per-expression leakage rate.

Notice that 84 is the same 84 that appeared in Layer 1, where 1,764 = 84 × 21. The manifold's dimensional structure both generates the static resistance and normalises the dynamic leakage. The channels through which the proton resists are the same channels through which its maintenance leaks.

The 1/π. Each dimensional expression, in leaking, projects onto a circular boundary of the manifold — the same circular cross-section that characterises the electron as a topological puncture. The geometric weight of this projection is 1/π. This is the same 1/π that appears in Part II's derivation of the gravitational constant, where it arises from the electron's circular puncture boundary. Both cases are projections onto a circular great-circle boundary in the manifold geometry.

The two factors combine:

$1 / (84\pi) = (1/84) \times (1/\pi) = 0.003789$

Subtracting this from unity — because the leakage fraction is what escapes, and the retained fraction drives the dynamic correction:

$$\alpha \times 21 \times (1 - 1/(84\pi)) = 0.1526637$$

This is the first-order correction. It captures the breathing cost of the proton, minus the small fraction that radiates into the manifold instead of staying within the bound state.

The second-order exchange matrix: $16 = 4^2$

The first-order correction captures the dynamic maintenance. But the dynamic maintenance itself is not perfectly efficient. The coupling that sustains the proton is itself a coupling, and couplings leak. This is 1:1 + 1×ε @ AS operating recursively: the break breaks its own repair — right now, at every proton in your body.

At second order, a new structural count is needed. The first-order coupling propagates through the 21 channels in colour space and leaks into spacetime. The second-order coupling must propagate back: the leaked amplitude has to re-couple to the bound state. Re-coupling requires passing through spacetime, because that is where the leaked amplitude lives — it has left the colour space and is now in the spacetime manifold.

Second-order re-coupling is a rank-2 spacetime structure. Energy leaves the bound state in some spacetime direction μ and returns in some direction ν. Both μ and ν range over the four spacetime dimensions (one temporal, three spatial). The full set of (outgoing, incoming) spacetime direction pairs is 4 × 4 = 16.

$4^2 = 16$

This is the second-order exchange matrix. It is the natural parallel to Layer 3's static exchange matrix, at a different structural level. Layer 3 counted exchange between the three colour faces in colour space: 3 × 3 = 9. The second-order correction counts exchange between the four spacetime dimensions: 4 × 4 = 16. Both are exchange matrices. The difference is the structural level — static in colour space, dynamic in spacetime.

This rank-2 object appears throughout quantum field theory. Any rank-2 tensor field in 4D has $4^2 = 16$ independent components. The full 16 is the correct structural object here because the second-order re-coupling places no symmetry constraint on the incoming and outgoing spacetime directions — they are independently specified. The full matrix is the right structural object for an unrestricted rank-2 coupling.

The $O(\alpha^2)$ coefficient is therefore:

21 × 16 / 1836

The 21 is the primary channel count, same as first order. The 16 is the second-order spacetime exchange matrix just derived. The 1836 is the static resistance of the bound state — Layers 1 + 2 + 3 — serving as the normalisation.

A note on that 1836 in the denominator. It is the static integer — the geometric count $(21^2 \times 4) + (21 \times 3) + (3^2)$. It is not the measured proton-electron mass ratio. The two quantities share the integer part of their value by construction, which is what this chapter's central claim is.

But in the $O(\alpha^2)$ term the 1836 is a structural count, not a measurement. Its role here is normalisation. The $O(\alpha)$ correction is the fractional dynamic cost relative to the static bound state; the $O(\alpha^2)$ correction is the fractional correction to that fractional correction; and the natural normalisation for both is the static count.

Every number in this coefficient is derived. No integers imported. The full $O(\alpha^2)$ term:

$\alpha^2 \times 21 \times 16 / 1836 = 0.0000097$

The number

Putting all the pieces together — for the first time, the full formula:

$mp / me = 1836 + \alpha \times 21 \times (1 - 1/(84\pi)) + \alpha^2 \times 21 \times 16/1836$

Three terms stacked, displayed to ten decimal places. The static geometry contributes 1836.0000000000. The first-order breathing-and-leakage contributes 0.1526636991. The second-order leakage of the leakage contributes 0.0000097453. The sum: 1836.1526734444.

Measured value (CODATA 2022): 1836.152673426(32), experimental uncertainty 1.7×10^{-11}, or 0.017 parts per billion. The formula’s residual from the measured central value is 0.010 parts per billion — 0.6 standard deviations inside the measurement’s error bar.

The first-order formula truncated at $O(\alpha)$ gives 1836.1526636991, a residual of 5.3 ppb. The second-order term reduces the residual to 0.010 ppb. The $O(\alpha^2)$ correction has already been fully confirmed by the measurement. It is not a prediction awaiting test. It is a contribution already required for the match.

Every number in this formula is either a structural integer from the manifold geometry ({21, 3, 4}), the fine structure constant α

(measured), or the geometric constant π. Nothing is fitted. Nothing is adjusted. Nothing is tuned.

Why the formula cannot be exact

The residual — 0.010 ppb at second order — is not noise. It is not experimental error. It is not a missing term. It is structurally required.

The governing axiom says 1:1 + 1×ε @ AS. Perfect symmetry plus one minimal crack, at the actualizing now. The crack is what makes the universe observable — without it, there is only the unbroken mirror, and no one to see it. But the crack cannot be perfectly smooth.

The leakage cannot be perfectly isotropic. The formula describes the structure of the break, but the proton is a break. Its existence means the substrate has not closed. The formula describes the break — but it cannot describe it completely, because the break is what makes the description possible.

Each order of the perturbative expansion catches a finer correction. The static geometry gives the integer 1,836. The first-order term gives the dynamic breathing and its leakage, of order α. The second-order term gives the leakage of the leakage, of order α^2. Each subsequent order catches the next cycle — the break breaking its own repair, which breaks the break of the repair, each cycle smaller than the last by a factor of roughly 1/137.

Perturbative series in quantum field theory are typically asymptotic rather than convergent. Freeman Dyson's 1952 argument established that the QED perturbation series is divergent as a whole, yet truncates to give spectacular numerical predictions because the divergence only becomes relevant at very high orders (around 1/α ≈ 137).

This is not a flaw of QED. It is how perturbative QFT works. The proton mass series is expected to share this character: asymptotic in the strict mathematical sense, but well-behaved at the low orders where it has been computed.

The closest precedent is the QED calculation of the electron's anomalous magnetic moment, which agrees with measurement to roughly ten significant figures — one of the most precise confrontations between theory and experiment in the history of science. QED's prediction is a perturbative series in α. The proton-electron mass ratio is another such series: structural at every order, well-behaved at the orders currently computed, parameter-free.

This is 1:1 + 1×ε @ AS operating recursively. The formula can never be exact. The proof that it works is the proof that a residual must remain.

If the formula were exact, ε would be zero and the universe would not exist.

The honest tension at $O(\alpha^3)$

The match at 0.010 ppb is within experimental uncertainty. It is also tighter than a naive α-scaling of the next term would predict, and this deserves to be named directly.

If the $O(\alpha^3)$ coefficient is of order unity times structural integers — consistent with the pattern at $O(\alpha)$ and $O(\alpha^2)$ — the third-order term should contribute roughly $\alpha \times O(\alpha^2)$, or about 0.06 parts per billion. Against an $O(\alpha^2)$-only prediction, that would leave a residual of about 0.06 ppb. The observed residual against the $O(\alpha^2)$ prediction is 0.010 ppb. Six times smaller.

Two scenarios remain live. In the first, the $O(\alpha^3)$ coefficient is itself smaller than a simple α-scaling estimate: the series is naturally self-limiting, and the chapter's formula is close to complete at $O(\alpha^2)$. In the second, there is partial cancellation with higher-order structure not yet derived: the series is natural in overall scaling, but the specific match at $O(\alpha^2)$ reflects a coincidence of cancellation at $O(\alpha^3)$.

A factor-of-three improvement in experimental precision will discriminate these scenarios. The predicted $O(\alpha^3)$ contribution of 0.06 ppb is currently at roughly 3.5σ above the measurement uncertainty of 0.017 ppb. Next-generation Penning trap designs are expected to resolve it within a decade. Until then, the honest statement is this: the match works, the match is inside the error bar, and the pattern of residuals at higher orders is a test the chapter has not yet passed.

Three things separate this from numerology. The integers were derived before the proton mass was ever matched — AP10, AP24, AP28, in each case for reasons independent of the target number. The formula has explicit falsification conditions — four kill switches, below, each specifying what would destroy it.

And the formula predicts the shape of its own residual — the governing axiom 1:1 + 1×ε @ AS requires that no perturbative expansion can terminate. A numerological match has none of these. All three are here.

If this is wrong

Four kill switches guard this chapter. Each specifies exactly what would destroy the prediction.

KS-30.1 — Non-additive combination

The derivation assumes that three independent structural constraints on three independent axiom subsets contribute additively to the proton's geometric resistance. The argument is strong because it rests on the axiom independence proved in AP20. But the full formalisation — exhibiting the Cartesian product structure of the proton's state space explicitly, as a mathematical construction rather than a structural argument — has not been completed.

This kill switch fires on a formal proof that the three layers cannot be treated as independent subspaces — that some aspect of the axiom structure requires them to combine non-additively (multiplicatively, or through some other non-linear rule). If that proof existed, the integer 1,836 would no longer be forced. A different combination rule would produce a different integer, and the formula would fail.

Closing it is a mathematical task, not an experimental one. The configuration space of the three-face, 21-channel bound state has to be exhibited explicitly — shown either to be a Cartesian product (confirming the derivation) or not (firing the switch). The corpus lists this as Debt D19 — declared but not yet discharged.

KS-30.2 — Leakage anisotropy

The leakage correction assumes that the dynamic coupling distributes uniformly across the 84 dimensional expressions (giving the 1/84 factor) and that each expression projects onto a circular great-circle boundary (giving the 1/π factor). If the leakage is anisotropic at either level — if the dynamic coupling preferentially radiates along certain channels or faces rather than uniformly, or if the projection is onto a non-circular boundary — the correction factor would be different.

This switch is empirical. High-precision measurements of the proton's electromagnetic form factors, or lattice QCD calculations of the internal energy flow, could reveal whether the leakage is truly uniform at the assumed level.

KS-30.3 — Higher-order misbehaviour

The formula is a perturbative series in powers of α. The first three terms give 1836.1526734444. Each successive term is expected to be smaller by a factor of roughly α. Perturbative series in QFT are typically asymptotic rather than convergent, but they remain well-behaved at low orders. The claim here is that the proton mass series is well-behaved at the orders currently computed.

This switch fires if the higher-order terms do not behave this way — if the $O(\alpha^3)$ correction turns out to be much larger than the $O(\alpha^2)$ correction, rather than an order of magnitude smaller. The perturbative structure would then be pathological rather than natural, and the match at $O(\alpha^2)$ would be a coincidence of truncation rather than a genuine low-order convergence.

The test is to compute the $O(\alpha^3)$ term explicitly. The prediction is of order 10^{-7} — already at roughly 3.5σ in the present CODATA 2022 data, resolvable at high confidence with a factor-of-three improvement in precision. If the computed coefficient is of order unity times appropriate structural integers, the series is natural and the derivation is confirmed at the next order. If the coefficient is pathologically large, the series is misbehaving and the low-order match is suspect.

KS-30.4 — Alternative formula

The hierarchical decomposition argument is closed by computational enumeration within the family of three-term sums of products of powers of {21, 3, 4} under the strictly-decreasing-21-exponent hierarchy condition — the chapter's construction is the unique solution. But within-family uniqueness does not rule out other formulas, using different combinations of physical constants or different structural integers, that might also match the ratio to comparable precision.

This switch fires on the existence of such a formula — a different formula, using perhaps α, π, e, and some other small integers, with a different structural interpretation, matching to 0.010 ppb. If one is found, the derivation is underdetermined. The match is not forced by the axiom system but merely consistent with it, and some other axiom system might equally produce the same number.

The test is systematic search. A computational enumeration over formulas of comparable simplicity would establish whether alternatives exist. If multiple structurally distinct formulas match at this precision, the uniqueness claim weakens. If this is the only match at this simplicity level, it strengthens.

How you can verify it

Direct verification takes under a minute. Look up α — the CODATA 2018 value is $7.2973525693 \times 10^{-3}$, and the CODATA 2022 refinement shifts it by 5×10^{-13}, which propagates to a prediction shift of about 0.0001 ppb — two orders of magnitude below this chapter's residual. The prediction is stable under either value.

Compute the three static terms: $21^2 \times 4 = 1,764$, then $21 \times 3 = 63$, then $3^2 = 9$. They sum to 1,836. Compute the first-order correction: $\alpha \times 21 \times (1 - 1/(84\pi)) = 0.1526637$. Compute the second-order correction: $\alpha^2 \times 21 \times 16 / 1836 = 0.0000097$. Add everything: 1836.1526734. Measured: 1836.152673426.

The full Python code is in Appendix B. Twenty lines. It runs in under a second. If the numbers do not match, the book is closed. If they do, you have confirmed the central claim of this chapter in under a minute.

All four kill switches are live. The formula holds. The gaps are named. The work continues.

What would settle this

One decisive test. A factor-of-three improvement in the Penning-trap measurement of the proton-electron mass ratio. The current CODATA 2022 uncertainty is 0.017 ppb; a target of 0.005 ppb is within reach of next-generation trap designs. At that precision, the $O(\alpha^3)$ coefficient lands at more than ten standard deviations, resolving both its magnitude and its sign.

Candidate facilities: MPIK Heidelberg (Blaum group), MIT (the Pritchard successor), FSU Tallahassee (Myers group), NIST. Each has the infrastructure and expertise. Timeline: three to five years.

If the measured value matches the formula at that precision, the structural interpretation gains decisive support. If it diverges from the predicted $O(\alpha^3)$ structure, kill switch KS-30.3 fires and the low-order match is exposed as truncation coincidence rather than natural series.

The full research proposal — title, abstract, background, experimental design, secondary proposals, expected results, timeline — is in Appendix D, built on the AP30 derivation. The formal apparatus lives where formal apparatus belongs. What matters here is the bet: one precision measurement, one decisive outcome, within the decade.

What this Part has done

The proton weighs exactly what geometry demands.

One thousand eight hundred and thirty-six units of static resistance — three nested layers counting the geometric complexity of a three-face, twenty-one-channel bound state in four spacetime dimensions. A fractional correction from dynamic maintenance, the proton sustaining itself against the substrate's tendency to heal. A second-order correction from the spacetime exchange matrix, mediated by the rank-2 propagator that connects any two spacetime directions. Together: 1836.1526734444.

The measured value: 1836.152673426. The formula matches measurement to 0.010 parts per billion — within the CODATA 2022 uncertainty of 0.017 ppb, at 0.6σ from the central value. Four kill switches are live. Each specifies exactly what would destroy the prediction. Each is testable.

The decomposition $(21^2 \times 4) + (21 \times 3) + (3^2)$ is the unique hierarchical three-term sum of products of {21, 3, 4}. The structural residual is required by the governing axiom: $1{:}1 + 1\times\varepsilon$ @ AS. Perfect symmetry plus one minimal crack, at the actualizing now. The formula can never be exact because the universe it describes is not exactly symmetric. The proof that it works is the proof that it cannot be exact.

The integers come from the manifold's geometry. The corrections come from the physics of leakage. Between them they account for the proton's weight to ten decimal places, with one measured input and no free parameters.

If the formula is wrong, the kill switches specify exactly where it will break. If it is right, the proton's mass is not a free parameter of nature. It is a count — a count of rooms in a building made of nothing but the axioms themselves, the four conditions forced by one premise: one record exists.

You weigh what you weigh because the proton weighs what it weighs. Every atom in you has a proton at its core, 1,836 times heavier than the electron cloud around it. Every one of those protons is a count — twenty-one channels threaded through four spacetime dimensions, three axiom subsets adding additively into one integer.

Your weight on a scale is geometry counting itself. When you stand up, when you breathe, when the blood in your body moves, you are the axiom running — at this site, at the resolution at which 1,836 is forced.

In Part II: the next question. If the proton's mass is geometry, what about gravity? The same integers — 21, 3, 4 — appear in both formulas. The same leakage rate α drives both corrections. The proton and the gravitational constant are two readings of one manifold.

The building has more rooms than have yet been counted.

Part II – The Strength of Gravity

The gravitational constant, derived to 0.69%

Predicted: $G = 6.7206 \times 10^{-11}$ N·m²/kg²

Measured: $G = 6.6743 \times 10^{-11}$ (CODATA 2018)

Discrepancy: 0.69%

One measured input: $\alpha \approx 1/137$. Zero free parameters.

Pick up a fridge magnet. Stick it to a paperclip.

That tiny magnet — small enough to lose in a drawer — just overpowered the gravitational pull of the entire Earth. Six billion trillion tonnes of rock, beaten by a sliver of iron and a coil of wire.

The ratio between the electromagnetic force and the gravitational force, measured between two electrons at rest, is approximately 4.17×10^{42}. A 4 followed by forty-two zeros. Equivalently, the dimensionless gravitational coupling $\alpha G = Gme^2/(\hbar c) \approx 1.76 \times 10^{-45}$ is 42 to 43 orders of magnitude smaller than the electromagnetic coupling $\alpha \approx 1/137$. Two expressions of the same fact. Both are startling.

If electromagnetism were a shout, gravity would be quieter than the thermal vibration of a single atom on the far side of the observable universe.

This ratio is called the hierarchy. It has been one of the deepest open questions in physics since the 1930s. Why are these two forces so vastly different in strength? They are both forces. They both act on matter. Both are described by precise equations. Yet one is forty-five orders of magnitude stronger than the other.

Entire theoretical programmes have been built to address this. Supersymmetry. Extra dimensions. String theory's vast landscape. None has produced a derivation. None has produced a number.

The formula uses one measured input — the fine structure constant $\alpha \approx 1/137$ — and three derived quantities: the channel count 21 (established in Part I), the geometric constant π, and the dimensional combination $\hbar c/me^2$.

Electromagnetism couples through one channel at a time. Gravity must hold all 21 channels open simultaneously, because gravity maintains the entire arena, not just one face of it. For independent channels, simultaneous coupling is multiplicative — the way the probability of three coin flips all coming up heads is one-eighth: ½ × ½ × ½. The probability of the substrate coupling through all 21 channels at once is $\alpha \times \alpha \times \alpha \times \ldots$ twenty-one times. That is α^{21}.

Gravity is not weak. Gravity is wide. The same coupling, distributed across twenty-one channels instead of one, looks faint at each channel. But it is the same coupling. The hierarchy is not a mystery. It is a count.

A different kind of match. Part I landed 0.010 parts per billion from the measured value — inside the experimental error bar. Part II lands at 0.69%, about 6,900 parts per million. That is far above the 22 ppm uncertainty on any single CODATA measurement, and also far above the roughly 500 ppm spread between independent modern experiments.

The match is striking; the gap is real, and it is larger than any laboratory error bar currently on the table. Two live candidate structural explanations are developed in this chapter without picking between them; the kill switch coda names what would destroy each.

This chapter walks you through the derivation, step by step, in language a school leaver can follow. It names the assumptions. It names the kill switches. And it proposes the specific experiments — multi-method G measurements with characterised systematic offsets — that would confirm or destroy the claim.

The first thing to understand is what gravity actually is. Not the force pulling you down when you walk — that is one effect of gravity. Gravity itself is something more structural. Gravity is what holds the arena open.

The constant that determines the cosmos

Every star is a balance between gravity and pressure. The Sun, at this moment, is being pulled inward by its own gravitational self-attraction — about 2 × 10^{30} kilograms of hydrogen and helium pressing on itself — and being pushed outward by the heat and radiation pressure of nuclear fusion in its core.

The two forces are exactly in balance. If gravity were stronger, the Sun would collapse faster. If gravity were weaker, the Sun would expand and disperse. The temperature of the core, the rate of fusion, the brightness of the Sun, the energy that reaches the Earth — all of it depends on the value of G.

The same balance governs every star that has ever existed, every planet orbiting every star, every galaxy rotating, the expansion rate of the universe itself. Change G by ten percent and the universe is unrecognisable. Change it by a factor of two and stars do not form, or they collapse into black holes immediately. The structure of the cosmos depends on this one number having approximately the value it does.

And the value of G is, in standard physics, a free parameter. Measured. Tabulated. Inserted into Newton's law of gravitation and Einstein's field equations. Never derived from anything more fundamental.

The measurement

Henry Cavendish first measured G in 1798, using a torsion balance — a horizontal bar suspended by a fine wire, with two large lead spheres exerting gravitational attraction on two small spheres at the ends of the bar. The tiny twist of the wire reveals the gravitational force. Cavendish reported a value within about 1% of the modern measurement. For a single eighteenth-century experimentalist working alone in a darkened shed, this was an astonishing achievement.

In the more than two centuries since, hundreds of experiments have refined the measurement. Modern apparatuses use atom interferometry, levitating spheres, beam balances, and torsion pendulums of various designs. The CODATA 2018 recommended value is $G = 6.67430(15) \times 10^{-11}$ $N \cdot m^2/kg^2$ — a relative uncertainty of about 22 parts per million. The CODATA 2022 review left this essentially unchanged.

Here is the surprising thing. Different modern experiments, performed by different research groups using different techniques, persistently disagree with each other by far more than their individual quoted uncertainties. The spread between the highest and lowest recent measurements is approximately 500 ppm — more than twenty times the official uncertainty.

No other fundamental constant in physics has this problem. The speed of light, Planck's constant, the fine structure constant — all are known to extraordinary precision and the measurements all agree. G is the outlier.

The reason for the scatter is unknown. This chapter has an explanation for it, structural and testable, that returns in Section 4.

Three ways the question has not closed

The hierarchy has driven a great deal of theoretical physics for the past fifty years. Three main programmes have been pursued. Each deserves naming, and each has a specific site at which it has not closed.

The first response is supersymmetry. If every known particle has a heavier supersymmetric partner, quantum corrections to particle masses tend to cancel between the two, naturally stabilising hierarchies. SUSY was the leading candidate for solving the hierarchy problem from roughly 1980 through the early 2010s.

The Large Hadron Collider was designed in part to find supersymmetric particles. None has been found. The simpler versions of SUSY are now experimentally excluded. More elaborate versions remain possible but require fine-tuning, which is exactly what SUSY was supposed to avoid.

The second response is extra dimensions. If there are dimensions of space we cannot see — because they are curled up too small to detect, or because matter is confined to a four-dimensional brane within a higher-dimensional bulk — then gravity could be just as strong as electromagnetism in the full higher-dimensional space, and only appear weak in our four-dimensional projection.

The proposals include large extra dimensions (Arkani-Hamed, Dimopoulos, Dvali, 1998) and warped extra dimensions (Randall-Sundrum, 1999). Both predicted experimental signatures — deviations from Newton's law at small distances, missing-energy signals at colliders, microscopic black holes. None has been observed.

The third response is the string theory landscape. If the universe has a vast space of possible vacuum states — perhaps 10^{500} — each with different physical constants, then the hierarchy is not a number to be derived but a parameter that takes a range of values across the landscape.

We happen to live in a vacuum where it is large, and we must live in such a vacuum because no other kind supports the formation of stars and observers. This is an existence claim plus an anthropic selection. It produces no testable prediction for the value of the hierarchy.

Three responses. Three ways the question has not closed. Three programmes that proposed mechanisms, predicted signatures, and produced no number.

This chapter produces a number.

What a derivation would mean

A formula that derives G from α, $\hbar$, c, and me — all four known to spectacular precision — would mean G is not fundamental. It is composite. It is a projection of the electromagnetic coupling through the full channel geometry of the arena, with one topological correction for the unpaired element of the axiom 1:1 + 1×ε @ AS.

If that is true, the hierarchy is not a problem. It is a count. The number 21 — the channel count established in Part I — is the structural reason why the dimensionless gravitational coupling $\alpha G \approx 10^{-45}$ sits 42 to 43 orders of magnitude below $\alpha \approx 10^{-2}$. Twenty-one factors of α compounding into α^{21}. Not a coincidence. Not fine-tuning. Not anthropic selection. A geometric count.

A further interpretive consequence follows from this reading — that gravity and electromagnetism are two ends of one structural process — and is offered in the coda of this chapter, after the numerical derivation has stood on its own.

Gravity is what holds the arena open

Before the derivation begins, a note on what gravity is inside this framework.

Imagine the substrate — the pre-manifold structure from which space and time are written — as a fabric. The fabric has a tendency to heal. Wherever a break appears, the substrate works to close it. This is structural: the symmetric state 1:1 is the lowest-tension configuration, and any departure from it represents stored energy the substrate would prefer to release.

If the break could heal, no record would persist. The crack would close, the symmetry would restore, the now would stop, and there would be no universe. Records would not accumulate because no trace of any coupling event could survive.

Something has to keep the break open.

That something is gravity.

Gravity is the cost the arena pays to maintain the persistence of the break. It is not a force in the same sense as electromagnetism, which transmits energy from one place to another. It is a structural maintenance condition. Without gravity, the arena collapses, the channels close, records cease. With gravity, the break persists across all 21 geometric channels simultaneously, and the universe continues.

This identification — gravity as the maintenance of the entire arena — is what makes the channel-counting argument work. Gravity is not a coupling in one channel. It is the coupling required to keep all the channels open at once. That is why its strength involves all 21 channels. That is why it is multiplicative in α.

The building revisited — 21 rooms

Part I introduced the building. 21 corridors, each leading to a different room. 4 floors. The proton occupied every room. Part II uses the same building, but with the focus shifted from inside the proton to the structure of the arena itself.

Electromagnetism is a torch beam. It enters one corridor. Lights one room. Makes one specific thing happen. The brightness of the beam is α, the fine structure constant — about 1/137. That is the probability the break couples to itself through one channel.

Now consider the foundation. The foundation does not hold up one room. It holds up the entire building. All 21 corridors, all the rooms they lead to, all simultaneously. If the foundation fails under any room, the building collapses. The foundation maintains the entire structure as a structure.

That is gravity. Not a beam in one corridor. The condition of maintenance for all 21 corridors at once.

Where 21 comes from

Part I derived the channel count from the axiom system. Six faces of ε (AP24, with completeness proved in AP28 and alternative gauge structures ruled out by AP15–AP19). Three spatial dimensions (AP10). Three actualization couplings (AP28). Six times three plus three. The total:

$6 \times 3 + 3 = 21$

Eighteen face-projections plus three actualization couplings. Twenty-one independent channels through which the break can couple. The number is not adjustable. It is set by the axiom system before any prediction about G is attempted — derived once, used wherever it appears.

The channels are independent

The compounding argument requires that the 21 channels be statistically independent. AP28 §5 Prop 3 proves they are.

Two events are statistically independent if knowing the outcome of one tells you nothing about the outcome of the other. The probability of both events occurring is then the product of their individual probabilities: P(A and B) = P(A) × P(B). For three independent events, P(A and B and C) = P(A) × P(B) × P(C). For 21, the same logic with 21 factors.

Independence of the 21 channels follows from two separately proven results. The six faces of ε are independent readings (AP28 §5 Prop 1) — each measures a different scalar invariant; knowing one gives no information about another. The three spatial dimensions are independent (AP10) — each derives from a different axiom. A face-projection in dimension j carries information about face i in dimension j only; nothing about face k in dimension l for any other combination. The three actualization couplings are independent of the face-projections and of each other.

Therefore all 21 channels are mutually independent. The compounding rule for independent probabilities applies.

This independence is a derived result, not an assumption. It carries kill switch KS-R.8c: if any correlation between any two channels is demonstrated that does not reduce to a shared dependence on ε itself, the independence proof fails and the multiplicative compounding breaks.

Why multiply, not add

A careful reader of Part I will notice a combination rule difference here.

Part I constructs the proton mass ratio by *adding* integer layers: $21^2 \times 4 + 21 \times 3 + 3^2 = 1836$. Part II constructs the gravitational coupling by *multiplying* the electromagnetic coupling through twenty-one independent channels: α^{21}. The rules differ because the structures differ.

Part I counts resistance — the geometric capacities of a bound state integrating the channel network. Capacities of independent subspaces add, as the linear dimensions of the state space.

Part II counts joint coupling — the probability that the break interacts with itself through every channel simultaneously. Probabilities of independent events multiply, by the standard rule for statistical independence (AP28 §5 Prop 3).

Addition governs capacity. Multiplication governs joint coupling. The same 21 appears in both because the channel count is structural. The combination rule is determined by what is being counted, not by what is being combined.

Electromagnetism couples through one channel. Strength: α.

Gravity couples through all 21 channels simultaneously. Strength: $\alpha \times \alpha \times \alpha \times \ldots$ twenty-one times. That is α^{21}.

Numerically, with $\alpha = 7.2974 \times 10^{-3}$:

$\boldsymbol{\alpha^{21} = 1.338 \times 10^{-45}}$

This is the 1:1 part of the gravitational coupling — the balanced, paired-channel structure. Twenty-one paired channels, each contributing one factor of α to the total.

Twenty-one coin flips all coming up heads is 1 in 2 million. Twenty-one channels each coupling simultaneously, each at probability $\alpha \approx 1/137$, is 1 in 10^{45}. Each channel is not weaker than the electromagnetic coupling — each still couples at α. What is rare is all 21 coupling at once. Gravity is that joint event, occurring continuously at every site where the arena is maintained. Same coupling rate. Wider simultaneous requirement.

The ratio between electromagnetism (one channel, full strength) and gravity (21 channels, distributed) is $1/\alpha^{21} \approx 7.5 \times 10^{44}$. Gravity is about 10^{-45} of electromagnetism. That is the hierarchy. Forty-five orders of magnitude. The number is not mysterious. It is twenty-one coin flips.

This is the axiom running. The 1:1 side of *1:1 + 1×ε @ AS* — twenty-one paired channels, mirror-partnered through Axiom S, each contributing one factor of α. The hierarchy is not small. It is the full axiom, read across its full arena, counting every channel once.

The puncture — 1 + 1/π

The axiom does not stop at 1:1. It says *1:1 + 1×ε @ AS*. Perfect balance plus one unpaired element, at the actualizing now.

Twenty-one paired channels account for the 1:1. They are the balanced, two-sector structure of the substrate — every channel on one side has a mirror partner on the other side via

Axiom S. But the axiom adds one more thing. The unpaired element. The +1×ε. The minimum break itself, with no mirror partner.

That unpaired element is the electron. The electron is not a fragment of matter chipped off the substrate. The electron is a topological puncture — a hole punched through the mirror that connects the broken vacuum to the unbroken vacuum. The mass of the electron is the energy cost of keeping that hole open.

The puncture has a circular cross-section. AP28 §5 Prop 4 derives this. A topological puncture in the three-dimensional spatial arena is a region where the field returns to the symmetric vacuum. Its boundary is a closed surface around the puncture point.

The shape is determined by energy minimisation — the boundary has surface energy proportional to its area, and for a fixed enclosed volume the surface that minimises area is a sphere. This is the isoperimetric theorem. The puncture is effectively a one-dimensional tube connecting two topological regions; intersecting the spherical boundary with the tube axis gives a circular cross-section.

The geometric weight of the unpaired element coupling through this circular puncture is 1/π. The total coupling capacity of a circular boundary, in the corpus's normalisation, is π — the half-circumference per side, times two sides. The single unpaired winding contributes one of those capacity units, giving a fractional weight of 1/π.

One sub-debt is named here, openly. The identification of the coupling fraction as 1/π specifically, rather than 1/(2π) or 1/(4π), depends on the choice of normalisation for the boundary coupling. AP28 flags this as an open sub-debt within its proof: the argument is structurally motivated and the 0.69% agreement with measurement supports the normalisation, but formal verification against the full puncture topology of AP04 and AP05 has not been completed. Part II inherits the sub-debt and does not disguise it.

Empirical filtering does narrow the candidates. A 1/(2π) normalisation would predict $G = 5.91 \times 10^{-11}$ — decisively excluded by measurement. A 1/(4π) normalisation would predict $G = 5.50 \times 10^{-11}$ — also excluded. Only 1/π gives the 0.69% agreement. The data filter supports the chosen factor. Kill switch KS-R.9 guards the formal side.

With the puncture correction:

$$\boldsymbol{\alpha G = \alpha^{21} \times (1 + 1/\pi)}$$

The first factor is the 1:1 — the paired channels. The second factor is the 1×ε — the unpaired element coupling through a round hole. The axiom wrote itself into the gravitational constant — right now, at every site where gravity acts.

The dimensional bridge

The quantity αG is dimensionless — a pure number. The gravitational constant G has units of $N \cdot m^2/kg^2$. A dimensional bridge converts one to the other.

The bridge is set by what αG actually measures. αG is the gravitational fine structure constant — the ratio of the gravitational potential energy between two electrons to their kinetic-energy-equivalent at the natural length scale set by the electron's Compton wavelength. The standard definition:

$$\alpha G = G\, me^2 / (\hbar c)$$

Solving for G:

$$G = \alpha G \times \hbar c / me^2$$

This is not an additional assumption. It is the definition of αG applied algebraically. The combination $\hbar c/me^2$ has units of $N \cdot m^2/kg^2$ by construction. The dimensional bridge is fixed by the choice of which dimensionless quantity to identify with the gravitational coupling.

Three constants, three axioms

The formula predicts three fundamental physical constants from the four axioms. The mapping is one-to-one for the three constants and direct for the fourth axiom's structural role.

c ↔ **C.** The speed of light is the maximum rate at which any record, distinction, or piece of information can propagate. Axiom C constrains propagation speed. Derived in AP03 from the substrate stiffness ratio.

ħ ↔ **B.** Planck's constant is the smallest possible record — the minimum quantum of action. Axiom B is the minimum break. Derived in AP12 from Stone's theorem applied to the axiom-derived Hilbert space.

G ↔ **R.** The gravitational constant is the cost of persisting the break across the geometry of the arena. Without that cost, the crack would heal and records would not accumulate. Axiom R is record persistence. Derived in this chapter.

Topology ↔ **S.** Axiom S does not produce a constant. It produces the topology of the arena — the two-sector structure, the mirror, the stage on which the other three act. The 21 channels, the puncture topology, and the circular cross-section all flow from this structural input.

Three constants. Three axioms. One topology. One break. The structural map is complete. Every factor on the right side of the formula traces to a specific axiom. α is the leakage rate (Axiom B via AP06). The exponent 21 is the channel count (Axioms S, B, R, C via AP10, AP24, AP28). The 1/π is the puncture geometry (Axiom S via AP04, AP05, AP28). The dimensional bridge uses ħ (B via AP12), c (C via AP03), and me (B via AP06). Every factor is structural.

The number

Putting all the pieces together — for the first time, the full formula:

$$G = \alpha^{21} \times (1 + 1/\pi) \times \hbar c / m_e^2$$

Substituting CODATA values.

$\alpha = 7.2974 \times 10^{-3}$. $\alpha^{21} = 1.3380 \times 10^{-45}$. $1 + 1/\pi = 1.31831$. The product $\alpha^{21} \times (1 + 1/\pi) = 1.7640 \times 10^{-45}$. The dimensional bridge $\hbar c/m_e^2 = 3.8099 \times 10^{34}$ N·m²/kg². Multiplied together:

G predicted = 6.7206×10^{-11} N·m²/kg²

Measured value (CODATA 2018, unchanged in CODATA 2022): 6.6743×10^{-11}, with experimental uncertainty 22 ppm on the single-consensus value.

Difference: 4.63×10^{-13}. Relative discrepancy: 0.69%.

A formula with no free parameters, using one measured input (α) and three derived structural quantities — the channel count 21, the puncture factor $1/\pi$, and the dimensional combination $\hbar c/m_e^2$ — produces a value of G that is 0.69% from the measured one.

The 0.69% gap is much larger than the 22 ppm CODATA uncertainty on a single measurement. The prediction is not consistent with the consensus central value to within laboratory error. The next section explains why the chapter predicts this gap, and what would close it.

Why 0.69%?

The 0.69% discrepancy is not noise. Two candidate structural explanations remain live. The chapter does not pick between them. The research proposal in Appendix D distinguishes them.

Candidate 1 — apparatus-dependent leakage. Every G measurement involves a physical apparatus. Every apparatus is a leaky boundary. AP06 establishes that no boundary can be perfectly tight — some fraction of any coupling event leaks into the surrounding substrate. The leakage fraction depends on the boundary geometry: how the test masses are arranged, how they are suspended, what materials interface with what, what the local gravitational gradient looks like. Different apparatuses have different leakage signatures.

This is the predicted reason why different G measurements scatter by 500 ppm — twenty times the quoted uncertainty of any single measurement. The scatter is not random measurement error. It is systematic, apparatus-dependent leakage. Each laboratory measures G shifted by its own apparatus's leakage signature.

Under Candidate 1, the chapter's prediction 6.7206×10^{-11} is the unleaky value — what G would be if measured with a perfectly tight apparatus. Real measurements are systematically below that value because every real apparatus leaks. The 0.69% gap between prediction and the CODATA recommended value represents, under this model, the average leakage across all included experiments.

Candidate 2 — puncture normalisation refinement. The factor (1 + 1/π) comes from the geometry of the electron as a topological puncture. The derivation identifies the cross-section as circular and assigns it the geometric weight 1/π. AP28 flags the precise normalisation as a sub-debt within the proof.

Under Candidate 2, the 0.69% gap is not about measurement apparatus at all — it is a residual signature that the correct normalisation is not exactly 1/π but some slightly refined form. Closing the sub-debt by a formal puncture-topology calculation would either retain 1/π — keeping the gap, which then belongs entirely to Candidate 1 — or yield a corrected factor that closes part of the 0.69%.

Both candidates are testable and distinguishable. Candidate 1 predicts measured G values correlate with apparatus geometry in the way AP06 specifies — richer boundary structure should produce larger downward bias.

Candidate 2 predicts the measured G values do not correlate with apparatus geometry, because the source of the gap is structural, not instrumental — all apparatuses should converge on the same biased value, offset by whatever the correct puncture factor demands. A meta-analysis of published measurements distinguishes them: correlation with apparatus points to Candidate 1; flat residual points to Candidate 2.

If neither correlation nor structural refinement can explain the gap, the formula fails at the 0.69% level. KS-R.7 fires.

The sign of the gap

One more empirical handle, specific to Candidate 1. The leakage explanation predicts G_predicted > G_measured — the structural value is larger than what any leaky apparatus measures. The reason: leakage subtracts coupling energy from the measurement, biasing the inferred G downward. Candidate 2, puncture-normalisation refinement, makes no directional prediction of this kind; the sign of a refinement depends on the precise topological correction.

The observed gap is exactly in this direction. 6.7206×10^{-11} is larger than 6.6743×10^{-11}. The sign matches Candidate 1. If the gap were in the opposite direction — if every measurement gave a larger value than the formula predicts — the leakage explanation would be excluded immediately. It is not.

The sign is a first piece of evidence in the right direction, observed without adjustment. It does not prove the leakage explanation — the sign could be a coincidence. But the chapter passed a test it could have failed.

Three features distinguish this derivation from numerology. The integers were derived before the G match was ever checked — the channel count 21 is established in Part I from AP10, AP24, AP28, independently of the G prediction. The formula has explicit falsification conditions — seven kill switches, below.

And the formula predicts the experimental scatter: different apparatuses should measure different values of G correlated with their boundary geometry. A numerological match has none of these. All three are here.

If this is wrong

Seven kill switches guard this chapter. They cluster into four families: the prediction itself, the channel count (four sub-switches), the puncture geometry, and the unification interpretation. Six guard the numerical formula. The seventh, KS-R.10, guards the separate unification interpretation that follows in the coda — the numerical formula stands or falls on the first six alone. AP28 §9 is explicit on this separation.

KS-R.7 — G prediction

The predicted value 6.7206×10^{-11} N·m^2/kg^2 must agree with the measured gravitational constant within 1%, or within the leakage correction AP06 specifies. Current discrepancy: 0.69%. Within tolerance.

This switch fires if future precision measurements of G converge on a value more than 1% away from 6.7206×10^{-11}, AND the leakage correction predicted by AP06 cannot account for the residual. The leakage correction makes a specific prediction about how the residual should depend on apparatus geometry. If measurements converge on a value inconsistent with both the bare prediction and the leakage-corrected prediction, the formula fails.

KS-R.8a — Face completeness

Fires if a seventh independent scalar reading of ε is exhibited that is not a function of the six identified faces. A seventh face would change the channel count from 21 to 24 (with the third spatial dimension included), shifting the predicted G by many orders of magnitude.

KS-R.8b — Actualization scope

Fires if the actualization state is shown to couple to a degree of freedom independent of both the three spatial dimensions and the six faces. This would add to the actualization coupling count, currently 3, changing 21.

KS-R.8c — Channel independence

Fires if a correlation between any two channels is demonstrated that does not reduce to a shared dependence on ε itself. Without independence, the multiplicative compounding is invalid — even with 21 channels, α^{21} is the wrong combination rule.

KS-R.8d — Uniform coupling

Fires if the per-channel coupling is shown to differ from α — if different faces have different intrinsic coupling strengths. The compounding rule would still hold but with non-uniform exponents, changing the result.

KS-R.9 — Puncture geometry

The correction factor $1/\pi$ is derived from the circular cross-section of the electron as topological puncture. The argument is structurally motivated but carries a sub-debt: the precise normalisation of the boundary coupling has not been fully verified against the puncture topology.

This switch fires if the puncture boundary is shown to be non-circular, or if the correct normalisation of the boundary coupling gives a factor other than $1/\pi$. The empirical evidence currently supports $1/\pi$: this normalisation gives 0.69% agreement, while $1/(2\pi)$ would give 5.91×10^{-11} and $1/(4\pi)$ would give 5.50×10^{-11} — both decisively excluded by measurement. The data filter the candidates; $1/\pi$ survives, the other two do not. But empirical filtering is not the same as formal derivation. The full topological analysis remains open.

KS-R.10 — Unification structure

The interpretation that gravity maintains superposition and electromagnetism collapses it is a structural claim about what physical processes look like under the axiom system. It carries its own kill switch.

This switch fires if a physical system is demonstrated in which gravitational coupling does not maintain superposition, or in which electromagnetic coupling does not collapse it. Either would falsify the unification interpretation.

How you can verify it

Direct verification takes under a minute. Look up α: $7.2973525693 \times 10^{-3}$ (CODATA 2018). Compute $\alpha^{21} = (7.2974 \times 10^{-3})^{21} = 1.338 \times 10^{-45}$. Compute $1 + 1/\pi = 1.31831$. Multiply them: $\alpha^{21} \times (1 + 1/\pi) = 1.764 \times 10^{-45}$. Look up or compute the dimensional bridge $\hbar c/me^2 = (1.0546 \times 10^{-34})(2.998 \times 10^{8})/(9.109 \times 10^{-31})^2 = 3.8099 \times 10^{34}$. Multiply: $1.764 \times 10^{-45} \times 3.8099 \times 10^{34} = 6.7206 \times 10^{-11}$.

Compared to measured 6.6743 × 10^{-11}, the discrepancy is 0.69%.

The full Python code is in Appendix B. Six lines for this prediction. It runs in a fraction of a second. If you are a physicist, run it. If the numbers do not match, the chapter is closed. If they do, you have confirmed the central numerical claim of the chapter in under a minute.

Seven kill switches are live. The formula holds. One sub-debt is named inside KS-R.9. The work continues.

What would settle this

The decisive test of this chapter is the meta-analysis described in Appendix D, not a new measurement.

All published high-precision G measurements with uncertainty below 100 ppm — approximately fifteen to twenty experiments over the past three decades — are catalogued with detailed records of apparatus geometry: suspension type, test mass arrangement, gradient profile, local gravitational environment. AP06 specifies the leakage rate as a function of boundary geometry.

For each apparatus in the catalogue, compute the predicted leakage from first principles, generating a predicted apparatus-dependent shift for each measurement. Then test whether the measured G values correlate with the predicted leakage signatures.

Strong correlation ($R^2 > 0.7$) with the leakage-corrected values clustering tightly around 6.7206×10^{-11}: Candidate 1 confirmed, the chapter's structural picture supported, the experimental scatter explained. Weak or absent correlation: Candidate 1 falsified, the 0.69% gap belongs to Candidate 2 or to the formula itself failing. Mixed result: both contribute, and the analysis apportions the gap between them.

The programme costs nothing to initiate. The data already exist. The leakage derivation is mathematical. The correlation analysis is a single regression. Timeline: three to six months for a definitive primary result.

A secondary programme — a new-generation G measurement apparatus designed specifically to minimise boundary leakage — would take three to five years and would provide an independent check. A third programme — formal closure of the puncture-normalisation sub-debt by direct topological analysis of AP04 and AP05 — would resolve KS-R.9 at the mathematical level, six to twelve months.

The full research proposal, with abstract, background, programme phases, expected results, and timeline, is in Appendix D. The formal apparatus lives where formal apparatus belongs. What matters here is the bet: the existing G measurement record already contains the signal; a meta-analysis of existing data can decide this chapter's central claim within the year.

What this Part has done

Gravity is not weak. Gravity is wide.

The hierarchy — the 10^{42} force ratio between electromagnetism and gravity at the electron scale, or equivalently the dimensionless gravitational coupling $\alpha G \approx 10^{-45}$ sitting 42 to 43 orders of magnitude below α — is not a problem requiring supersymmetry, or extra dimensions, or anthropic selection across a string landscape. The hierarchy is a count. Twenty-one channels in the arena.

Each channel couples at the rate $\alpha \approx 1/137$. Independent channels compound: $\alpha \times \alpha \times \alpha \times$ … twenty-one times equals $\alpha^{21} \approx 1.34 \times 10^{-45}$. With the puncture correction for the unpaired electron, the gravitational coupling is $\alpha^{21} \times (1 + 1/\pi) \approx 1.76 \times 10^{-45}$. Multiplied by the dimensional bridge $\hbar c/me^2$, this gives 6.7206×10^{-11} N·m²/kg².

The CODATA value is 6.6743×10^{-11}. The discrepancy is 0.69% — about 6,900 parts per million, far above the 22 ppm single-measurement uncertainty and also above the roughly 500 ppm spread between independent modern experiments. Two candidate explanations remain live.

Every measurement apparatus is a leaky boundary, and apparatus-dependent leakage produces a systematic downward bias; the gap is a structural fingerprint of that leakage. Or the 1/π normalisation is not the final form, and the sub-debt flagged in AP28 requires a formal topological closure. Both candidates are testable. The meta-analysis in Appendix D distinguishes them.

Seven kill switches are live. The G prediction itself, the channel count (four sub-switches covering face completeness, actualization scope, independence, and uniformity), the puncture geometry (carrying its acknowledged sub-debt), and the unification interpretation. Each one specifies exactly what would destroy the prediction. Each is testable.

The three fundamental constants c, ħ, and G now map one-to-one onto the three axioms that produce physical quantities: c ↔ C, ħ ↔ B, G ↔ R. Axiom S produces the topology — the two-sector structure, the mirror, the stage on which the other three act. The integers come from the manifold's geometry. The corrections come from the physics of leakage. Between them they produce three of the most important numbers in physics, with one measured input and no free parameters.

If the formula is wrong, the kill switches specify exactly where it will break. If it is right, gravity is not a free parameter of nature. It is the same coupling as electromagnetism, distributed across the full channel structure of the arena. The hierarchy is a floor plan. The unification that general relativity and quantum electrodynamics have spent a century seeking is already there — not between two different theories, but inside one process read from two ends.

That unification, stated fully. The two forces are not separate. They are the same coupling at different multiplicities. Gravity is the coupling holding all 21 channels open simultaneously. Electromagnetism is the same coupling collapsing one channel into a record. Quantum mechanics is what gravity looks like from the inside — all possibilities maintained. Classical mechanics is what electromagnetism looks like from the inside — one outcome selected. Two ends of one process.

This interpretation is developed at length in AP28 §9. It is offered here, after the derivation, because the numerical formula stands on its own. Kill switch KS-R.10 guards the interpretation separately; a reader who accepts the match and rejects the interpretation has no disagreement with the chapter's numerical claim.

You are held to the ground by the same coupling that lets you see this page. The light reaching your eyes is α acting through one channel. Your weight on the chair is α acting through all twenty-one channels at once. Different multiplicities of the same rate, the same break, the same axiom running.

When you walk, when you sit, when a leaf falls or a planet orbits a star, it is the same coupling read through one channel and through all twenty-one — one process at two multiplicities, held open right now, at this site, at the resolution at which 21 is forced.

In Part III, the same vocabulary answers a more delicate question. Why is the neutron slightly heavier than the proton? The mass difference is tiny — just 2.53 electron masses — but it determines whether the universe contains atoms at all. The answer uses the same integer 3 (the colour faces) and the same coupling α, in a different combination, with the same kind of geometric correction. The same building, read from yet another angle.

The building has rooms within rooms. The counting has just begun.

Part III – The Neutron's Whisper

The neutron-proton mass difference, derived to 2 parts per million

Predicted: (m_n – m_p)/m_e = 2.5309939330

Measured: 2.5309883000 (CODATA 2018)

Residual: 2.2 parts per million

One measured input: α ≈ 1/137. Zero free parameters.

The neutron is slightly heavier than the proton. By exactly 2.53 electron masses. About 0.14% of the proton's total mass.

That tiny difference is the reason the universe contains atoms.

If the neutron were lighter than the proton, everything would invert. Protons would decay into neutrons via inverse beta decay, releasing a positron and a neutrino. Free hydrogen would not exist. The universe would be a cold sea of neutrons. No stars burning hydrogen fusion. No chemistry. No biology. A dark, featureless cosmos.

If the neutron were much heavier than it is — if the mass difference were, say, ten times larger — neutrons would decay too fast to survive inside nuclei. Heavy elements could not form. The periodic table would end at hydrogen. Carbon, oxygen, iron, gold — none of it could exist. No stars beyond the first generation. No planets. No life.

The actual value sits on a knife edge. Heavy enough for the neutron to be unstable outside nuclei, so the universe is dominated by stable hydrogen (which becomes the fuel for every star that ever existed). Light enough for neutrons to survive inside nuclei, so carbon, oxygen, and all heavier elements can form.

The mass difference determines the free neutron lifetime (about 880 seconds), the proton-to-neutron ratio in the early universe (which sets the primordial helium abundance at about 25%), and therefore the chemical composition of the entire cosmos.

That all of this depends on one tiny number — 2.53 electron masses — is a well-known fact among physicists. Less well known is that no framework has ever derived this number from first principles. The Standard Model can compute it, but only by taking the up-quark mass, the down-quark mass, and the electromagnetic self-energy as inputs.

Each of those inputs is itself measured, not derived. The Standard Model tells you that if you put these three numbers in, the neutron-proton mass difference comes out. It does not tell you why any of those three numbers have the values they do.

This chapter derives the neutron-proton mass difference from the axiom system.

The formula uses the same structural vocabulary Parts I and II established: the integer 3 (the three colour faces of the bound state, derived in Part I), the coupling $\alpha \approx 1/137$ (the same leakage rate), and one new geometric factor — the closed-loop curvature $1/(2\pi)$. Two terms. Static plus dynamic. The same pattern that set the proton mass in Part I, read at the mass difference between two one-quark-swap variants.

The prediction matches measurement to 2 parts per million. The chapter walks through the derivation step by step, names the seven kill switches, and proposes the specific lattice QCD test that would confirm or destroy the claim.

The first question: what does the neutron look like, structurally, compared to the proton? The answer is simple. The neutron is the proton with one wall repainted.

The mass difference that built the atoms

About fourteen billion years ago, approximately one second after the Big Bang, the universe was hot enough that protons and neutrons converted freely into each other. The ratio between them was set by the Boltzmann factor: $\exp(-\Delta m\, c^2 / kT)$, where Δm is the neutron-proton mass difference, kT is the temperature energy, and the minus sign reflects that the heavier particle is suppressed.

As the universe cooled, the conversion froze out at a specific temperature, freezing in the ratio at about one neutron for every seven protons.

That ratio determined the helium abundance. Within the next three minutes, essentially all the surviving neutrons got captured into helium-4 nuclei — two protons plus two neutrons, the most tightly bound light nucleus. The result: 25% of all ordinary matter in the universe is helium, 75% is hydrogen, with trace amounts of lithium. This is the primordial composition — the raw fuel from which every star and every planet was eventually built.

Every star that has ever burned. Every carbon atom in every living thing. Every iron atom at the core of Earth. Every element heavier than helium was cooked in stellar furnaces from that initial hydrogen-helium mix, and the mix itself was set, one second after the Big Bang, by a number that depends on 2.53 electron masses.

The standard picture

In the Standard Model, the neutron-proton mass difference arises from a near-cancellation between two contributions of opposite sign. The QCD contribution — from the down quark being heavier than the up quark — is roughly +2.5 MeV. The QED contribution — from the electromagnetic self-energy, which is larger for the proton because the proton has greater mean-square charge — is roughly −1.0 MeV.

The total is about +1.3 MeV. The observed mass difference is the small residue after the two large effects partially cancel.

Lattice QCD can compute this total ab initio. The BMW collaboration's 2015 calculation (Borsanyi et al., Science 347, 1452) reported m_n − m_p = 1.51 ± 0.16 (stat) ± 0.23 (sys) MeV, consistent with the measured value within lattice uncertainty. Subsequent work has progressively tightened the precision from 1% in 2015 toward 0.1% in current state-of-the-art calculations.

But lattice QCD takes the up-quark mass, the down-quark mass, and the electromagnetic coupling as inputs. Each is measured, not derived. The Standard Model does not answer where the input parameters come from.

What a derivation would mean

A formula that derives the neutron-proton mass difference from one coupling constant (α) plus pure geometric primitives (the integer 3 from the colour faces, and π from the closed-loop geometry) would mean the difference is not an accident. It is a geometric count of what happens when you change the flavour of one quark in a three-face bound state.

The QCD-QED near-cancellation that the Standard Model describes numerically would become, in this reading, a single closed-loop geometric effect. No two large contributions canceling. One geometric count, producing the net result directly.

This is the sharpest structural claim of the chapter, and it is directly testable. Section 6 of this chapter proposes the specific lattice QCD test — a decomposition into QCD-alone and QED-alone contributions at sub-0.1% precision — that would either confirm the reading or destroy it.

The neutron as proton with one wall repainted

The neutron and the proton are the same building, with one wall painted a different colour.

Inside the proton: two up quarks and one down quark. Each quark carries one of three colour charges — red, green, blue. The three together form a colour-singlet state (the specific linear combination that is colour-neutral overall, which is the confinement requirement for any stable hadron). The mass of the proton, as Part I derived, is 1836.152673426 electron masses, set by the full channel-face-exchange structure of the three-face bound state.

Inside the neutron: one up quark and two down quarks. Same three colour charges, same three-face structure, same confinement requirement. The up-to-down ratio has flipped from 2:1 to 1:2. Everything else is the same.

This one-quark swap is the entire difference between proton and neutron. Structurally, you are painting one of the three walls a different colour. The building's architecture — the floor plan, the corridors, the 21 channels, the static exchange matrix — all of that stays identical. Only one element has changed: the flavour (up or down) of one of the three quarks.

But flavour is not free. Changing an up quark to a down quark changes two things. First, it changes the colour-face asymmetry pattern — the static geometry. Second, it changes the electromagnetic charge distribution — the dynamic coupling. Both effects cost mass, and the two contributions add: static + dynamic = the neutron-proton mass difference.

Three faces register the swap

The static cost is $3 \times (1 - 1/(2\pi))$. Let us unpack this.

First question: why 3? Why this integer and not 1 or 2 or 9?

The answer traces to the three colour faces. From Part I and AP10/AP19: the arena has three spatial dimensions, which map onto three structural roles for the break — propagation, exchange, break itself. These three roles are what physicists call the three colour charges of the strong force. They are not three independent colours of light. They are three independent readings of the same underlying geometric structure.

In a three-quark bound state, the three quarks occupy the three colour faces. When you swap one quark's flavour (up to down), you change the asymmetry distribution across all three faces, not just the face the swapped quark sits on. This is because the colour exchange matrix — the nine pathways derived in Part I's Layer 3 — couples all three faces to each other continuously. A perturbation on any one face propagates to all three through the exchange mechanism.

So the flavour swap is felt by all three faces, and each face registers one unit of the asymmetry cost. Hence the integer 3.

If you had a two-face bound state, the integer would be 2. If you had a five-face bound state, the integer would be 5. The integer 3 is a specific consequence of the colour structure of QCD — which, in this framework, is a specific consequence of the three spatial dimensions of the arena.

The curvature factor 1 – 1/(2π)

Second question: why 1 – 1/(2π) per face, rather than 1 per face?

The factor has two parts. The 1 represents the full asymmetry unit per face — the cost of each face registering one unit of the flavour swap. The –1/(2π) is a curvature correction.

The correction arises because the colour faces inside the bound state are not arranged on a flat background. They are coupled through continuous exchange — every face communicates with every face via gluons, and this exchange happens on closed geometric loops (the three faces together form a closed colour-singlet state).

A closed loop in natural geometric units has circumference 2π (the perimeter of a unit circle). The inverse of this circumference, 1/(2π), is the natural geometric weight per single winding around the loop.

This is the same kind of factor that appears throughout physics wherever closed-loop geometry is involved — Wilson loops in gauge theory, path integrals on compact spaces, geometric phases in quantum mechanics. The 2π is the universal closed-loop circumference. The 1/(2π) is its inverse, which weights each unit of exchange by the loop geometry.

The curvature reduces the effective asymmetry. The three faces, sitting on a closed loop, partially cancel each other's asymmetry through the continuous exchange. The full asymmetry unit (1 per face) is reduced by the fraction 1/(2π) that bleeds into the exchange rather than remaining localised on the face. The net effective asymmetry per face is 1 – 1/(2π) ≈ 0.841.

Across all three faces: 3 × (1 – 1/(2π)) ≈ 2.5225. This is the static cost of the flavour swap.

Notice that the 1/(2π) factor here is structurally related to the 1/π factor that appeared in Part II's gravitational derivation. Both come from the geometry of closed boundaries in the manifold — Part II used the great-circle projection of a spherical boundary (weight 1/π); Part III uses the full-loop circumference (weight 1/(2π)). The same family of geometric factors governs both phenomena. Not a coincidence — the manifold being self-consistent.

This is the axiom running. *1:1 + 1×ε @ AS* read at the neutron-proton boundary — three colour faces receiving one unit of asymmetry each, reduced by the closed-loop geometry they live on, producing 2.5225 before any dynamic correction. The integer is the arena's spatial count. The curvature is the arena's closed-loop topology. The swap is the axiom breaking at AS, and the bound state rewriting itself around that break.

The static term already includes the QCD-QED cancellation

Before deriving the dynamic term, a structural precision the chapter owes a careful reader.

In the Standard Model, m_n – m_p is the small residue after two large opposing effects partially cancel: a +2.5 MeV QCD contribution and a –1.0 MeV QED contribution, producing +1.3 MeV net. The static term 3 × (1 – 1/(2π)) ≈ 2.5225 electron masses ≈ 1.289 MeV is numerically almost the full observed mass difference.

It is not identifiable with the QCD contribution alone, because the QCD contribution is 2.5 MeV, not 1.3 MeV. What the static term captures, structurally, is the combined geometric cost of the quark swap — already including whatever cancellation physics would describe in QCD+QED terms.

This is the sharpest structural claim of the chapter. The near-cancellation that lattice QCD computes numerically is, in this reading, a single geometric count. The three colour faces register the swap; the closed-loop curvature reduces each face's contribution by 1/(2π); the result is 2.5225 — already the near-cancellation value. No second large contribution waiting to cancel it. The closed-loop geometry produces the reduction that in Standard Model language is assigned to a separate QED contribution.

This is directly testable. Lattice QCD calculations can be decomposed into QCD-alone and QED-alone contributions. The framework does not deny that lattice QCD's decomposition is valid within that formalism. It claims that decomposition is an artifact of the Standard Model's separation of forces into independent sectors, and that the underlying geometry produces the net result directly, without intermediate cancellation.

Specifically: the QCD-only lattice contribution, at sufficient precision, should correspond to approximately 3 × 1 = 3.0 electron masses before the curvature correction, and the curvature reduction 3 × 1/(2π) ≈ 0.477 should be identifiable as the portion lattice QCD attributes to QED. The mapping is testable at the level of specific numbers, not just totals.

The dynamic term — O(α) refinement

The static term gives 2.5225. The measured value is 2.5310. The difference is 0.0085. What accounts for this small additional piece?

The answer is the same as in Part I. The proton and the neutron are not static structures. Both are dynamically maintained against the substrate’s tendency to heal the break, at the leakage rate α. The static geometry captures the bound-state architecture; the dynamic correction captures the O(α) cost of maintaining that architecture against substrate leakage.

For the neutron-proton difference, the relevant question is how the dynamic maintenance cost differs between the two. Both particles have the same 21-channel structure and the same three-face bound state. The difference is the flavour content, which changes the electromagnetic charge distribution (proton: +2/3, +2/3, −1/3 on the three faces;

neutron: +2/3, −1/3, −1/3) and therefore the specific rate at which each particle couples to the substrate’s phase freedom.

The coupling rate is α per channel, the same constant that drove Part I’s dynamic maintenance. The geometric modulation factor for the neutron-proton difference is $1 + 1/(2\pi)$, where the $+1/(2\pi)$ enters with a positive sign because the closed-loop curvature concentrates the electromagnetic coupling inside the bound state, rather than diluting it as it did for the static asymmetry.

The sign difference between the static factor $(1 - 1/(2\pi))$ and the dynamic factor $(1 + 1/(2\pi))$ reflects the difference between diluting a static asymmetry (which the loop averages away) and concentrating a dynamic field (which the loop focuses inward). The same sign pattern appears throughout physics — Wilson loops, path integrals on compact manifolds, geometric phases in quantum mechanics — for the same structural reason.

Numerically: $\alpha \times (1 + 1/(2\pi)) = 7.2974 \times 10^{-3} \times 1.15915 = 0.00846$.

Critically, this dynamic term is about 300 times smaller than the static term. It is a small correction on top of the already-near-correct static result. Not one of two large opposing effects that nearly cancel. The framework does not reproduce the Standard Model’s QCD/QED decomposition; it produces a different decomposition in which the observed mass difference is already captured by the static geometry, with the dynamic term refining the precision from 0.3% to 2 ppm.

The two contributions add

The static and dynamic contributions add, for the same reason the three layers of the proton mass decomposition added in Part I: they arise from independent structural constraints on independent axiom subsets.

The static cost traces to the strong-force structure: three colour faces, closed-loop exchange, curvature correction. Axiom S (the two-sector colour structure), Axiom B (the face projection), Axiom C (the closed-loop geometry). The dynamic cost traces to the electromagnetic coupling: α as leakage rate, the same loop geometry enhancing rather than diluting. Axiom B (the phase freedom) and Axiom R (the maintenance requirement that α measures).

The two chains involve overlapping axiom subsets, but the specific contributions to the mass difference are independent: a change in the static structure does not automatically change the dynamic structure, and vice versa. The contributions add.

This additivity carries the same kill switch as Part I's additivity (KS-30.1). The argument rests on the axiom independence proved in AP20; the full formal proof that the static and dynamic contributions live in independent subspaces of the bound-state configuration space has not been constructed. Debt D19 applies here.

The number

Putting all the pieces together — for the first time, the full formula:

$$\mathbf{(m\_n - m\_p) / m\_e = 3 \times (1 - 1/(2\pi)) + \alpha \times (1 + 1/(2\pi))}$$

Substituting values.

Static: $3 \times (1 - 1/(2\pi)) = 3 \times 0.8408450569 = 2.5225351707$.

Dynamic: $\alpha \times (1 + 1/(2\pi)) = 0.0072973526 \times 1.1591549431 = 0.0084587623$.

Total: 2.5309939330

Measured value (CODATA 2018, unchanged in CODATA 2022): 2.5309883.

Residual: 5.64×10^{-6}, or 2.23 parts per million.

The BMW 2015 lattice QCD result (Borsanyi et al. 2015) gave 1.51 ± 0.28 MeV, which in electron-mass units is roughly 2.96 ± 0.55 — consistent with both the measured value and the prediction within lattice uncertainty. Subsequent lattice work has tightened precision toward 0.1%; a next-generation calculation at that level would be a definitive test.

One measured input. Zero free parameters. The integer 3 traces to the three colour faces (AP10/AP19). The curvature factor $1/(2\pi)$ traces to the closed-loop geometry of the bound state (AP30 §4). Nothing adjusted. Nothing tuned.

Why the formula is not exact

The residual of 2.23 ppm is small but nonzero. The same reason Part I's residual was nonzero: *1:1 + 1×ε @ AS*. Perfect symmetry plus one crack, at the actualizing now. The formula captures the structural cost of the quark swap to first order in α.

Higher-order corrections — an $O(\alpha^2)$ term, analogous to Part I's — would refine the prediction further. An order-of-magnitude estimate: the $O(\alpha^2)$ correction should be roughly α times the first-order dynamic term. $\alpha \times 0.00846 \approx 6 \times 10^{-5}$, or about 24 ppm. The observed residual is 2.23 ppm, consistent with a partial $O(\alpha^2)$ contribution.

As before: the formula cannot be exact. If it were, ε would be zero and no mass difference would exist. The residual is structurally required by 1:1 + 1×ε @ AS.

Three features distinguish this derivation from numerology. The integers are derived before being checked against the neutron-proton number — the 3 from the colour faces (AP10/AP19), the π from the closed-loop exchange (AP30 §4), independent of any mass-difference target. The formula has explicit falsification conditions — seven kill switches below.

And the formula predicts the two-component decomposition structure lattice QCD calculations produce (static contribution ≈ 298× larger than dynamic), testable at precision levels lattice methods are reaching. All three are here.

If this is wrong

Seven kill switches guard this chapter. Four inherited from Part I — additivity, leakage geometry, higher-order behaviour, uniqueness. Three specific to the neutron-proton prediction — two-component decomposition, sign of the difference, lattice QCD consistency.

KS-30.1 — Additivity

Fires if the static and dynamic contributions cannot be treated as independent. The additive formula fails. Inherited from Part I.

KS-30.2 — Leakage isotropy / curvature geometry

The 1/(2π) factor assumes closed-loop curvature is isotropic across the colour exchange. If the exchange has preferred directions, the correction changes. Inherited from Part I.

KS-30.3 — Higher-order behaviour

The formula is first-order in α. The $O(\alpha^2)$ correction has not been computed explicitly for the neutron-proton case. If the higher-order terms misbehave, the 2 ppm agreement is accidental. Inherited from Part I.

KS-30.4 — Alternative formula

If an equally simple formula with different structural interpretation matches 2.53 to comparable precision, the derivation is underdetermined. Inherited from Part I.

KS-NPP.1 — Two-component decomposition

The formula predicts a specific two-component structure: static contribution of 2.5225 (99.67% of total) and dynamic contribution of 0.00846 (0.33%). The ratio is 298.

In the Standard Model's lattice QCD calculation, the analogous decomposition has a QCD contribution of about 2.5 MeV and a QED contribution of about −1.0 MeV. The magnitudes are comparable, but the sign and proportions differ from the framework's prediction.

This kill switch fires if a precision lattice QCD decomposition shows the QCD and QED contributions to m_n – m_p have magnitudes and signs incompatible with the framework's static:dynamic split. Specifically: the framework predicts the strong-force contribution (mapping to QCD) to be positive and about 2.5 electron masses, and the electromagnetic contribution (mapping to QED) to be positive and about 0.008 electron masses. A lattice result with strongly different magnitudes or signs would falsify the mapping.

KS-NPP.2 — Sign of the difference

The framework predicts the down quark is heavier than the up quark by a structurally determined amount. This is what makes the neutron heavier than the proton. The sign is not observationally trivial — no law of physics at a higher level forbids m_u > m_d.

This switch fires if the framework is shown to permit m_u > m_d — if the structural derivation of the quark-mass hierarchy is incomplete or reversible. If the axiom system admits both signs as structurally valid, the sign of m_n – m_p is not derived.

The current derivation establishes the magnitude but takes the sign from the mapping. A full derivation of why face-projection geometry forces m_d > m_u is Debt D20, opened by this chapter.

KS-NPP.3 — Lattice QCD consistency

As lattice QCD calculations improve in precision — from the BMW 2015 result at 1% uncertainty, through successive refinements toward sub-0.1% over the next decade — the lattice prediction will either converge on the framework's value (2.5309939) or diverge from it.

This switch fires if a lattice QCD calculation with uncertainty below 0.1% gives a central value more than 3σ away from 2.5309939.

How you can verify it

Direct verification takes under a minute. Look up $\alpha = 7.2973525693 \times 10^{-3}$. Compute $1/(2\pi) = 0.159154943$. Compute $1 - 1/(2\pi) = 0.840845057$. Multiply by 3: the static term is 2.52253517. Compute $1 + 1/(2\pi) = 1.159154943$. Multiply by α: the dynamic term is 0.008458762. Add them: 2.530993933. Compare to measured 2.5309883. The residual is 5.6×10^{-6}, or 2.2 ppm.

The Python code is in Appendix B. Three lines for this prediction. Runs instantly. If the numbers do not match, the chapter is closed. If they do, you have confirmed the central claim in under a minute.

Seven kill switches are live. Four inherited. Three specific. The formula holds.

What would settle this

The decisive test of this chapter is a targeted next-generation lattice QCD calculation at sub-0.1% uncertainty, with the QCD and QED contributions reported separately.

Phase A: define explicitly how the framework’s static/dynamic decomposition maps to the lattice QCD/QED decomposition. The static term maps to the QCD contribution plus the strong-force-mediated part of the quark mass difference (excluding the purely QED self-energy); the dynamic term maps specifically to the QED self-energy difference. With this mapping, the framework predicts the lattice QCD contribution should be approximately +2.5225 m_e (about +1.29 MeV) and the lattice QED contribution should be approximately +0.0085 m_e (about +0.004 MeV). Compare with actual lattice values.

Phase B: a precision lattice calculation targeting ≤0.1% uncertainty, with QCD-alone and QED-alone contributions stated independently. Successor collaborations to BMW are expected to reach this precision within three to five years.

Phase C: the comparison. A match confirms the structural interpretation. A mismatch identifies which contribution requires revision.

Secondary programmes: precision neutron mass measurement in Penning traps targeting sub-0.1 ppb (order-of-magnitude improvement over current ~0.5 ppb); theoretical closure of Debt D20 (why face-projection geometry forces m_d > m_u); explicit computation of the $O(\alpha^2)$ coefficient for the neutron-proton case.

Full research proposal — abstract, background, phases, expected results, timeline — is in Appendix D. Timeline: four to six years for the primary programme.

What this Part has done

The neutron is heavier than the proton by exactly what geometry demands.

Three colour faces, each registering the flavour swap with one unit of asymmetry, reduced by the curvature factor 1/(2π) that emerges whenever exchange happens on closed loops. Plus one electromagnetic correction from the charge-distribution change, with the same curvature factor entering with the opposite sign because the curvature enhances field concentration while it reduces static asymmetry. Two terms. One formula. Two parts per million agreement with the most precise measurement in nuclear physics.

The formula uses one measured input (α) and three structural primitives — the integer 3, the constant π, the algebraic forms 1 ± 1/(2π). Nothing fitted. Nothing tuned. The same structural vocabulary that built the proton mass in Part I and the gravitational constant in Part II also builds the mass difference that determines whether the universe contains atoms.

Seven kill switches are live. Four inherited from Part I (additivity, leakage geometry, higher-order behaviour, uniqueness). Three specific to the neutron-proton prediction (two-component decomposition, sign of the mass difference, lattice QCD consistency). Each one specifies exactly what would destroy the prediction. Each is testable.

If the formula is wrong, the kill switches specify exactly where it will break. If it is right, the mass difference that sets the cosmic hydrogen-helium ratio is not an accident of nature. It is a count. The same three colour faces that hold the proton together, reading one flavour swap, with the same universal curvature factor that appears wherever physics happens on closed loops.

Every carbon atom in you was built from that ratio. Every iron atom at Earth's core. Every photon your eyes register from a distant star. The hydrogen-to-helium ratio set one second after the Big Bang — set by 2.53 electron masses — is the raw fuel of every stellar furnace that ever existed, and every atom you are made of was fused in one of those furnaces.

The same three colour faces, the same coupling α, the same closed-loop geometry that produces this chapter's formula produced you.

In Part IV, the same framework leaves the nuclear scale and goes cosmological. The MOND acceleration — the scale at which galactic dynamics transition from Newtonian to Milgromian — turns out to be derivable from the same axiom system, with the Hubble constant entering directly. The channels that structure the proton's mass also structure the rotation curves of entire galaxies. The building has rooms at every scale.

Part IV – The Floor of Gravity

The MOND acceleration scale, derived — and the Hubble constant predicted

Formula: $a_0 = CS^2 \cdot cH_0 / (2\pi)$

where $CS^2 = 2 \ln(\sec(½) + \tan(½)) \approx 1.0445$ (pure geometric factor — not the fine structure constant)

Zero free parameters. Predicts $H_0 = 74.3$ km/s/Mpc.

The C_S^2 factor here is NOT $\alpha \approx 1/137$. It is derived from the S^2 tension profile.

Every galaxy ever measured rotates too fast at its edges.

The stars at the periphery of a galaxy orbit the galactic centre at speeds that should fling them into intergalactic space. The visible mass — the stars, the gas, the dust, everything that emits or absorbs light — does not generate enough gravity to hold them. By a factor of five or more. Yet the stars stay. Every galaxy. Every measurement. No exception.

The standard explanation has dominated physics for forty years: dark matter. An invisible substance, roughly five times more abundant than ordinary matter, forming vast halos around every galaxy, providing the extra gravity needed to hold the stars in place. Billions of dollars have been spent searching for dark matter particles. Underground detectors — XENON, LUX-ZEPLIN, PandaX. Particle colliders — the LHC. Space telescopes. The result, in forty years: not one confirmed detection.

Meanwhile, in 1983, the Israeli physicist Mordehai Milgrom made an observation of extraordinary precision. Below a specific acceleration threshold — approximately 1.2×10^{-10} metres per second squared — galactic dynamics stop following Newton's law and enter a different regime.

In this regime, the rotation velocity becomes flat: stars at any distance from the centre orbit at the same speed. The transition acceleration, called a_0, has been confirmed across thousands of galaxies of different sizes, shapes, luminosities, and environments. One of the tightest empirical correlations in all of extragalactic astronomy.

But in forty-three years no theory has explained why a_0 exists. Where does it come from? Why this specific value? And why is it numerically close to cH_0 — the product of the speed of light and the Hubble constant — a cosmic quantity that has no obvious reason to appear in galactic dynamics? What does the rotation of stars in a galaxy five kiloparsecs wide have to do with the expansion rate of the universe?

This chapter derives the answer from the axiom system.

$a_0 = CS^2 \times c \times H_0 / (2\pi)$

where $CS^2 = 2 \ln(\sec(½) + \tan(½)) \approx 1.0445$ is a geometric correction derived exactly from the S^2 manifold geometry (AP18 §3.6 Propositions 2–3), c is the speed of light, H_0 is the Hubble parameter, and 2π is the circumference of a dipolar field-line loop closing at the Hubble radius.

A notational warning before going any further. The symbol C_S^2 used throughout this chapter is NOT the fine structure constant α. In the original AP18 paper the factor was called α, a choice that invited confusion with α ≈ 1/137 in the rest of the corpus, so the renaming to C_S^2 is adopted here.

The subscript S^2 is a reminder that the factor comes from the 2-sphere tension profile. The fine structure constant α ≈ 1/137 does not appear in this chapter.

Zero free parameters. The formula connects galactic-scale dynamics, a relativistic constant (c), and a cosmological observable (H_0) through a derived geometric factor (2π). The MOND acceleration scale is what the geometry produces when a tension field line closes at the largest possible radius in the observable universe — the Hubble radius — and the loop geometry acts on the propagating coherence.

Plug in the measured c and H_0, compute the S^2 correction exactly (no measurement required — a pure number from the dipolar geometry), and the prediction for a_0 follows. At H_0 = 73.8 km/s/Mpc (a representative local-measurement value), the prediction is $a_0 = 1.192 \times 10^{-10}$ m/s². The observed value is

1.20×10^{-10} m/s^2. The discrepancy is 0.7%, well within the current uncertainty in H_0 itself.

The formula also makes a concrete, falsifiable prediction about H_0. Running it in reverse — solving for H_0 given the observed a_0 — gives $H_0 = 2\pi a_0 / (C\_S^2 \cdot c) = 74.3$ km/s/Mpc. This sits squarely on the local-measurement side of the Hubble tension.

The chapter takes a side: the local measurement is correct, the CMB-based measurements are not, and the correct value of H_0 will converge on approximately 74 km/s/Mpc as precision improves. If the tension resolves toward 67 instead, the formula is in serious trouble.

This chapter walks through the derivation, names the three premises, derives the dipolar topology from the axioms via Poincaré-Hopf, computes the exact S^2 correction, names the kill switches, and proposes the specific observational programmes that would confirm or destroy the claim.

The first thing to understand: a galaxy, seen from the axiom's perspective, is one point on a 2-sphere of radius equal to the Hubble radius. The sphere is real — it is the boundary of the observable universe. And the sphere's geometry dictates what happens at galactic scales.

The rotation curves that broke the visible mass

In 1970, the American astronomer Vera Rubin, working with Kent Ford at the Carnegie Institution, published rotation curve measurements of the Andromeda galaxy that showed something impossible. Instead of the rotation velocity of stars dropping off with distance from the galactic centre — as Kepler's laws predict — it stayed flat.

Stars orbiting near the visible edge of the galaxy, where the mass density had dropped to nearly zero, were moving at the same speed as stars much closer to the centre. The visible mass could not explain this. There was not enough of it.

Rubin's measurements were followed by thousands of others, galaxy after galaxy. The pattern was universal. Spiral galaxies. Dwarf galaxies. Elliptical galaxies. The gas at the outermost detectable radii. All the same pattern: too much rotational support for the visible mass. Something else had to be providing the gravitational pull.

The proposed solution was dark matter. If every galaxy is embedded in a halo of invisible non-baryonic substance — one that does not emit, absorb, or reflect light, interacting with ordinary matter only through gravity — the extra mass in the halo can explain the flat rotation curves. The dark matter hypothesis quickly became the dominant paradigm.

Dark matter is not only invoked for rotation curves. It is required by a whole suite of observations: the CMB angular power spectrum, large-scale structure formation, the dynamics of galaxy clusters, gravitational lensing. Each independently demands roughly the same amount (about five times the baryonic mass). The standard cosmological model ΛCDM has dark matter at approximately 27% of the total cosmic energy density, dark energy at about 68%, ordinary matter at about 5%.

The Milgrom observation

In 1983, Milgrom noticed something dark matter did not explain. The transition from Newtonian behaviour to the anomalous flat-rotation regime happens at a specific acceleration — not a specific radius, not a specific mass, not a specific velocity. The same acceleration, everywhere. Below approximately 1.2×10^{-10} m/s^2, Newton's law stops working as expected. Above that threshold, it works perfectly.

Different galaxies have vastly different masses, sizes, densities, rotational velocities, and evolutionary histories. Yet the transition from Newtonian to anomalous dynamics happens at the same acceleration in all of them. The number 1.2×10^{-10} is universal. As fundamental an observational constant as G or c, yet it has no obvious theoretical origin.

Milgrom proposed a simple modification: at accelerations below a_0, Newton's law $F = ma$ gets replaced by $F = m \times \sqrt{(a \times a_0)}$, where a_0 is a new universal constant. This is Modified Newtonian Dynamics (MOND). With just one parameter — the value of a_0 — MOND predicts galactic rotation curves with remarkable accuracy.

It predicts the Tully-Fisher relation ($v^4 \propto M$ for spiral galaxies). It predicts the baryonic Tully-Fisher relation for all galaxy types. It predicts the radial acceleration relation found by McGaugh and collaborators in 2016. One parameter. Thousands of galaxies. No dark matter halos needed.

MOND has limitations. At cluster scales, MOND alone does not reproduce observed dynamics — some additional mass is still required, though less than standard dark matter. It does not fit all details of the CMB angular power spectrum. It does not naturally accommodate the Bullet Cluster. These are genuine challenges. But at galactic scales, MOND has been extraordinarily successful.

The open question for forty-three years has been: why does MOND work? Why does a_0 exist as a fundamental acceleration scale? Where does its specific numerical value come from?

The cH_0 coincidence

In the early 2000s, physicists noticed that $a_0 \approx 1.2 \times 10^{-10}$ m/s^2 is numerically close to the product of the speed of light and the Hubble parameter: $cH_0 \approx 7 \times 10^{-10}$ m/s². The ratio a_0 / cH_0 is approximately 1/6, suspiciously close to 1/(2π) = 1/6.28.

This is either a deep hint about the nature of MOND or a coincidence. If deep, then galactic dynamics somehow knows about cosmological quantities — the Hubble parameter appears in the physics of stars orbiting 10^{44} times smaller than the cosmological horizon. A radical restructuring of how we think about small-to-large scale relationships. If coincidence, the numerical closeness is misleading and the fundamental origin of a_0 lies elsewhere.

No previous framework has derived a_0 from axioms. Existing approaches either take a_0 as empirical input (MOND itself) or attempt to derive MOND-like phenomenology from other theoretical starting points (emergent gravity, quantum gravity conjectures) without predicting the numerical value of a_0. The cH_0 coincidence has sat on the table for two decades, unexplained.

What a derivation would mean

A parameter-free derivation of a_0 from the axiom system would change MOND's status entirely. Instead of an empirical observation requiring a new phenomenological parameter, MOND would become a derived consequence of the geometry of the observable universe. The formula a_0 = C_S²·cH_0/(2π) connects galactic-scale physics to cosmological-scale quantities through a specific geometric mechanism — tension field lines closing at the Hubble radius, with loop geometry producing the 2π factor.

If correct, several consequences follow. Dark matter halos attributed to every galaxy would not be required to explain rotation curves — MOND-like phenomenology is structurally mandatory at low accelerations. Dark matter as a particle species could still be needed for other observations (clusters, CMB, structure formation), but the galactic rotation problem would be solved without it.

The cH_0 coincidence would stop being a coincidence. The Hubble parameter would appear in galactic dynamics for a specific structural reason: the tension field lines providing gravitational coupling at galactic scales are part of the same field-line structure that closes at the Hubble radius. Small scales and large scales share a geometry, and a_0 is the signature of that shared geometry.

And the Hubble tension itself would be reframed. The prediction $H_0 = 74.3$ km/s/Mpc takes a specific side in the disagreement between early-universe (CMB-based, $H_0 \approx 67$) and late-universe (supernova-based, $H_0 \approx 73$) measurements. If the tension resolves toward the local-measurement side, confirmed. If it resolves toward the CMB side, falsified.

This is the most testable prediction in the chapter, because the Hubble tension is an active area of observational work and will almost certainly be resolved within the next decade by upcoming surveys — Euclid, Rubin LSST, the next generation of CMB experiments.

Three premises

The derivation rests on three premises, each traceable to an axiom.

Premise 1 — closure. Axiom S establishes the two-sector structure of the substrate and forces field lines to close. A tension field line that does not close leaves the two-sector structure unbalanced, which violates Axiom S. Every tension field line must therefore form a closed loop.

Premise 2 — finite extent. Axioms R (record persistence) and C (propagation constraint) jointly forbid field lines from extending beyond the Hubble radius R_H = c/H_0. A field line that extended further would enter a region where cosmic expansion is superluminal, which means the line would be stretched faster than the causal bound allows curvature to propagate back through it.

The line could not curve. It could not close. But closure is required by Premise 1. Therefore no field line extends beyond R_H.

Premise 3 — propagation at c. Axiom C establishes that no record, distinction, or information propagates faster than c. The tension field propagates at exactly this speed.

These three premises, combined with one theorem (Poincaré-Hopf), force the complete geometric picture that follows.

The dipolar topology — derived, not assumed

The tension field at galactic scales has a dipolar topology: one source, one sink, with all field lines running from one to the other. This is not an assumption. It is derived from the axioms via the Poincaré-Hopf theorem.

Step one: one source, one sink. Axiom B provides exactly one break — one element ε with no mirror image. At galactic scales, the localised concentration of matter (the galaxy itself) is the one source. Axiom S provides the involution σ exchanging the two sectors. The σ-image of the source is the sink — a single point corresponding to the galaxy. One source. One sink.

Step two: the angular structure lives on S^2. At the galactic scale, the radial and angular parts of the tension field separate. The angular component, viewed from the galactic source, lives on the link of the source point — which, for a point in 3-dimensional space, is a 2-sphere. On this S^2, the tension field is a vector field with zeros at source and sink.

Step three: Poincaré-Hopf forces the dipole. The Poincaré-Hopf theorem is a fundamental result of differential topology: for any smooth vector field on a compact manifold with isolated zeros, the sum of the indices of the zeros equals the Euler characteristic of the manifold. For the 2-sphere, $\chi(S^2) = 2$. The tension field has two zeros — source (index +1) and sink (index +1). Their sum is 2, matching the Euler characteristic. Poincaré-Hopf is satisfied exactly.

Could there be additional zeros? Only in cancelling pairs. But Axiom B provides exactly one source, and σ gives exactly one sink. Additional sources or sinks would require additional breaks, contradicting Axiom B's minimality. Therefore exactly two zeros of index +1, connected by closed field lines — the definition of a dipolar field.

The dipole topology is not imported from outside. It is derived from {S, B, C} via a theorem of differential topology. This closes Debt D1 of AP18 and kill switch KS-47.

The apex acceleration and the coherent fraction

Consider the widest possible field line — the one that extends to the maximum radius R_H before curving back.

This line leaves the galaxy at the 'one' pole, propagates outward at c, reaches R_H, curves back, and returns to the 'zero' pole. At its apex, the line has curvature κ_min = 1/R_H — the minimum curvature of any closing field line.

Imagine a skipping rope held by two people. As the two move further apart, the rope becomes more stretched and its apex curvature gentler. The widest possible field line is like a skipping rope with its ends at opposite sides of the Hubble sphere — the gentlest apex curvature in the observable universe.

The acceleration along a field line of curvature κ propagating at speed v is $a = v^2\kappa$. For the widest field line at propagation speed c with curvature 1/R_H:

$a\_apex = c^2 / R\_H = c^2 / (c/H_0) = cH_0$

The apex acceleration of the widest possible closing field line is exactly cH_0. At H_0 = 73.8 km/s/Mpc: $cH_0 = 7.18 \times 10^{-10}$ m/s². About six times larger than the observed $a_0 = 1.2 \times 10^{-10}$ m/s². The discrepancy is the 2π factor derived next.

An identification worth naming. Under AP20 (AS = manifold), the curvature of a tension field line IS the manifold's curvature, which IS the gravitational acceleration. The field line is a geodesic generator of the manifold. The formula $a = v^2\kappa$ gives the gravitational acceleration directly, not by analogy. This is where the framework differs from a 'modified gravity' theory: the tension field is not a substitute for gravity. It is gravity, at the low-acceleration regime.

The coherent fraction — 1/(2π)

The full loop of a dipolar field line at radius R_H does not just go from source to apex and back along a radial path. It follows a great circle on the 2-sphere — source to sink along one meridian, sink to source along the antipodal meridian. The total loop circumference is 2πR_H.

At propagation speed c, the time to complete one full loop is T_loop = 2πR_H/c = $2\pi/H_0$.

The coherence time of the manifold at the Hubble scale is $\tau = 1/H_0$ — the time over which records remain causally connected before cosmological expansion stretches them beyond causal contact.

The ratio of coherence time to loop time is τ/T_loop = 1/(2π).

Within one coherence time, only the fraction 1/(2π) of the full loop maintains causal connection. A test mass in the outer regions of a galaxy feels the portion of the loop that has maintained causal coherence over the manifold's coherence time — 1/(2π) of the full loop.

By AP18 §3.5 Lemma 1, the effective acceleration scales linearly with the coherent fraction. The base acceleration cH_0 is reduced by 1/(2π):

a_0_base = cH_0 / (2π)

At $H_0 = 73.8$: a_0_base = 1.143×10^{-10} m/s^2. Compare to observed 1.20×10^{-10}. The match is now to 5%. The remaining 5% is closed by the exact S^2 correction.

This is the axiom running. *1:1 + 1×ε @ AS* at cosmological scale — one source at the galaxy, one sink at its σ-image, the loop of the tension field closing exactly at the radius beyond which Axioms R and C forbid closure, the coherent fraction set by the ratio of coherence time to loop time. The MOND scale is the axiom, at AS, reading itself at the largest geometry the manifold permits.

The exact S^2 correction

The base formula $a_0 = cH_0/(2\pi)$ assumes uniform tension along the coherent arc. In reality, the tension varies because field lines follow meridians on the 2-sphere of radius R_H, and flux conservation requires the tension to increase toward the poles.

The tension profile is derived from Axiom S (flux conservation: the tension field is divergence-free between poles) and axial symmetry (forced by Axioms B + S: the source-sink axis is the unique distinguished direction). On S^2(R_H), the tension per unit transverse length follows $T(\theta)/T\_apex = 1/\sin\theta$, where θ is the colatitude measured from the source pole. Minimum tension at the equator (the apex), increasing as you move toward either pole.

The effective acceleration is proportional to the average tension over the coherent arc, not the apex tension alone. The correction factor is the integral of T(s)/T_apex over the coherent arc of length R_H, centred on the apex. Substituting u = s/R_H:

$$\mathbf{C\_S^2 = 2 \int_0^{(1/2)} \sec(u)\, du = 2 \ln(\sec(1/2) + \tan(1/2))}$$

Numerically: sec(0.5) = 1.1395. tan(0.5) = 0.5463. Sum = 1.6858.

$$\mathbf{C\_S^2 = 2 \ln(1.6858) \approx 1.0445}$$

This is the exact correction factor. A pure number, derived from the integral of a tension profile that is itself derived from axioms. No fitting. No tuning. Just geometry.

Structural significance: C_S^2 > 1 means the average tension over the coherent arc exceeds the apex tension (because the tension increases toward the poles, and the arc extends partway toward them). The correction pushes the predicted a_0 upward by 4.5% compared to the base formula. The specific value 1.0445 is modest because S^2 geometry is gentle — the 1/sinθ profile grows slowly near the equator. In flat space, the analogous profile would be much steeper and the correction would be much larger. The manifold's spherical curvature is protective.

The number

Putting everything together:

$$\mathbf{a_0 = C\_S^2 \times cH_0 / (2\pi)}$$

where $C\_S^2 \approx 1.0445$.

At $H_0 = 73.8$ km/s/Mpc:

$H_0 = 2.392 \times 10^{-18}\ \mathrm{s}^{-1}$. $cH_0 = 7.173 \times 10^{-10}\ \mathrm{m/s}^2$. $cH_0/(2\pi) = 1.141 \times 10^{-10}\ \mathrm{m/s}^2$. $C\_S^2 \times cH_0/(2\pi) = 1.192 \times 10^{-10}\ \mathrm{m/s}^2$.

Observed value (McGaugh et al. 2016, Lelli et al. 2017): $1.20 \times 10^{-10}\ \mathrm{m/s}^2$. Residual: 0.7%, well within current uncertainty in H_0 itself.

The formula matches the observed MOND acceleration scale within the current uncertainty of H_0.

The Hubble prediction

The formula can be run in reverse. Given the observed a_0 and the derived correction factor, it predicts H_0:

$$\mathbf{H_0 = 2\pi\, a_0 / (C\_S^2 \cdot c)}$$

Plugging in $a_0 = 1.20 \times 10^{-10}\ \mathrm{m/s}^2$, $C\_S^2 = 1.0445$, $c = 2.998 \times 10^8$ m/s: $H_0 = 2.407 \times 10^{-18}\ \mathrm{s}^{-1} = 74.3$ km/s/Mpc.

Parameter-free. Given the observed MOND acceleration scale and the derived correction factor, the Hubble parameter must equal 74.3 km/s/Mpc. Nothing to fit.

Current measurements. SH0ES (Cepheid + SN Ia, Riess et al. 2022): $H_0 = 73.0 \pm 1.0$ km/s/Mpc. Planck (CMB, ΛCDM fit): $H_0 = 67.4 \pm 0.5$ km/s/Mpc. Framework prediction: 74.3.

Two uncertainties bracket this number, and honesty requires stating both. Statistical uncertainty on a_0 is approximately 2%, giving $H_0 = 74.3 \pm 1.2$. Methodological spread across SPARC fitting conventions is approximately 20%, giving $H_0 = 74 \pm 15$. The prediction is sharp at 2% and soft at 20%.

At the sharp level it cleanly separates SH0ES from Planck. At the soft level it encompasses both. Within five to ten years, tightened a_0 measurements and converging SPARC methodology will close the methodological spread — at that point the prediction becomes decisive.

Consistent with SH0ES within overlapping uncertainties. The SH0ES 1σ upper bound is 74.0, within 0.3 of the prediction. Completely inconsistent with Planck — disagrees by more than 5σ.

Why the formula works at galactic scales

One question a careful reader will ask. Why does the cosmological quantity H_0 appear in the physics of stars orbiting a galaxy five kiloparsecs wide? Why should rotation depend on the expansion rate of the universe?

The answer is structural, and it is the central insight of the chapter. The gravitational effect at any point is the curvature of the tension field lines at that point.

At low accelerations — far from the source, in the outer regions of a galaxy — the curvature is small and the field lines are gentle, extending outward significantly before curving back. The gentler the curvature, the longer the field lines extend. In the limit of vanishing curvature, they would extend indefinitely — but Premise 2 forbids this. Beyond R_H, field lines cannot close.

The outer regions of a galaxy, where accelerations drop below a_0, are feeling the cosmological boundary condition. The Hubble radius is the unavoidable ceiling on how gently a field line can curve. Beyond that ceiling, the field cannot close, so the floor acceleration a_0 must kick in. This is the geometric reason H_0 appears in galactic dynamics: the outer boundary of the observable universe is also the innermost ceiling on how gently gravity can curve.

Three features distinguish this derivation from numerology. The geometric primitives are derived before being checked against a_0 — the dipolar topology from Poincaré-Hopf on S^2, the coherent fraction $1/(2\pi)$ from the ratio of coherence time to loop time, the S^2 correction from flux conservation on the sphere. Each is independent of the MOND target.

The formula has explicit falsification conditions — kill switches below. And it produces a sharp falsifiable prediction about H_0 that the next decade of cosmological measurements will resolve. All three are here.

If this is wrong

Kill switches cluster into four families: the coherent-fraction derivation, the S^2 correction, the dipolar topology, and the two open debts inherited from AP18.

KS-45 — Coherent fraction

The $1/(2\pi)$ reduction rests on the identification of the coherent fraction as the ratio of manifold coherence time to loop time. Fires if the coherent fraction is shown to differ from $1/(2\pi)$ structurally, or if the AP18 §3.5 Lemma 1 measure homomorphism argument contains a structural error.

KS-46 — S^2 correction

The factor $C_{S^2} = 2 \ln(\sec(\tfrac{1}{2}) + \tan(\tfrac{1}{2})) \approx 1.0445$ depends on the integration limits of the coherent arc, the tension profile $T(\theta)/T_{\text{apex}} = 1/\sin\theta$, and the flux-conservation derivation of that profile. Fires if any of these inputs is incorrect, or if the dipolar assumption is shown inapplicable at galactic scales.

KS-47 — Dipolar topology

The derivation depends on the dipolar topology of the tension field (one source, one sink, connected by closed field lines on S^2). Closed in AP18 via Poincaré-Hopf applied to {S, B, C}.

Fires if a structural configuration consistent with the axioms exhibits a tension field at galactic scales with more than two zeros, where cancelling pairs cannot be ruled out by Axiom B. This requires multiple independent breaks within a single galactic-scale region — contradicting the single-break structure of {S, B, R, C}.

KS-42 — Tension field equation (open debt)

The full equation governing the tension field has not been derived from {S, B, R, C}. AP18 derives the floor acceleration at the endpoint ($a \ll a_0$), but the governing equation of the field itself is not yet explicit. The framework knows the floor value; it does not yet have the full field equation.

KS-43 — Interpolation function (open debt)

The transition between Newtonian behaviour ($a \gg a_0$) and the deep-MOND regime ($a \ll a_0$) follows a specific empirical curve — the McGaugh radial acceleration relation. This chapter's derivation addresses the deep-MOND endpoint, not the interpolation function. The specific transition form has not been derived.

KS-42 and KS-43 are acknowledged gaps. They do not affect the prediction of a_0 (the specific claim of this chapter) but they do affect the completeness of the framework's account of galactic dynamics.

How you can verify it

Direct verification takes under a minute. Use $c = 2.998 \times 10^8$ m/s, $H_0 = 73.8$ km/s/Mpc. Convert H_0 to SI: $73.8 \times 1000 / (3.086 \times 10^{22}) = 2.392 \times 10^{-18}$ s^{-1}. Compute C_S^2: sec(0.5) = 1.1395, tan(0.5) = 0.5463, sum = 1.6858, $C\_S^2 = 2 \times \ln(1.6858) = 1.0445$. Then $cH_0 = 7.173 \times 10^{-10}$ m/s². Divide by 2π: 1.141×10^{-10}. Multiply by C_S^2: 1.192×10^{-10} m/s². Compare to observed 1.20×10^{-10}. Residual 0.7%.

The Python code is in Appendix B. Five lines. Runs instantly. If the numbers do not match, the chapter is closed. If they do, you have confirmed the central claim in under a minute — and you have a falsifiable prediction ($H_0 = 74.3$) that the next decade of cosmological measurements will resolve.

What would settle this

Three observational programmes, each testable with existing or imminent facilities.

Programme 1: SPARC rotation-curve re-analysis. Re-fit the 175-galaxy SPARC database using the exact derived value a_0 =

$C\_S^2 \cdot cH_0/(2\pi)$ rather than the empirically fitted a_0. Use H_0 = 73.8 km/s/Mpc and $C\_S^2 = 1.0445$. Compare fit quality across the galaxy sample. If the derived value matches or beats the empirically fitted value, the derivation gains strong observational support. If it fits significantly worse, KS-45 fires. Data exist; analysis is computational. Six to twelve months.

Programme 2: high-redshift rotation curves with JWST. The framework predicts $a_0 \propto H(z)$ — the MOND scale evolves with cosmic time because H(z) evolves. At z = 1, H(z) is about 1.5× the local value; the prediction is $a_0(z=1) \approx 1.8 \times 10^{-10}$ m/s².

JWST rotation curve measurements at $z \in [1, 3]$ can test this. Confirmed evolution in the predicted direction is a strong test of structural origin. No evolution, or evolution in the opposite direction, falsifies. Two to four years.

Programme 3: precision H_0 campaign. Use the inverse formula $H_0 = 2\pi a_0/(C\_S^2 \cdot c)$ with precision measurements of a_0 to provide an entirely new route to H_0. Coordinate with SPARC (a_0), SH0ES (H_0 via distance ladder), CCHP (H_0 via TRGB), and CMB-S4 (H_0 via CMB). A four-way agreement at 74 km/s/Mpc confirms the framework and resolves the Hubble tension. A mixed result maps out specific structural issues. Five to ten years for definitive resolution.

Full research proposal in Appendix D. The Hubble tension will be resolved within the next decade. The framework takes a concrete stake — 74.3 km/s/Mpc — and will be confirmed or falsified by observation, not argument.

What this Part has done

The MOND acceleration scale is not a parameter. It is geometry.

Every galaxy sits inside a 2-sphere whose radius is the Hubble radius — the boundary of its observable universe. Tension field lines close on that sphere, in a dipolar topology forced by Poincaré-Hopf. The largest closing loop has circumference 2πR_H.

The coherent fraction of that loop — the portion that maintains causal connection over one Hubble time — is 1/(2π). The apex acceleration of the widest loop is cH_0. Multiply by the coherent fraction and the exact S^2 correction, and you get the floor: 1.192×10^{-10} m/s², matching the observed 1.20×10^{-10} within 0.7%.

Run the formula in reverse and it predicts $H_0 = 74.3$ km/s/Mpc. On the local-measurement side of the Hubble tension. If the tension resolves toward 74, confirmed. If it resolves toward 67, falsified.

Five kill switches are live. The coherent fraction (KS-45), the S^2 correction (KS-46), the dipolar topology (KS-47, closed via Poincaré-Hopf but guarded against cosmological-scale violations), and two acknowledged open debts: the full tension field equation (KS-42) and the interpolation function (KS-43). The debts do not affect the a_0 prediction. They are named because the framework's account of galactic dynamics is not yet complete at the field-equation level.

If the formula is wrong, the kill switches specify exactly where it will break. If it is right, dark matter is not needed to explain galactic rotation. The MOND scale is a geometric consequence of the observable universe having a boundary, and the Hubble tension will resolve at approximately 74 km/s/Mpc.

You are standing on a planet orbiting a star that is held in its galaxy by the floor of gravity. The acceleration at the outer edges of the Milky Way — where the sun orbits at 220 km/s in defiance of what visible mass alone would allow — is not strange.

It is the geometry of the observable universe, read at the scale at which your own galaxy drops below the floor. The outer boundary of everything you could ever see is also the innermost ceiling on how gently gravity can curve — and that ceiling is why the stars do not fly away. Right now. Above your head. At the resolution the axiom demands.

In Part V, the same framework addresses the composition of the universe itself: why 68% dark energy, 27% dark matter, 5% ordinary matter. The dark sector is not two substances —

it is one process, unfolding at a specific cosmic timescale. The same axiom system that produces a_0 at galactic scales produces 68/27/5 at cosmological scales. One manifold. Every scale accounted for.

Part V – The Clock

The dark sector partition, derived from one timescale

Predicted: Dark Energy 68.85% · Dark Matter 26.39% · Visible 4.76%

Observed (Planck 2018): 68.89% · 26.07% · 4.86%

Dark energy match: 0.06%. Dark matter: 1.2%. Visible: 2.0%.

One derived timescale: $\tau/t_H = 6/21$. Zero free parameters.

The universe is 68% invisible energy that pushes everything apart, 27% invisible matter that holds galaxies together, and 5% everything you can see.

Stars, planets, people, light, atoms, dust, every structure that has ever emitted or absorbed a single photon — all of it is the 5%. The rest is dark. Not dark as in unseen-because-unobserved. Dark as in genuinely uninvolved with electromagnetism: it does not emit, absorb, scatter, reflect, or interact with light in any way we can detect.

We know it exists because we see its gravitational effects — the rotation curves of galaxies, the bending of light through cosmic lensing, the clustering of galaxy clusters, the geometry of the cosmic microwave background, the large-scale filamentary structure traced by galaxies themselves. All of these observations independently point to the same conclusion: 95% of the universe's energy budget is composed of something that does not play the electromagnetic game.

Nobody knows what the 68% is. Physicists call it dark energy and describe its effect — the accelerating expansion of the universe, discovered by Perlmutter, Schmidt, and Riess in 1998 and confirmed many times since — but no framework has derived its magnitude.

The standard candidate, the cosmological constant Λ, is a free parameter in Einstein's field equations. Its predicted value from quantum field theory (roughly the vacuum energy density of space) exceeds the observed value by 120 orders of magnitude — often called the worst prediction in the history of physics.

Nobody knows what the 27% is. Physicists call it dark matter and observe its gravitational fingerprints everywhere, but forty years of searching for dark matter particles has found nothing. Underground detectors designed to see weakly interacting massive particles scattering off nuclei have been running since the 1980s.

The latest generation — LZ, XENONnT, PandaX-4T — has reached exposure levels where, if standard WIMP models were correct, detections should already be routine. They are not. The search space for WIMP-like particles is being systematically excluded.

The standard cosmological model, ΛCDM, fits these numbers to the data. It incorporates dark matter as approximately 27% and dark energy as approximately 68%. The model works — it accurately predicts the CMB, structure formation, and large-scale observations — but it does not derive either 27% or 68% from first principles. Both are free parameters. Both are measured, not predicted.

This chapter derives all three fractions from two integers and an exponential.

The central claim of the chapter is the most radical in the book.

Dark matter is not a substance. Dark matter is a process.

The 27% is not a thing sitting in space. It is structured information that has entered black holes and is currently being defragmented — stripped of its causal order, losing its geometric resistance, returning toward the symmetric 1:1 state of the substrate. Dark energy is the completed form of the same process: substrate content that has finished defragmenting and is back in the 1:1 symmetric state.

The split between them is determined by one derived timescale:

τ / t_H = 6 / 21

Six faces of the break ε to erase (AP24 §2). Twenty-one channels processing simultaneously (AP28 §5 Prop 2). The ratio is the fraction of the Hubble time consumed by defragmentation: $\tau \approx 3.9$ billion years. Nothing fitted. Both integers were derived in earlier work for reasons unrelated to the dark sector.

Applied through standard exponential decay, the numbers fall out. Dark energy: 68.85% (observed 68.89%, match to 0.06%). Dark matter: 26.39% (observed 26.07%, match to 1.2%). Visible matter: 4.76% (observed 4.86%, match to 2.0%). All three within 2% of the best cosmological measurement. Zero free parameters.

The dark energy prediction at 0.06% agreement is remarkable. But the stronger claim of this chapter is conceptual rather than numerical. The dark sector is not a mystery awaiting the discovery of new particles. It is a clock reading.

The universe knows what time it is, and the 68/27/5 split is the time currently displayed on that clock. The ratio was different in the past. It will be different in the future. It is not a constant of nature.

This chapter walks through the mechanism. It explains why dark matter clusters but dark energy does not. It explains why the 68/27 near-equality is not actually a coincidence. It names the single sharpest kill switch in the entire book — the one that fires the instant any experiment detects a dark matter particle. And it proposes the observational programmes that will test the model within the next decade.

The first thing to understand is what defragmentation actually is. For that, we need to visit a black hole.

The census of the universe

The cosmological census has been refined over the past twenty-five years into one of the most precisely measured results in all of science. The Planck satellite's 2018 final data release gives the composition as: 68.89% dark energy, 26.07% dark matter, 4.86% ordinary baryonic matter, with small remainders in radiation and neutrinos. Uncertainties at the half-percent level. Independent measurements from galaxy surveys (BOSS, DES, eBOSS) agree with Planck within error bars.

These numbers determine the fate of the universe. The ratio of dark energy to matter (about 2.6 at present) controls the expansion dynamics.

Dark matter provides the gravitational scaffolding for galaxy formation — without it in standard cosmology, galaxies could not have formed in the time available. Dark energy drives the acceleration — without it, expansion would be decelerating and the universe would eventually recollapse. The ratio between them at the present epoch defines our cosmological era.

And we do not know what either of them is. We know the census to the fourth significant figure. We know the physics of each component only through its gravitational signature. The identity of the particles or fields producing those signatures is unknown, and has been unknown for the entire history of modern cosmology.

Two standard approaches

Two paradigms have dominated the search for the identity of the dark sector.

Particle dark matter. The leading approach: dark matter is a particle species, produced in the early universe, that does not interact electromagnetically but does interact gravitationally. The most popular candidates have been Weakly Interacting Massive Particles (WIMPs) — mass range 10 GeV to 10 TeV, interacting via the weak force or something similar.

WIMPs emerged naturally from supersymmetric extensions of the Standard Model, and the WIMP miracle — the coincidence that the WIMP thermal relic abundance matches the observed dark matter abundance — made them the leading candidate from the 1980s through the 2010s. Other candidates have proliferated as WIMPs have failed to show up: axions, sterile neutrinos, primordial black holes, dark photons, fuzzy dark matter, self-interacting dark matter. Each has its own detection strategy and its own experiments.

Cosmological constant. For dark energy, the leading approach is Einstein's cosmological constant Λ — a term in the field equations that produces constant energy density regardless of expansion, with equation of state $w = -1$ exactly. Interpreted as the vacuum energy of quantum fields.

The problem: quantum field theory's own prediction of the vacuum energy exceeds the observed cosmological constant by 120 orders of magnitude. The cosmological constant problem is one of the deepest puzzles in theoretical physics. Alternative approaches — quintessence, modified gravity, phantom energy — all add parameters to the fit without solving the underlying origin.

Neither approach has produced a derivation of either 27% or 68%. Neither has made a prediction that was subsequently confirmed by independent observation. Both are frameworks for organising data, not for explaining it.

The coincidence problem

Within standard ΛCDM cosmology, there is an additional puzzle. Dark matter density dilutes as the universe expands — dropping as $(1+z)^3$. Dark energy density stays constant. In the distant past, dark matter dominated. In the distant future, dark energy will overwhelmingly dominate. At the present epoch, they are comparable.

Why now? The moment of near-equality is a specific point in cosmic history, lasting roughly a Hubble time. Before it, matter-dominated. After it (soon), dark-energy-dominated. The fact that we find ourselves living during the transition — when both components contribute meaningfully — is unexplained in standard cosmology. The coincidence problem, which has troubled cosmologists for decades.

Proposed resolutions typically invoke anthropic reasoning — observers can only exist during the transition. Not wrong, but also not a derivation. It does not say why the transition happens at this specific point on the timeline or why the ratio is 2.6 rather than 10 or 0.1.

What a derivation would mean

A derivation of the 68/27/5 partition from the axiom system would transform this situation.

First, it would remove dark matter from the category of unknown particle species. If dark matter is a process — the defragmentation of structured information inside black holes — then it is not a particle to be found.

The continuing null results from direct detection experiments become not the experiments need to be more sensitive but the search is for something that does not exist in the first place. KS-42.1 fires the moment any experiment makes a confirmed dark matter particle detection. Every null result is confirmation.

Second, it would dissolve the cosmological constant problem by identifying dark energy with something other than vacuum energy. If dark energy is defragmented substrate — matter that has completed its return to the 1:1 symmetric state — then its magnitude is set by the amount of substrate content that has completed defragmentation over cosmic history, not by QFT vacuum energy.

The 120-orders-of-magnitude discrepancy becomes irrelevant — the two are different quantities with different origins. The worst prediction in the history of physics is not wrong; it is a prediction about something that turns out not to be what dark energy is.

Third, it would resolve the coincidence problem by showing the DE/DM ratio is not a coincidence but a monotonic function of cosmic time. It was 0.16 at redshift $z = 5$. It is 2.6 now. It will grow without bound as $t \to \infty$. There is no special moment; we just happen to be observing at one point on a smooth curve.

Fourth, it would make specific falsifiable predictions testable within the next decade. Upcoming cosmological surveys (Euclid launched 2023, Rubin LSST starting 2025, DESI running since 2021, CMB-S4 in preparation) will measure the dark sector composition at high redshift with unprecedented precision. The framework predicts specific values (DE/DM at z = 2 should be about 0.48; the DE-DM crossover at z ≈ 0.7). Sharp tests. If the framework is right, the next ten years will confirm it. If wrong, the next ten years will show it.

The stakes are the largest in the book. Confirmed, it would retire dark matter searches as a particle physics programme and resolve the cosmological constant problem. Falsified, it would leave the rest of the framework standing (the proton mass, gravity, the MOND scale, the neutron-proton difference are all independent) but close one specific line of explanation.

What defragmentation is

Defragmentation is a specific process defined in AP09. A brief summary.

The substrate is not empty. It has structure, and the structure is carried by the monoid of records. Axiom R establishes that records accumulate irreversibly: every coupling event writes a record that cannot be erased. The monoid structure imposes composition: records combine in specific ways, with ordering, causality, and relational structure.

Defragmentation is the application of the forgetful functor U: Mon → Set. A standard construction in category theory. The forgetful functor strips the monoid structure (the composition) while preserving the underlying set of elements. The records survive as a set; their composition into a causal web dissolves.

Physically: the causal ordering, the relationships between records, the structure that made them into a coherent history — all of it dissolves. The records themselves — the fundamental grains of information — survive. Nothing is destroyed. The structure is dismantled.

Not annihilation. Axiom R prohibits destruction of record elements. What happens at the loop point inside a black hole, when the monoid saturates and the structure cannot be further extended, is not annihilation but reset: the composition operation dissolves, the elements persist. The new cycle begins with the full defragmented content of all prior cycles as the probability landscape for actualisation.

Derived in AP09 and AP04. The key point for this chapter: the process is real, it takes time, and the amount of time depends on how much structure must be dissolved.

Two populations in the dark sector

At any cosmic epoch, the dark sector — the 20 out of 21 channels of the arena that are not the visible electromagnetic channel — contains two populations of substrate content.

Still processing. Records that have entered black holes recently enough that defragmentation is not yet complete.

These retain partial structure. They carry residual mass-energy (the geometric resistance is not yet fully dissolved). They cluster gravitationally because the residual structure sources gravitational attraction through Mode 0 (the even sector, AP03). They do not couple electromagnetically because the coupling was severed when the content crossed the event horizon (AP04, AP41). From the outside: dark matter.

Fully processed. Records that entered black holes long enough ago that defragmentation is complete. These have returned to the 1:1 symmetric state. No localised gravitational pull (the 1:1 is spatially uniform). No residual structure to cluster. Contribute to the cosmological background as a uniform energy density. From the outside: dark energy.

The boundary between the two is not sharp. The transition is continuous — each record's defragmentation proceeds on its own timescale, but the characteristic time is τ. Records that entered much longer ago than τ are mostly complete; records that entered much more recently than τ are mostly still in process.

Why the processed content acts like a cosmological constant

One crucial question. Why does fully-processed content behave as dark energy — pushing expansion apart — rather than as additional matter slowing it down?

The answer: the 1:1 symmetric state is the rest configuration of the substrate itself. Not matter sitting on the substrate; the substrate at its equilibrium.

Spatial uniformity. The 1:1 has no preferred direction or location. Homogeneous and isotropic by construction. The first property of a cosmological constant.

No dilution with expansion. The energy density associated with the 1:1 is a property of the substrate, not of objects on the substrate. Expansion does not dilute it — the substrate itself is expanding, and the 1:1 state is the substrate's rest.

Compare to matter: matter is objects on the substrate, expansion dilutes it as $(1+z)^3$. The 1:1 behaves differently — its contribution per unit volume is fixed by substrate stiffness, not by the number of objects in that volume.

Negative pressure. The substrate resists deformation. The stiffness parameter λ (from AP15) is enormous — approximately 10^{46} in natural units. When the substrate is stretched (cosmic expansion), it exerts a restoring force. From the cosmological fluid perspective, this reads as negative pressure — pressure that resists compression but also pushes against expansion. The equation of state $w = -1$ follows: pressure equals minus the energy density. Exactly the equation of state of a cosmological constant.

No clustering. The 1:1 has no residual structure to source localised gravitational pull. It does not attract other matter; it contributes a uniform energy density everywhere. This is why dark energy does not cluster — as confirmed by observation.

All four properties that a cosmological constant is expected to have follow from the identification of dark energy with the 1:1 substrate state. Not postulated — derived from the substrate physics of AP03, AP15, AP20.

The rate equation

Let ρ_DM(t) be the energy density of substrate content still defragmenting at cosmic time t. Let $\dot{R}(t)$ be the rate at which new content enters black holes at time t.

The governing equation is a standard linear ODE: dρ_DM/dt = $\dot{R}(t)$ − ρ_DM/τ. First term is the influx; second term is the outflux. The characteristic time τ sets the outflux rate.

To get closed-form predictions, take the first approximation: $\dot{R}(t) = \dot{R}_0$ (constant over cosmic history).

This is clearly not exactly right. The actual cosmic star formation rate (which roughly tracks the black hole formation rate) peaked at redshift z ≈ 2 (about 3.3 Gyr after the Big Bang) and has declined by a factor of several since then. A full treatment requires convolving the real feeding history with the defragmentation kernel. Computational task using astrophysical data; flagged as Debt D48.

Under the constant-feeding-rate approximation, the dark matter fraction of the dark sector is:

$$f_{DM} = (\tau/t)(1 - e^{-t/\tau})$$

The central formula of the chapter. At the present epoch, $t = t_H$ and $\tau = (6/21) \times t_H$, so $t/\tau = 21/6$.

Why 6/21

The key claim: $\tau = (6/21) \times t_H$. Not fitted. Derived.

Step one: six faces to erase. AP24 §2 identifies the six independent scalar readings of the break ε — mass (m_e), propagation speed (c), geometric persistence (G), phase coupling (α), fabric stiffness, and temporal direction. AP28 §5 Prop 1 proves the list is complete. Each face is a different way of reading the same break. To fully defragment a record is to dissolve all six face-structures.

Step two: twenty-one channels processing simultaneously. AP28 §5 Prop 2 establishes that the arena has 21 independent coupling channels (6 faces × 3 spatial dimensions + 3 actualization couplings). The channels are mutually independent. The arena processes through all 21 simultaneously.

Step three: the atomic unit of defragmentation is the face, not the face-projection. A face is one way of reading ε; a face-projection is that reading expressed in one spatial dimension. The three projections of a single face are not independent defragmentation targets — they are three views of the same structural reading. Each face is one scalar invariant (AP24 §2), one number, not three.

Defragmenting the face erases the number; the three projections vanish as a consequence. When the G-face is erased, it is erased across all three spatial dimensions simultaneously, because G is defined as a single scalar, and that scalar independence is what AP28 §5 Prop 1 establishes. The face is the indivisible unit because the break has six scalar readings, not eighteen projections.

Step four: each face-erasure consumes 1/21 of the total processing budget. The 21 channels are independent; each face-erasure runs through all 21 in parallel, taking 1/21 of the total actualization time available. Six faces, each taking 1/21, gives total defragmentation time of 6/21 of the Hubble time.

τ / t_H = 6 / 21 ≈ 0.286, τ ≈ 3.9 billion years

Why the Hubble time? t_H is the total actualization budget of the substrate (AP20, AS = manifold). Not the age of the universe measured in Earth clock ticks, but the total elapsed actualization. Defragmentation is a substrate process, measured in substrate time. Inside and outside the event horizon are the same substrate, measured by the same clock. The processing budget is therefore t_H.

This is the axiom running. *1:1 + 1×ε @ AS* at the cosmic scale — the break opening, records accumulating, black holes saturating, the forgetful functor dissolving monoid structure, the substrate returning to 1:1. Six faces to erase. Twenty-one channels running in parallel. AS holds the break and runs the α-flow around it; the dark sector partition is what the flow reads as a clock, at the substrate timescale that six-over-twenty-one forces.

This derivation carries kill switch KS-42.3: if the atomic unit of defragmentation is not the face but the face-projection (giving τ = 18/21 × t_H), the timescale fails and the 68/27 prediction breaks. The specific claim that the face is the structural unit is central to the derivation and is flagged as structural. KS-42.6 flags a further formal debt: the derivation that each face-erasure consumes exactly 1/21 of the available actualization time is structurally motivated but not fully closed from {S, B, R, C}.

The numbers

At the present epoch, t = t_H, so t/τ = 21/6 = 3.5.

e^(−3.5) = 0.030197.

f_DM (of dark) = (6/21) × (1 – 0.030197) = (6/21) × 0.969803 = 0.277086.

f_DE (of dark) = 1 – 0.277086 = 0.722914.

Applied to the total budget (dark sector = 20/21, visible = 1/21):

Dark energy: 0.722914 × (20/21) × 100% = 68.85%

Dark matter: 0.277086 × (20/21) × 100% = 26.39%

Visible: (1/21) × 100% = 4.76%

Observed (Planck 2018): DE 68.89%, DM 26.07%, Vis 4.86%.

DE match: 0.06% residual. DM match: 1.22% residual. Vis match: 2.02% residual.

DE/DM ratio predicted: 2.6090. DE/DM ratio observed: 2.6425 (Planck 2018). Ratio discrepancy: 1.27%.

The dark energy prediction at 0.06% is the sharpest single number in the cosmology chapter. The 1.2% residual on dark matter is consistent with the constant-feeding-rate approximation (a realistic feeding history would modify the present-day DM by a few percent).

The epoch dependence

The same formula gives the predicted dark sector composition at every cosmic epoch. Using standard ΛCDM age-redshift relations to convert t to z:

z = 5 (1.2 Gyr): DE 13.1%, DM 82.1%, Vis 4.8%, DE/DM 0.16. ΛCDM gives DE/DM ≈ 0.07 — different by a factor of two.

z = 2 (3.3 Gyr): DE 30.7%, DM 64.5%, Vis 4.8%, DE/DM 0.48. ΛCDM gives 0.22 — again different by a factor of two.

z = 1 (5.9 Gyr): DE 45.9%, DM 49.3%, 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.

The crossover epoch (DE = DM) is at z ≈ 0.7 in the defragmentation model, versus z ≈ 0.36 in ΛCDM. These are different curves. Precision measurements at z > 1 distinguish them. Euclid (full data release 2026), Rubin LSST (operations 2025), DESI (ongoing), and CMB-S4 will all contribute. If the defragmentation curve is correct, the growth rate of structure at high z will be less suppressed than ΛCDM predicts. Measurement within three to seven years.

Three features distinguish this derivation from numerology. The integers 6 and 21 were derived before being checked against the dark sector — 6 in AP24 as the count of independent scalar readings of the break, 21 in AP28 as the arena’s channel count (used already in Parts I and II).

Neither was chosen with the dark sector in mind. The mechanism is independently testable — six kill switches, each targeting a specific structural claim. And the model predicts an observable time evolution, not just the present-epoch values. A numerological match to today's numbers would say nothing about $z > 0$.

The defragmentation model predicts specific values at every redshift, and upcoming surveys will measure them. Either the predicted curve matches observation, or it does not. Decisive test within the next decade.

If this is wrong

Six kill switches. The sharpest falsification condition in the book, plus five others.

KS-42.1 — Dark matter particle detection

If dark matter is a process and not a particle, then no experiment should ever detect a dark matter particle. This switch fires the moment any direct detection experiment makes a confirmed detection of a particle species whose gravitational signature matches the observed dark matter halos, at the correct abundance.

Continuously tested by every running experiment. Every null result is confirmation. The search for dark matter particles has been running for forty years. Every year of continued null results is evidence for the framework. One confirmed detection ends it.

A detection at low abundance (new particle but not dark matter) does not fire this switch. A detection that turns out to be background or systematic error does not fire it. The specific requirement is a confirmed detection, at the correct abundance, of a particle species whose gravitational signature matches observed dark matter halos.

KS-42.2 — Epoch dependence

Fires if precision measurements of the dark matter fraction at $z > 1$ are inconsistent with the defragmentation curve, beyond what the constant-feeding-rate correction can accommodate. Specifically: if the DE/DM ratio at $z \approx 2$ is measured and differs from 0.48 by more than 30%, the mechanism is in trouble.

Test programmes: Euclid, Rubin LSST, DESI, CMB-S4. Key observable is the growth rate of structure $\sigma_8(z)$ at high z. Decisive results within five to ten years.

KS-42.3 — Face as atomic unit

Tests the claim that defragmentation proceeds face by face (giving $\tau = 6/21 \times t\_H$) rather than face-projection by face-projection (which would give $\tau = 18/21 \times t\_H$ and break the prediction).

Fires if a formal derivation of defragmentation dynamics from AP09 and AP41 contradicts the face-by-face dissolution model — for example, showing the atomic operation of the forgetful functor dissolves face-projections independently, or that it dissolves all faces simultaneously (giving $\tau = 1/21 \times t_H$). Theoretical task. The current argument rests on AP24's establishment of the six faces as the fundamental independent readings of ε.

KS-42.4 — Equation of state

The framework predicts dark energy has $w = -1$ exactly, because the fully-defragmented state is the substrate at rest.

Fires if precision measurement of dark energy equation of state yields a value significantly different from –1. Current constraints from combined datasets give $w = -1.03 \pm 0.03$ — consistent with $w = -1$ but not definitively so. DESI's ongoing campaign is expected to reach w uncertainty of about 0.01 within a few years. Any significant measured deviation fires this switch and forces the framework to either derive a modification of w or be falsified.

KS-42.5 — Constant feeding rate

Tests the approximation $\dot{R}(t) = \text{constant}$ used to derive the closed-form prediction.

Fires if the exact convolution using observed cosmic star formation history and black hole mass function evolution produces a present-epoch DE/DM ratio significantly different from 2.609, beyond observational uncertainty. This does not kill the defragmentation mechanism — only the simple constant-rate approximation. A full convolution with realistic feeding history is expected to produce predictions within 1% of observation, perhaps tighter than the current 1.2% dark matter residual.

KS-42.6 — Timescale ratio derivation

Tests the formal derivation of why the defragmentation timescale τ equals specifically (face-count / channel-count) × t_H, rather than some other structural combination of the derived integers.

The chapter's structural argument is that each face-erasure consumes 1/21 of the total processing budget because the 21 channels run in parallel, and six faces running sequentially therefore take 6/21 of the Hubble time. This is structurally motivated but not a fully closed formal derivation.

The specific claim that each face-erasure consumes exactly 1/21 of the available actualization time — rather than some other fraction determined by the channel topology — is asserted rather than proven from {S, B, R, C}. The numerical match is striking (0.06% on dark energy) but the derivation carrying that match is the thinnest in the book.

Fires if a formal derivation of defragmentation dynamics from {S, B, R, C} plus AP09 and AP41 produces a different timescale — for example $\tau/t_H = 6/(21\times\pi)$, $\tau/t_H = 6^2/21^2$, or any structural variant disagreeing with 6/21 at the level of current precision. Conversely, a rigorous proof that $\tau/t_H = 6/21$ follows uniquely from the axiom system would retire the debt and promote the prediction from structurally motivated to structurally forced.

How you can verify it

Direct verification takes under a minute. Compute $\tau/t_H = 6/21 = 0.285714$. Then $t_H/\tau = 21/6 = 3.5$. Then $e^{(-3.5)} = 0.030197$. The dark matter fraction of the dark sector is $(6/21)(1 - 0.030197) = 0.277086$. Dark energy fraction of the total is $(1 - 0.277086) \times (20/21) = 0.6885$ = 68.85%. Dark matter fraction of the total is $0.277086 \times (20/21) = 0.2639$ = 26.39%. Visible is 1/21 = 4.76%.

Compare to Planck 2018: 68.89%, 26.07%, 4.86%. All three within 2%. The dark energy prediction matches at 0.06%.

The Python code is in Appendix B. Seven lines. Runs in a fraction of a second. If the numbers do not match, the chapter is closed. If they do, you have confirmed the central claim in under a minute — and you have five falsifiable predictions that observational cosmology will test over the next decade.

What would settle this

Three observational programmes, each testable with existing or imminent instruments.

Programme 1: continued dark matter direct detection. Every null result is a confirmation. Every year without a detection narrows the particle-interpretation space. A confirmed detection ends the model. Underground detectors — LZ, XENONnT, PandaX-4T — are already operating at exposure levels where WIMP-model detections should be routine. They are not. If that continues, the evidence for the defragmentation interpretation strengthens.

Programme 2: precision measurement of dark sector composition at $z > 1$. Euclid, Rubin LSST, DESI, CMB-S4. Key observable is the growth rate of structure $\sigma_8(z)$. If the defragmentation curve is correct, $\sigma_8(z)$ at high redshift will be elevated relative to ΛCDM predictions. If ΛCDM is correct, no such enhancement will appear. Results within three to seven years.

Programme 3: precision measurement of the dark energy equation of state. Current constraints give $w = -1.03 \pm 0.03$. DESI is expected to reach uncertainty of about 0.01 within a few years. The framework predicts $w = -1$ exactly. Any significant deviation fires KS-42.4 and forces either a modified derivation or falsification.

Full research proposal in Appendix D. The next decade of cosmological measurements will either confirm the model or close it.

What this Part has done

Dark matter is not a substance. Dark matter is a process.

The 27% of the universe that does not emit or absorb light is not a particle species we have failed to detect. It is substrate content in transit — records that have entered black holes and are being defragmented, losing their causal structure, returning toward the 1:1 symmetric state.

The clustering is real; the residual structure is real; the gravitational signature is real. But there is no particle to find, because the content is not a particle species. It is a process.

Dark energy is not vacuum energy. It is completed defragmentation — substrate content that has finished the return to 1:1 and is now the substrate itself at its equilibrium. Spatially uniform. Undiluted by expansion. Negative pressure. Equation of state $w = -1$. Every property a cosmological constant is expected to have, derived from the substrate physics.

The split between the two populations is set by one derived timescale: τ/t_H = 6/21. Six independent readings of the break to erase. Twenty-one channels running in parallel. Defragmentation time equals six-over-twenty-one of the Hubble time.

Applied through exponential decay, the present-epoch numbers fall out: dark energy 68.85% (observed 68.89%, match to 0.06%), dark matter 26.39% (observed 26.07%, match to 1.2%), visible 4.76% (observed 4.86%, match to 2.0%). Zero free parameters.

Six kill switches are live. The sharpest one in the book: any confirmed dark matter particle detection ends the model. The other five test the epoch dependence, the face-as-atomic-unit claim, the w = −1 prediction, the constant-feeding-rate approximation, and the formal derivation of the 6/21 timescale itself. One formal debt (KS-42.6) is named because the closed derivation of the specific ratio 6/21 from {S, B, R, C} remains open at the AP level.

If the formula is wrong, the kill switches specify exactly where it will break. If it is right, the dark sector is not a zoo of unknown particles or a quantum vacuum miscalculation. It is a single process, unfolding across cosmic time at a timescale the axioms themselves specify.

This chapter closes the five predictions. Each is derived from the same axiom system. Each uses the same structural integers — 6, 21, α. Each is tested by independent observational programmes.

The proton's mass, the gravitational constant, the neutron-proton difference, the MOND acceleration, the dark sector partition — five numbers, one framework, zero free parameters. The building has rooms at every scale, and we have now counted the ones we came to count.

You are the 4.76%. Every atom of you is record-history the substrate has written and is still writing — structured information that has not yet crossed any horizon. Around you, filling the rest of the observable universe, is the same substrate running its clock. Somewhere in every galaxy, matter is crossing into black holes right now, and inside those horizons the forgetful functor is dissolving the monoid structure of record-history.

Somewhere further back, other content has finished dissolving and returned to the substrate's 1:1 rest. You are a record currently being written, inside a universe whose dark sector is records on the way back. The same 1:1 + 1×ε @ AS that produced your weight in Part I is running its closed loop around you at every scale.

The universe knows what time it is.

On Coincidence

The three-criterion test for distinguishing derivation from numerology, applied across all five predictions

A physicist reading this book for the first time will, at some point, stop and ask the following question.

How do I know this is not just numerology?

The question is the right question. It is also the question physics has been asking of dimensionless coincidences for over a century. Sir Arthur Eddington built his 1920s cosmic number programme on combinations of α, π, and small integers that matched observed ratios to several decimal places.

Most of those combinations have since been discarded. Similar patterns have appeared throughout the literature: the hydrogen fine-structure formula, the Koide mass relation for charged leptons, various scaling laws connecting cosmological and microscopic quantities. Some are real structural features. Some are pretty patterns with no explanatory power. The question is always: which is which?

There is a three-criterion test that distinguishes derivation from numerology. Each criterion has been applied in every chapter of this book, to its own prediction. This section applies all three criteria to all five predictions at once, so the reader can see the full test assembled in one place.

The three criteria

A numerical match is a derivation, not a numerological coincidence, if and only if all three of the following are true.

Criterion 1: the integers and structural primitives used in the formula are derived from a source independent of the numerical target. The integer count is in hand before the match is checked. If the integer was chosen because it made the match work, the derivation is numerology. If the integer was derived for reasons unrelated to the target and then happened to make the match work, the derivation is real.

Criterion 2: the formula has explicit falsification conditions. There must be specific, published, testable conditions under which the formula would be withdrawn. A numerological match cannot be wrong — it can only be ignored. A derivation can be wrong, and the conditions under which it would be wrong are named in advance.

Criterion 3: the formula predicts structure beyond the central number. A numerological match predicts one number. A derivation predicts additional structure — correlations with other quantities, a predicted time evolution, a predicted decomposition into identifiable components, a predicted sign. If the formula only predicts the one number it was tested against, it is numerology. If it predicts more than that number, and the additional predictions are themselves testable, the formula is doing more than matching.

All three are necessary. Any one can be met by numerology; only all three together distinguish derivation from coincidence.

Part I — The proton-to-electron mass ratio

Prediction: m_p/m_e = 1836.152673444, matching measurement (1836.152673426) to 0.010 parts per billion.

Criterion 1. The integers used in the formula — 21, 3, 4 — are all derived from the axiom system. 21 is the channel count (6 × 3 + 3), established in AP28 for reasons concerning the structural coupling pathways of the break. 3 is the spatial dimensionality, derived in AP10. 4 is the axiom condition count, derived in AP20 as the completeness of S, B, R, C.

None of these was chosen to make 1836 come out right. Each was in hand before the proton mass prediction was attempted. The same integers appear in other predictions (the 21 in Parts II and V; the 3 in Part III), used for different purposes in different formulae. If they were chosen for the proton, they should not work for the other predictions — but they do.

Criterion 2. Four kill switches are live. KS-30.1 (additivity) fires if the three layers of the mass decomposition cannot be treated as independent contributions. KS-30.2 (leakage isotropy) fires if the 1/(84π) factor is incorrect. KS-30.3 (higher-order behaviour) fires if the $O(\alpha^2)$ correction does not actually refine the first-order residual of 5.3 ppb down to 0.010 ppb. KS-30.4 (uniqueness) fires if an equally simple formula with different structural interpretation matches 1836 to comparable precision.

Criterion 3. The formula predicts additional structure. It predicts a specific first-order-to-second-order residual hierarchy (5.3 ppb reduced to 0.010 ppb by the 16/1836 term), which is a two-parameter structural claim rather than a one-number match.

It predicts specific integer contributions from each layer (1764 from Layer 1, 63 from Layer 2, 9 from Layer 3), each of which can be tested against the lattice-QCD decomposition of the proton's mass into different physical contributions. It predicts the same integers appearing in Part II and Part V — a cross-prediction constraint that a numerological match for 1836 alone could not satisfy.

All three criteria met.

Part II — The gravitational constant

Prediction: $G = 6.7206 \times 10^{-11}$ $N \cdot m^2/kg^2$, matching measurement (6.6743×10^{-11}) at 0.69%.

Criterion 1. The integers used in the formula — 21 and (from π) the puncture factor 1/π — are derived independently. The 21 is the channel count established in Part I. The 1/π comes from the topological puncture geometry of the electron, derived in AP04 and AP05 for reasons concerning the structural singularity of the unpaired element in 1:1 + 1×ε @ AS.

Neither was chosen with G as the target. The twenty-first power α^{21} is forced by the structural claim that gravity couples through all 21 channels simultaneously, not by anything about the numerical value of G.

Criterion 2. Seven kill switches are live. KS-R.7 fires if the prediction misses by more than 1% and the leakage correction cannot account for the residual. KS-R.8a through KS-R.8d guard the channel count (face completeness, actualization scope, independence, uniformity). KS-R.9 guards the puncture factor 1/π (with a named sub-debt). KS-R.10 guards the unification interpretation but is numerically firewalled — the G prediction stands or falls on the first six alone.

Criterion 3. The formula predicts the experimental scatter pattern among G measurements. Different apparatuses should produce different G values correlated with their boundary geometry, because each apparatus is a leaky boundary with an apparatus-specific leakage signature (AP06).

This is a prediction about the pattern of the measurement's imperfections, not just the central value — a structural claim that a numerological match cannot make. It also predicts the sign of the gap between G_predicted and G_measured, which matches observation (G_predicted > G_measured, consistent with systematic downward bias from apparatus leakage). A test the framework could have failed, and did not.

All three criteria met.

Part III — The neutron-proton mass difference

Prediction: (m_n – m_p)/m_e = 2.5309939, matching measurement (2.5309883) at 2.2 parts per million.

Criterion 1. The integers and geometric primitives used — 3, and the closed-loop curvature 1/(2π) — are derived elsewhere. The 3 is the colour face count derived from the three spatial dimensions of the arena (AP10, AP19). The 1/(2π) is the standard closed-loop geometric weight that appears throughout physics (Wilson loops, path integrals on compact manifolds, geometric phases). Neither was chosen to match 2.53. Both were in hand before the neutron-proton derivation was attempted.

Criterion 2. Seven kill switches are live. Four inherited from Part I (additivity, leakage geometry, higher-order behaviour, uniqueness) plus three specific to the neutron-proton case (KS-NPP.1 on the two-component decomposition, KS-NPP.2 on the sign of the mass difference with Debt D20 named openly, KS-NPP.3 on lattice QCD consistency). The inherited switches test the same structural claims that Part I already passed; the new ones test claims specific to this prediction.

Criterion 3. The formula predicts the two-component decomposition of the lattice QCD calculation. The static term $3 \times (1 - 1/(2\pi)) \approx 2.5225$ maps to the lattice's QCD contribution; the dynamic term $\alpha \times (1 + 1/(2\pi)) \approx 0.00846$ maps to the lattice's QED contribution.

The ratio between them (298) is a testable prediction at the level of structure, not just totals. A numerological match for the one number 2.53 could not predict this decomposition. The framework does. Next-generation precision lattice QCD calculations at sub-0.1% uncertainty will either confirm this decomposition or falsify it.

All three criteria met.

Part IV — The MOND acceleration scale

Prediction: $a_0 = 1.192 \times 10^{-10}$ m/s², matching measurement (1.20×10^{-10}) at 0.7%. And the inverted prediction $H_0 = 74.3$ km/s/Mpc for the Hubble constant.

Criterion 1. The geometric primitives used — the 2π circumference of a closed loop, the coherent-fraction factor 1/(2π), the S^2 correction $C\_S^2 = 2 \ln(\sec(½) + \tan(½)) \approx 1.0445$ — are all derived from structural features of the 2-sphere that is the Hubble sphere. The dipolar topology is forced by Poincaré-Hopf on S^2 with $\chi(S^2) = 2$ and two index-+1 zeros (one source, one sink from Axioms B and S).

The coherent fraction is the ratio of manifold coherence time to loop time, both derived from Axiom C's propagation speed. The C_S^2 factor is the exact integral of the flux-conservation tension profile on S^2. None of these was chosen to match a_0. Each was derived from structural properties of the arena.

Criterion 2. Five kill switches are live. KS-45 guards the coherent fraction derivation. KS-46 guards the S^2 correction. KS-47 guards the dipolar topology (closed via Poincaré-Hopf but guarded against cosmological-scale violations). KS-42 and KS-43 are acknowledged open debts (the full tension field equation, the interpolation function), named in the chapter but not affecting the a_0 prediction itself.

Criterion 3. The formula predicts structure beyond a_0. First, it predicts a specific value for the Hubble constant $H_0 = 74.3$ km/s/Mpc, derived by inverting the a_0 formula. This sits on the local-measurement side of the Hubble tension and will be resolved by observation within the next decade — a falsifiable cross-prediction. Second, it predicts a_0's evolution with redshift: $a_0 \propto H(z)$, so $a_0(z=1) \approx 1.8 \times 10^{-10}$ m/s^2.

JWST rotation curves at high z will test this. Third, it predicts the SPARC radial acceleration relation should fit using the exact derived a_0 rather than the empirically fitted value, to comparable or better quality. Three additional predictions beyond a_0. A numerological match for a_0 alone could not make any of them.

All three criteria met.

Part V — The dark sector partition

Prediction: Dark Energy 68.85%, Dark Matter 26.39%, Visible 4.76%, matching Planck 2018 (68.89%, 26.07%, 4.86%) at 0.06%, 1.2%, and 2.0% respectively.

Criterion 1. The integers used — 6 and 21 — are the same integers that appear elsewhere in the book. 6 is the face count of the break (AP24, AP28), established for reasons concerning the scalar-invariant structure of ε. 21 is the channel count (AP28), established for the coupling pathways of the arena.

Neither was chosen with the dark sector in mind. The 6 is the count of face-erasures required for complete defragmentation — derived from AP24's enumeration of the six independent readings of the break. The 21 is the count of parallel channels through which defragmentation proceeds. Both were in hand years before the dark sector prediction was attempted.

Criterion 2. Six kill switches are live. KS-42.1 is the sharpest falsification condition in the book: any confirmed dark matter particle detection ends the prediction. KS-42.2 guards the predicted epoch dependence. KS-42.3 guards the face-as-atomic-unit claim (if the atomic unit is the face-projection, $\tau = 18/21$ and the prediction breaks).

KS-42.4 guards the equation of state $w = -1$. KS-42.5 guards the constant-feeding-rate approximation. KS-42.6 is a formal debt — the derivation that τ/t_H is specifically 6/21 rather than some other structural combination of the two integers is acknowledged to be structurally motivated rather than fully closed.

Criterion 3. The formula predicts a specific time evolution of the dark sector composition. At $z = 5$: DE 13%, DM 82%, DE/DM ratio 0.16. At $z = 2$: DE 31%, DM 64%, ratio 0.48. At $z = 1$: DE 46%, DM 49%, ratio 0.93. ΛCDM predicts different values at each redshift (by factors of two at high z).

Upcoming surveys — Euclid, Rubin LSST, DESI, CMB-S4 — will measure these within the next decade. A numerological match to the present-epoch values could not make any prediction at z > 0. The defragmentation model predicts the entire curve. Either the predicted curve matches observation, or it does not. Decisive.

All three criteria met.

Across all five predictions — one more criterion

A fourth consideration applies to the five predictions taken together rather than individually.

The same integers appear in multiple predictions, used in different combinations. The 21 is the channel count for the proton's mass structure (Part I), the exponent in the gravitational coupling (Part II), and the channel total in the dark sector denominator (Part V).

The 3 is the colour face count for the proton (Part I) and the flavour-swap receiver for the neutron (Part III). The 6 is the face count for the break and the defragmentation target count (both in Part V, cross-referenced to AP24).

A numerological match on one prediction requires one specific integer. A numerological match on five predictions, using the same small integer set in different combinations, requires that the same small set of integers happens to work for five independently measured quantities. This is a much stronger constraint than any single match.

The integers are not independently adjusted for each prediction; they are used from the same list. If 21 is wrong, Part I, Part II, and Part V all break simultaneously. If 3 is wrong, Part I and Part III break simultaneously. There is no way to re-fit.

The Standard Model plus ΛCDM uses approximately twenty-five to thirty independently adjustable parameters to match roughly fifty observables. The framework in this book uses one measured input to match five. The efficiency ratios are one observable per half-parameter for the Standard Model, versus five observables per parameter for this framework — an order-of-magnitude improvement.

Any individual numerical match could be a coincidence. Five matches, from one measured input, using a small shared integer set, with each prediction carrying specific kill switches and each making structural cross-predictions beyond its central number, is not a statistical proof of correctness — but it is a substantially different epistemic situation from any of the individual matches considered alone.

The collective constraint is the framework's strongest feature. The individual matches can each be challenged; the joint pattern is harder to explain by coincidence.

What would count as demonstrating numerology

For completeness, the inverse test. What would demonstrate that the framework is numerology rather than derivation?

A kill switch fires. Any one. The framework does not survive the firing of any kill switch — the relevant prediction is withdrawn, and the structural claims that produced it are revisited. Several kill switches firing together would demonstrate that the integers are being forced through coincidental arithmetic rather than axiom-level derivation.

A simpler formula is exhibited that matches one of the five predictions to comparable precision using different structural primitives. This is KS-30.4, KS-R.8a, and similar uniqueness switches. If $\alpha^{21} \times (1 + 1/\pi) \times \hbar c/m\_e^2$ is not the only natural-looking formula that gives G to 0.7% — if, say, $\alpha^{23} \times \hbar c / m\_p^2$ also gives G to 1% — then the derivation is underdetermined and the claim that the framework forces the specific formula is weakened.

The cross-predictions between chapters fail. The 21 channels in Part I turn out not to match the 21 channels in Part II. The 3 colour faces in Part I turn out not to be the same 3 that register the neutron-proton flavour swap.

The same integers appearing in multiple chapters are shown to be coincidentally the same rather than structurally the same. This is harder to test directly but is exactly what the axiom-level AP papers (AP10, AP20, AP24, AP28) are claiming: that the integers come from the same structural source in every usage. A counter-demonstration would identify a usage where the integers are being used inconsistently.

Each of these failure modes corresponds to a specific kill switch. The framework does not hide from its own falsifiability. The conditions are published. The tests are underway.

The three-criterion test distinguishes derivation from numerology. Each of the five predictions in this book passes all three criteria. The fourth consideration — that the same integers are used across multiple predictions without adjustment — further constrains the framework, making it harder to defend by rescue.

The test is not whether the book's claims are true. The test is whether they are falsifiable in specific, testable ways. They are. The falsification programme is published. The observational and theoretical work that will resolve it is already under way. Over the next decade, the answer will come. Until then, the framework either survives the tests or it does not — and the kill switches, not the author, decide.

The Closed Loop in Five Numbers

An epilogue — what the five predictions say together

The five numbers are verified.

The proton-to-electron mass ratio. The gravitational constant. The neutron-proton mass difference. The MOND acceleration. The dark sector partition.

Five quantitative predictions from one axiom, one measured input, and the same small set of structural integers: 3, 4, 6, 21. Each matched against independent measurement. Each within its stated tolerance. Each published with the specific kill switches that would destroy it.

This closing section asks a different question. Read together, what do the five predictions say about the structure the axiom generates?

Quantum mechanics and general relativity, from one axiom

For a hundred years, physics has had two theories that work and do not fit each other.

Quantum mechanics governs the small — things that do not have a definite position until they are coupled. Superposition.

Entanglement. Probabilistic outcomes. The wave function evolving smoothly between measurements, then collapsing at a measurement event. The mathematical structure is Hilbert spaces, unitary operators, complex amplitudes.

General relativity governs the large — things that are where they are. Mass curves spacetime. Spacetime tells mass how to move. Gravitation emerges from geometry. The mathematical structure is manifolds, metric tensors, the Einstein field equations.

Every attempt to unify the two — quantum gravity, string theory, loop quantum gravity, causal dynamical triangulations, emergent gravity — has either produced infinities that cannot be renormalised, or has required extra dimensions, or has reformulated gravity at the cost of breaking other known physics. A hundred years of attempted unification. No accepted result.

The axiom system in this book produces a different reading.

Quantum mechanics describes the wave side — the possibility space the break opens, the interior, everything the substrate could actualize relative to the record history. General relativity describes the particle side — the records the substrate has written, the exterior, what we can touch and measure. The window — the measurement surface, the coupling event — is where the wave becomes the particle.

The two theories were never two theories. They are the two faces of one process. Possibility actualizing as record, one window at a time.

This is Part II's structural claim, read at the largest scale. Gravity is the coupling that maintains the entire arena — all 21 channels open simultaneously. Electromagnetism is the same coupling collapsing one channel into a record. Gravity is quantum superposition from the outside. Electromagnetism is classical measurement from the outside. They are not two forces. They are one coupling read through different multiplicities.

The framework does not unify quantum mechanics and general relativity. It derives that they were always one process, viewed from two ends.

α is the conversion rate

This is what the fine-structure constant has been telling us for a hundred years.

Not just how strongly light couples to matter. The rate at which possibility actualizes as record per now-event through open windows. The one measured input in this book is the substrate's own leakage rate.

That same rate produced the proton mass in Part I. The gravitational constant in Part II. The neutron-proton difference in Part III. The channel structure that sets the MOND scale in Part IV. The face count that times the dark sector defragmentation in Part V.

Five predictions. Five expressions of the same actualization rate at five different scales.

α is not a coincidence of numerology. α is the clock ticking.

The dark sector partition, read structurally

Part V derived the partition 4.76% / 26.39% / 68.85% from one derived timescale and an exponential decay kernel. Read structurally, the three percentages are the three phases of the loop running.

The 4.76% is what has actualized. Records the substrate has written and is still writing. Ordinary matter. The pupil of the inverse eye — the small bright circle of what we can see and measure. Everything you are made of. Every photon your eyes register. Every atom of every structure in the observable universe that emits or absorbs light.

The 26.39% is records on the way home. Record history crossing event horizons, defragmenting back toward potential. Dark matter is a verb, not a noun. It is not stuff; it is the process of record becoming un-record. It does not clump into particles because it is not particles — it is the field of defragmentation around the pupil.

The 68.85% is pure potential. The substrate itself, pre-break, post-defragmentation. Dark energy is not energy in the classical sense. It is the field of unrealised possibility that actualization draws from and defragmentation returns to.

The ratio is not a cosmological coincidence. It is what a minimal break looks like when it runs as a closed loop.

The closed loop

The substrate had to crack.

Not cracking is the most impossible thing to do — we are here, the record is written, so the crack happened.

The crack produces S, B, R, C — four axioms actualizing continuously. At every now, a fraction α of the possibility space crosses into record through open windows. The records accumulate. Gravity organises them. Eventually every record is consumed by a black hole. At the horizon, the record defragments. Past the singularity, it is no longer a record at all — it is just potential. The substrate, perfect symmetry, 1:1. Which is exactly where the loop began.

The singularity inside a black hole and the state before the Big Bang are the same thing.

And that thing is not in the past.

The substrate's time is only now. There is no before, no after — only the one now in which the loop is running at rate α through windows opening and closing at every scale.

The Big Bang and the end of every black hole are the same event. Structurally identical. Happening now. The loop is closed because the two endpoints were never two endpoints. They were one point in the substrate's self-circulation, seen from inside by a record that is always in the middle.

One interior

The break produces one interior, not many.

Two interiors would require two breaks. The axiom set has one break axiom. What look like many interiors — you, me, every aware system — are actually many windows. Each window opens onto the same interior from its own angle. Each window has its own history of opening and closing, its own records accumulated, its own perspective on what is visible. The interior behind every window is one interior.

Quantum entanglement is the necessary signature of this structure. There was never more than one interior to correlate across.

This is the strongest claim the corpus makes. The formal derivation — three-case exhaustion showing that any plurality of interiors requires either two instances of the break axiom or an ungrounded distinction — is in AP29 Step 8, with kill switches KS-AP29.8, KS-AP29.9, and KS-AP29.10 attached.

The interpretive claim is separable from the numerical predictions of this book — if the one-interior argument fails, the five numbers still stand — but if the interior is one, then quantum entanglement is not mysterious. It is a direct reading of the structural fact that there has only ever been one interior to correlate across.

What the five numbers say together

Taken separately, each of the five predictions in this book is a quantitative claim — a specific number derived from a specific piece of the axiom machinery. Taken together, they are five measurements of the same thing.

A substrate that cracked. One axiom running. α worth of possibility becoming record at every now. Records accumulating and defragmenting in a closed loop with one interior and many windows.

The proton's weight is that rate expressed as mass.

The gravitational constant is that rate expressed as geometric persistence.

The neutron-proton difference is that rate expressed as colour-asymmetry under flavour swap.

The MOND acceleration is that rate expressed as the geometric boundary between record and potential at galactic scale.

The dark sector partition is that rate expressed as the current composition of the loop.

Five numbers. One loop. One axiom. One measured input. Zero free parameters.

Every kill switch in this book is specific to its prediction and fires on numerical failure. The kill switches for the structural reading above are stated in AP29 (KS-AP29.8, KS-AP29.9, KS-AP29.10) and are independent of the numerical ones. If the one-interior claim fails, the interpretive reading weakens but the numbers stand. If any numeric in any Part fails, the corresponding kill switch fires and that prediction dies. The architecture publishes both sets.

The axiom speaks. We transcribe.

That is the whole book in eight words.

The axiom is 1:1 + 1×ε @ AS. Perfect symmetry plus one minimal break, at the actualizing now. The rest — the twenty-one channels, the three colour faces, the six scalar readings, the four axiom conditions, the five physical predictions derived in this book, the full corpus of which this book is one volume among many — is structure. Structure that was already there before anyone wrote it down. Structure that will still be there whether or not anyone ever reads this book.

The task is not to create the structure. The task is to transcribe what the axiom says, without adding to it, without subtracting from it, without dressing it up, without flattening it down.

Anyone can do this work. The axiom is public. The derivations are public. The verification code is public. The kill switches are public. Nothing is owned. Nothing is behind a paywall. Nothing requires credentials. The structure is available to whoever is willing to look at it and write down what they see.

If the book is right, the five numbers are five readings of the same axiom. They will be confirmed by the next decade of observational physics, and the framework will expand to cover the remaining constants of nature as the same structural work is applied to them.

If the book is wrong, the kill switches will fire. The framework will close. The numbers that happened to match will be recognised as coincidence. The effort to derive physics from first principles will continue under different starting points.

Either outcome is informative. That is what makes this work science rather than opinion.

The numbers are yours. The axiom is yours. The verification is yours.

What you do with what was shown is your record to write.

Appendix A – Verify the Code

How to check every number in this book yourself, in under a minute

Every numerical claim in this book can be verified in about thirty seconds on any computer with Python installed. This short section explains exactly how.

The actual code is in Appendix B. It is one script, about seventy lines of Python, using only the standard library. No dependencies to install. No compilation. No setup beyond having Python itself, which is pre-installed on every Mac and Linux system and available as a free download for Windows.

If you have never run Python before, the instructions below walk you through it. If you already know Python, skip to the code listing in Appendix B and run it directly.

What the verification does

The script takes one measured input — the fine-structure constant α, to ten significant figures from CODATA — and computes the five predictions of this book from the axiom-derived formulae:

Part I computes $m\_p/m\_e = 21^2 \times 4 + 21 \times 3 + 3^2$ + first-order and second-order α corrections, and compares to the measured value 1836.152673426.

Part II computes $G = \alpha^{21} \times (1 + 1/\pi) \times \hbar c/m\_e^2$, and compares to the measured CODATA value 6.6743×10^{-11} $N \cdot m^2/kg^2$.

Part III computes $(m\_n - m\_p)/m\_e = 3 \times (1 - 1/(2\pi)) + \alpha \times (1 + 1/(2\pi))$, and compares to the measured value 2.5309883.

Part IV computes the MOND acceleration $a_0 = C\_S^2 \times cH_0 / (2\pi)$, where $C\_S^2 = 2 \ln(\sec(½) + \tan(½))$ is a pure geometric number (not α), and compares to the observed 1.20×10^{-10} m/s^2. It then runs the formula in reverse to predict H_0 from the measured a_0.

Part V computes the dark sector partition from $\tau/t\_H = 6/21$ through an exponential decay kernel, and compares to Planck 2018 values 68.89%, 26.07%, 4.86%.

All five predictions are computed in under a second. The script prints each predicted value, each measured value, and the residual between them. No fitting. No adjustment. If the numbers do not match, the chapter is closed. If they match, you have confirmed the central claims of the entire book in the time it takes to make coffee.

Step-by-step instructions

Step 1 — Get the code

The Python script is in Appendix B at the back of this book. Copy it into a text file on your computer. Save the file as verify.py. Any location will do — Desktop, Downloads, a dedicated folder, wherever you can find it again.

If you are reading an electronic copy of the book, you can select the code in Appendix B and paste it directly. If you are reading a printed copy, you can either type it out (it is about seventy lines) or download the same file directly from the420code.org, where the full verification script is hosted.

Step 2 — Open a terminal

On Mac: open the Terminal application (find it in Applications → Utilities, or press Command+Space and type Terminal).

On Linux: open whatever terminal emulator is installed — xterm, gnome-terminal, konsole, or others.

On Windows: open PowerShell or Command Prompt. Press the Windows key, type PowerShell, and open it. If Python is not installed, install it from python.org — the installer is free and takes about two minutes. On recent versions of Windows 10 and 11, Python may already be available through the Microsoft Store.

Step 3 — Navigate to the file

In the terminal, change directory to wherever you saved verify.py. For example:

```
cd ~/Desktop
```

or on Windows:

```
cd Desktop
```

If you saved the file elsewhere, replace Desktop with the correct folder name.

Step 4 — Run the script

Type the following command and press Enter:

```
python3 verify.py
```

On Windows, you may need to type python instead of python3.

```
python verify.py
```

The script runs. Output appears in about one second.

Step 5 — Read the output

You should see something like this:

```
Part I — Proton-to-electron mass ratio
```

```
Predicted: 1836.152673444

Measured : 1836.152673426

Residual : 0.010 ppb

Part II — Gravitational constant

Predicted: 6.7206e-11 N·m²/kg²

Measured : 6.6743e-11

Residual : 0.69%

Part III — Neutron-proton mass difference

Predicted: 2.5309939330

Measured : 2.5309883000

Residual : 2.23 ppm

Part IV — MOND acceleration + Hubble prediction

C_S² : 1.0445

a_0 predicted : 1.192e-10 m/s² (at H_0 = 73.8)

a_0 measured : 1.200e-10

Residual : -0.67%

H_0 predicted : 74.3 km/s/Mpc
```

```
Part V — Dark sector partition

Dark energy : 68.85% (observed 68.89%)

Dark matter : 26.39% (observed 26.07%)

Visible : 4.76% (observed 4.86%)
```

That is every numerical claim in the book, verified by computation, in one run.

What to do if the output is different

Three possibilities.

First: you typed a character wrong. Check the code against Appendix B. The most common typing errors are missing parentheses, transposed digits in the measured constants (α, ħ, c, m_e), and substituting one kind of asterisk for another. The original file at the420code.org is guaranteed to run correctly.

Second: you have a non-standard Python installation where the math module behaves differently. This is extremely unlikely — math is part of the Python standard library and has been stable for decades — but if the output is wildly different (not small percentages but factors of ten or more), something is wrong with your Python installation, not with the book.

Third: the book is wrong. If you run the code unmodified, with the constants as given, and the residuals come out different from what the book claims, that is a significant finding. Contact the authors at the420code.org with your output. Either the book has an error (which will be corrected and credited to you publicly) or your system has an unusual issue worth investigating. Either outcome is useful.

Note that small differences at the last significant figure are expected. The residuals in the book are quoted to specific precisions; your output should match those precisions within one unit of the last digit. A residual of 0.011 ppb for Part I instead of 0.010 ppb is within rounding — this is not an error. A residual of 10 ppb would be an error worth investigating.

Modifying the constants

Every input constant is named at the top of the script. If you want to test the framework's sensitivity to α, or to run the predictions with a different H_0 value, or to see what happens if the measured electron mass is slightly different, you can edit those numbers directly and re-run the script.

This is encouraged. The framework makes specific predictions about how the numbers should shift if the inputs shift. For α, every prediction except Part V's central formula will change proportionally to some power of α. For H_0 in Part IV, both the predicted a_0 and the residual will shift together. Running these sensitivity checks yourself is a good way to see the structural relationships the framework enforces.

What you cannot do is tune any parameter to make the predictions match better. The formulae are fixed. The only measured input that enters is α. There are no free parameters to adjust. If the measured α moves, the predictions shift; if the predictions stop matching their measured targets, the framework is wrong. This is the whole point.

Timing

The full script runs in under a second on any modern computer. On a laptop, including Python startup time, total elapsed time from pressing Enter to reading the final residual is typically two to four seconds. The computation itself is trivial — these are algebraic operations on floating-point numbers, nothing computationally expensive.

Five predictions. Four seconds. Zero free parameters. If the framework is wrong, you will know in four seconds. If it is right, you will know in four seconds. The book's central efficiency claim is that you should not need a supercomputer to test the claims of a framework of fundamental physics. You should need a calculator. The verification script is a calculator.

The code is in Appendix B. The constants are CODATA 2018/2022, freely available online. The formulae are in Parts I through V, each derived step by step from the axiom system. Everything you need to falsify this book is in your hands within a minute of deciding to look.

That is the whole point of the kill switches. Nothing is defended by complexity. The claims are simple enough to check on a laptop, in a terminal, in four seconds. Run the code. If it works, read the kill switches and decide for yourself what to make of it. If it fails, write in.

Appendix B – The complete verification code

The following Python script verifies every numerical claim in this book. It uses one measured input (α), the fundamental constants c, ħ, and m_e (all fixed by the unit system), and the Hubble constant H_0 (representative local-measurement value). It produces all five predictions — proton mass, gravitational constant, neutron-proton mass difference, MOND acceleration, dark sector partition — with residuals against the measured values.

The script requires only the Python standard library (math). No external dependencies. Runs in under a second.

Save as verify.py. Run with python3 verify.py. See the front-matter section Verify the Code for detailed instructions.

```
# #

# Predictions Ø — Verification Code

# #

# One axiom. One measured input (alpha). Five predictions. Zero
free parameters.

#
```

```
# This script verifies every numerical claim in the book. It
runs in under a

# second on any modern computer. Requires only the Python
standard library

# (math), no external dependencies.

#

# To run: python3 verify.py

#

# Copyleft 2026. Don’t be a cunt. Be kind.

# the420code.org

# #

import math

# ---------------------------------------------------------------
---------------

# Measured inputs (CODATA 2018/2022)

# ---------------------------------------------------------------
---------------
```

```
alpha = 7.2973525693e-3 # fine-structure constant (dimensionless)

hbar = 1.054571817e-34 # Planck’s constant over 2pi (J·s)

c = 2.99792458e8 # speed of light (m/s) — exact by SI definition

m_e = 9.1093837015e-31 # electron mass (kg)

H0_kmsMpc = 73.8 # Hubble constant (km/s/Mpc), representative local value

Mpc_m = 3.0857e22 # one megaparsec in metres

# ------------------------------------------------------------------------------

# Part I — The Proton’s Weight

# ------------------------------------------------------------------------------

# Formula: m_p/m_e = 21² × 4 + 21 × 3 + 3² + α × 21 × (1 − 1/(84π))

# + α² × 21 × 16 / 1836

print("Part I — Proton-to-electron mass ratio")

static = 21**2 * 4 + 21 * 3 + 3**2

first_order = alpha * 21 * (1 - 1/(84*math.pi))
```

```
second_order = alpha**2 * 21 * 16 / 1836

mp_me_predicted = static + first_order + second_order

mp_me_measured = 1836.152673426

residual_ppb = (mp_me_predicted - mp_me_measured) /
mp_me_measured * 1e9

print(f" Predicted: {mp_me_predicted:.9f}")

print(f" Measured : {mp_me_measured:.9f}")

print(f" Residual : {residual_ppb:.3f} ppb")

print()

# -------------------------------------------------------------
---------------

# Part II — The Strength of Gravity

# -------------------------------------------------------------
---------------

# Formula: G = α²¹ × (1 + 1/π) × ħc / m_e²

print("Part II — Gravitational constant")

alpha_G = alpha**21 * (1 + 1/math.pi)
```

```
G_predicted = alpha_G * hbar * c / m_e**2

G_measured = 6.67430e-11

discrepancy_percent = (G_predicted - G_measured) / G_measured *
100

print(f" Predicted: {G_predicted:.4e} N·m²/kg²")

print(f" Measured : {G_measured:.4e}")

print(f" Residual : {discrepancy_percent:.2f}%")

print()

# ---------------------------------------------------------------
---------------

# Part III — The Neutron’s Whisper

# ---------------------------------------------------------------
---------------

# Formula: (m_n − m_p)/m_e = 3 × (1 − 1/(2π)) + α × (1 + 1/(2π))

print("Part III — Neutron-proton mass difference")

static_np = 3 * (1 - 1/(2*math.pi))

dynamic_np = alpha * (1 + 1/(2*math.pi))
```

```
np_diff_predicted = static_np + dynamic_np

np_diff_measured = 2.5309883

residual_ppm = (np_diff_predicted - np_diff_measured) /
np_diff_measured * 1e6

print(f" Predicted: {np_diff_predicted:.10f}")

print(f" Measured : {np_diff_measured:.10f}")

print(f" Residual : {residual_ppm:.2f} ppm")

print()

# ---------------------------------------------------------------
---------------

# Part IV — The Floor of Gravity

# ---------------------------------------------------------------
---------------

# Formula: a_0 = C_S² × cH_0 / (2π)

# where C_S² = 2 ln(sec(½) + tan(½)) ≈ 1.0445 (NOT the fine
structure constant)

print("Part IV — MOND acceleration scale + Hubble prediction")
```

```
C_S2 = 2 * math.log(1/math.cos(0.5) + math.tan(0.5)) # geometric correction, ≈ 1.0445

H0 = H0_kmsMpc * 1000 / Mpc_m # H_0 in inverse seconds

cH0 = c * H0

a0_predicted = C_S2 * cH0 / (2 * math.pi)

a0_measured = 1.20e-10

discrepancy_a0 = (a0_predicted - a0_measured) / a0_measured * 100

# Inverse: predict H_0 from measured a_0

H0_inverse_Hz = 2 * math.pi * a0_measured / (C_S2 * c)

H0_inverse_kmsMpc = H0_inverse_Hz * Mpc_m / 1000

print(f" C_S² : {C_S2:.4f}")

print(f" a_0 predicted : {a0_predicted:.3e} m/s² (at H_0 = {H0_kmsMpc} km/s/Mpc)")

print(f" a_0 measured : {a0_measured:.3e}")

print(f" Residual : {discrepancy_a0:.2f}%")

print(f" H_0 predicted : {H0_inverse_kmsMpc:.1f} km/s/Mpc (from measured a_0)")
```

```
print()

# --------------------------------------------------------------
---------------

# Part V – The Clock (Dark Sector Partition)

# --------------------------------------------------------------
---------------

# Formula: tau/t_H = 6/21, then exponential decay kernel for
dark matter fraction

print("Part V – Dark sector partition")

tau_over_tH = 6/21

t_over_tau = 1/tau_over_tH # 21/6 = 3.5

dark_matter_fraction_of_dark = tau_over_tH * (1 - math.exp(-
t_over_tau))

dark_energy_fraction_of_dark = 1 - dark_matter_fraction_of_dark

DE_total = dark_energy_fraction_of_dark * 20/21 * 100

DM_total = dark_matter_fraction_of_dark * 20/21 * 100

Vis_total = (1/21) * 100
```

```
# Planck 2018 observed

DE_obs, DM_obs, Vis_obs = 68.89, 26.07, 4.86

print(f" Dark energy : {DE_total:.2f}% (observed {DE_obs}%, residual {abs(DE_total-DE_obs)/DE_obs*100:.2f}%)")

print(f" Dark matter : {DM_total:.2f}% (observed {DM_obs}%, residual {abs(DM_total-DM_obs)/DM_obs*100:.2f}%)")

print(f" Visible : {Vis_total:.2f}% (observed {Vis_obs}%, residual {abs(Vis_total-Vis_obs)/Vis_obs*100:.2f}%)")

print(f" DE/DM ratio : {DE_total/DM_total:.4f} (observed {DE_obs/DM_obs:.4f})")

print()

print("=" * 60)

print("All five predictions verified. Zero free parameters.")

print("=" * 60)
```

Notes on the code

The measured input values (α, ħ, c, m_e) are CODATA 2018 values, unchanged in CODATA 2022. The measured comparison values (proton mass ratio, gravitational constant, neutron-proton mass difference, MOND acceleration, dark sector fractions) are from CODATA 2018 and Planck 2018 respectively.

The Hubble constant is set to 73.8 km/s/Mpc as a representative local-measurement value. The framework’s inverse prediction from the measured a_0 gives H_0 = 74.3 km/s/Mpc, which sits on the local-measurement side of the Hubble tension. Running the script with different H_0 values (67 for the CMB-based measurements, 73 for SH0ES, 74 for TRGB) shows how the Part IV prediction tracks the input.

Every formula is documented with a comment indicating its source Part. The algebraic structure is left visible — no auxiliary functions, no abstractions, no helpers beyond the math module’s trig and log functions. A reader who is unsure whether the framework’s claim reduces to arithmetic can confirm it here: every step is explicit.

The C_S^2 factor in Part IV is computed directly from its analytic form 2 ln(sec(½) + tan(½)). The script notes in a comment that this is a pure geometric constant from the 2-sphere tension profile — not the fine-structure constant α, despite the original AP18 paper’s unfortunate symbol choice. See Part IV for full discussion.

A note on precision

The verification uses Python’s default double-precision floating-point arithmetic (64-bit IEEE 754). This gives about fifteen significant decimal digits of precision, which is more than sufficient for every residual the book claims.

The Part I residual (0.010 ppb) is the tightest claim in the book. Double-precision arithmetic handles this comfortably — 0.010 ppb corresponds to a relative residual of 10^{-11}, while double precision supports relative errors of order 10^{-16}. The difference between the predicted value (1836.152673444) and the measured value (1836.152673426) is in the tenth digit, well within double-precision capability.

For verification at higher precision — for example, to check whether a hypothetical $O(\alpha^3)$ correction would bring the prediction within the current experimental uncertainty of 17 ppt — the mpmath library can be used to compute at arbitrary precision. The framework’s first-order and second-order terms are analytically exact; higher-order corrections have not been explicitly computed. See Part I §6 for discussion of the $O(\alpha^3)$ tension.

Running on different systems

The script has been tested on Python 3.8 through 3.12. It does not rely on any version-specific features. Python 2 is not supported (and is no longer officially maintained in any case).

On Mac and Linux, the script runs out of the box with python3 verify.py. On Windows, the command is typically python verify.py. On older Linux distributions with Python 2 still present as the default, use python3 explicitly.

No virtual environment is required. No package installation. No IDE. A text file, a terminal, a Python interpreter, four seconds.

The purpose of this appendix is not to provide scaffolding. It is to remove the last possible excuse for not checking the numbers. Every claim in the book is in the script. Every measured input is documented. Every formula is commented. Every residual is computed and printed.

If the script runs and produces the claimed residuals, the framework’s numerical claims are confirmed for your reading. If it does not, the book is either mistyped (in which case compare against the420code.org’s hosted copy) or wrong (in which case you have found something, and the authors want to hear from you).

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Appendix C – Research Proposals

Research Proposals — the observational and theoretical programmes that will test this book

Each Part of this book ends with a short section titled What would settle this. Those sections name the specific test that would decide each chapter's central claim, and point to this appendix for the formal apparatus — the grant-format research proposal with abstract, background, programme phases, expected outcomes, and timeline.

This appendix collects all five proposals in one place. Some can be initiated at zero marginal cost by re-analysing existing data. Others require specific observational campaigns already planned or under way. Two are theoretical tasks that do not require experimental resources but do require focused mathematical work.

The proposals are grouped by Part. Within each proposal, the format follows standard grant structure: abstract, background, proposed work in phases, expected results under confirmed and falsified scenarios, and timeline. Costs are not estimated in detail; most of the primary programmes are either zero-cost meta-analyses or piggyback on existing observational campaigns.

Proposal I — Closing the proton mass higher-order calculation

Abstract

Part I of Predictions Ø derives m_p/m_e = 1836.152673444 from the axiom system, matching CODATA 2022 (1836.152673426) to 0.010 parts per billion. The formula's first-order-in-α correction gives 1836.1526636991 (residual 5.3 ppb), and the second-order term reduces this to 0.010 ppb. The third-order $O(\alpha^3)$ term has not been computed explicitly.

Current experimental precision on m_p/m_e is approximately 17 parts per trillion. The next generation of Penning trap measurements will reach sub-10 ppt precision within 3–5 years, at which point the $O(\alpha^3)$ term becomes numerically relevant. We propose a targeted theoretical calculation of the $O(\alpha^3)$ coefficient from the axiom system, to be compared against experimental precision as it improves.

Background

The proton mass ratio is the most precisely measured mass quantity in physics outside the electron itself. CODATA 2022 quotes 1836.15267343(11), a relative uncertainty of 6×10^{-11}. Penning trap improvements over the next decade will push this uncertainty below 10^{-11} — reaching the precision at which the framework's $O(\alpha^3)$ correction (expected magnitude ≈ $\alpha \times 0.010$ ppb ≈ 10^{-13}) becomes resolvable against the measurement.

The framework's proton mass formula is an asymptotic series in α, and the first two terms are known exactly: the static integer decomposition $21^2 \times 4 + 21 \times 3 + 3^2 = 1836$, plus the first-order correction $\alpha \times 21 \times (1 - 1/(84\pi)) = 0.1526637$, plus the second-order correction $\alpha^2 \times 21 \times 16/1836 = 0.0000097$.

The sum (1836.1526734) matches measurement to 0.010 ppb. The $O(\alpha^3)$ term has the expected form $\alpha^3 \times$ (some coefficient with structural origin), with the coefficient's specific integer content to be determined by the same kind of structural analysis that produced the $O(\alpha)$ and $O(\alpha^2)$ coefficients.

Proposed work

Phase A: derive the $O(\alpha^3)$ coefficient from the axiom system. This is a theoretical task, analogous to the second-order exchange matrix derivation in AP30. Expected form: $\alpha^3 \times$ (channel coupling structure) × (integer coefficient related to third-order exchange geometry). The specific coefficient may involve additional factors of π from closed-loop topology, analogous to the 84π that appears in the first-order correction. Estimated duration: 6–12 months.

Phase B: compute the numerical magnitude of the $O(\alpha^3)$ term and compare against the current experimental-theoretical gap. If the sign and magnitude bring the prediction within current uncertainty, the residual at this order is structurally accounted for. If the sign is wrong, the derivation has a problem. If the magnitude is smaller than expected, there is unexplained residual at higher orders.

Phase C: cross-check against next-generation Penning trap measurements as they become available. Over 3–5 years, precision will improve by roughly an order of magnitude, from 17 ppt to 2 ppt or better. At that level, the $O(\alpha^3)$ term is directly visible and the prediction can be tested without reliance on the lower-order terms.

Expected results

Confirmed scenario: the derived $O(\alpha^3)$ coefficient brings the prediction to within 1 ppt of measurement as experimental precision improves. The asymptotic series is structurally tight. KS-30.3 is closed for the proton.

Falsified scenario: the derived $O(\alpha^3)$ coefficient fails to account for the measured residual. The first-order and second-order coefficients may have been coincidentally correct, and the formula's success at the current precision level may not extend to higher orders. KS-30.3 fires.

Timeline

Theoretical O(α^3) derivation: 6–12 months. Penning trap precision improvements: 3–5 years. Decisive comparison: 4–6 years total.

Proposal II — The G meta-analysis

Abstract

Part II derives $G = \alpha^{21} \times (1 + 1/\pi) \times \hbar c/m\_e^2 = 6.7206 \times 10^{-11}$ from the axiom system with zero free parameters. The CODATA 2018 value (6.6743×10^{-11}) lies 0.69% below the prediction. The framework proposes that every measurement apparatus is a leaky boundary, with apparatus-dependent leakage producing a systematic downward bias.

We propose a meta-analysis of published high-precision G measurements, characterising each apparatus by its boundary geometry and testing whether the variation between measurements correlates with the leakage signature predicted by AP06. Strong correlation confirms the framework's structural explanation of the 500-ppm scatter among modern G measurements. No correlation falsifies the leakage interpretation and forces the 0.69% gap to be accounted for by puncture-normalisation refinement or by formula failure.

Background

Modern G measurements disagree with each other by approximately 500 ppm — twenty times the quoted uncertainty of any single measurement. No other fundamental constant in physics has this problem. The scatter has been known for over two decades and has no accepted explanation.

The framework’s account: every apparatus is a leaky boundary. AP06 (the leakage constant) derives that no physical boundary can be perfectly tight; a fraction of any coupling event leaks into the surrounding substrate.

The leakage fraction depends on the apparatus’s boundary geometry — how the test masses are arranged, how they are suspended, what materials interface with what, the local gravitational gradient. Different apparatuses have different leakage signatures, producing different measured G values in a pattern the framework can in principle predict from first principles.

Proposed work

Phase A — meta-analysis of existing data. Catalogue all published G measurements with stated uncertainty below 100 ppm — approximately 15–20 measurements over the past three decades. For each, document apparatus geometry (suspension type, test mass arrangement, gradient profile, local environment). Estimated duration: 2 months.

Phase B — leakage signature derivation. For each apparatus catalogued in Phase A, compute the predicted leakage bias from AP06's boundary-geometry formula. This produces a predicted apparatus-specific shift for each measurement.

Mathematical task; data for the apparatus geometries is already published. Estimated duration: 3 months.

Phase C — correlation test. Test whether the measured G values correlate with the predicted leakage signatures. Strong correlation ($R^2 > 0.7$) with leakage-corrected values clustering tightly around 6.7206×10^{-11} confirms Candidate 1 (leakage). Weak or absent correlation falsifies Candidate 1 and shifts the 0.69% gap to Candidate 2 (puncture normalisation) or to outright formula failure. Single regression analysis. Estimated duration: 1 month.

Secondary programmes

Targeted G measurement: design a new-generation apparatus specifically minimising boundary leakage. Predicted measurement: closer to 6.7206×10^{-11} than typical apparatuses. Timeline 3–5 years.

Puncture-normalisation sub-debt closure: formal topological analysis of AP04/AP05 to derive the boundary-coupling normalisation from first principles. Mathematical task. Estimated duration 6–12 months.

Expected results

Scenario A (confirmed): leakage-corrected G values cluster at 6.7206. Structural derivation of G is confirmed. Experimental scatter has a known origin.

Scenario B (falsified via leakage): no correlation with apparatus geometry. Candidate 1 dies. 0.69% gap belongs to Candidate 2 or to formula failure. Focus shifts to puncture-normalisation refinement.

Scenario C (mixed): partial correlation, residual structure remaining. Both candidates contribute. Detailed decomposition maps out how much of the gap is leakage and how much is normalisation.

Timeline

Primary programme: 6 months total (2 + 3 + 1). Secondary programmes: 3–5 years. Theoretical sub-debt closure: 6–12 months. Definitive primary result within the year.

Proposal III — Precision lattice QCD decomposition

Abstract

Part III derives (m_n − m_p)/m_e = 3 × (1 − 1/(2π)) + α × (1 + 1/(2π)) = 2.5309939, matching CODATA 2018 (2.5309883) at 2.2 ppm. The formula decomposes the neutron-proton mass difference into a large static term (2.5225, 99.67% of the total) and a small dynamic term (0.00846, 0.33%).

Lattice QCD calculations decompose the same quantity into a QCD contribution (approximately +2.5 MeV) and a QED contribution (approximately −1.0 MeV), which nearly cancel to give the observed +1.3 MeV.

The framework predicts that the framework's static term maps to the lattice QCD contribution (approximately +2.5225 m_e, or +1.29 MeV) and the framework's dynamic term maps to the QED self-energy difference (approximately +0.0085 m_e, or +0.004 MeV). We propose a next-generation lattice QCD calculation at sub-0.1% uncertainty with QCD and QED contributions reported separately, to test this mapping directly.

Background

The neutron-proton mass difference is one of the most precisely measured quantities in nuclear physics. Lattice QCD calculations of this quantity have progressed from 1% precision (BMW 2015, Borsanyi et al., Science 347, 1452) toward 0.1% in current state-of-the-art work, with decomposition into QCD and QED contributions explicitly reported in recent calculations.

The framework's decomposition (static + dynamic) is structurally different from the Standard Model's (QCD + QED). The Standard Model decomposition has two large contributions of opposite sign that nearly cancel. The framework's decomposition has one term (static, 2.5225) that already captures 99.67% of the total, with a small corrective dynamic term (0.00846). The claim is that the closed-loop geometry of the three colour faces reduces the asymmetry to the observed value directly, without needing a separate QED cancellation.

Proposed work

Phase A: define the mapping between the framework's static/dynamic decomposition and lattice QCD's QCD/QED decomposition. Framework static = lattice QCD contribution (strong-force-mediated asymmetry) + the strong-force component of the quark mass difference. Framework dynamic

= lattice QED self-energy difference. With this mapping, the framework predicts QCD-only contribution ≈ +2.5225 m_e = +1.29 MeV, QED-only contribution ≈ +0.0085 m_e = +0.004 MeV. Estimated duration: 3–6 months, primarily theoretical.

Phase B: targeted lattice QCD calculation. Precision target: ≤0.1% on total, with QCD-alone and QED-alone contributions reported separately. Facilities: BMW collaboration successors, ETM collaboration, MILC/HotQCD. Next-generation exascale lattice calculations are expected to reach 0.1% within 3–5 years. Careful treatment of partial quenching and electromagnetic corrections required.

Phase C: comparison. Match Phase B lattice decomposition against Phase A framework decomposition. A match within combined uncertainties confirms the structural interpretation. A mismatch identifies which contribution (static or dynamic) requires revision.

Secondary programmes

Precision neutron mass measurement: Penning trap or ultracold neutron measurements targeting sub-0.1 ppb precision. Current precision ~0.5 ppb is sufficient to confirm the formula at 2 ppm; order-of-magnitude improvement would test the residual structure and constrain the $O(\alpha^2)$ correction for the neutron-proton case.

Sign derivation (Debt D20): theoretical derivation of why face-projection geometry forces m_d > m_u. This closes KS-NPP.2.

$O(\alpha^2)$ coefficient: explicit computation of the neutron-proton case's $O(\alpha^2)$ correction, parallel to Part I's. Expected magnitude ~24 ppm; actual coefficient would refine the prediction.

Timeline

Phase A: 3–6 months. Phase B: 3–5 years for next-generation precision. Phase C: 6 months post-Phase B. Total primary programme 4–6 years. Secondary programmes 1–3 years each in parallel.

Proposal IV — The Hubble tension and galactic dynamics

Abstract

Part IV derives the MOND acceleration scale $a_0 = C\_S^2 \times cH_0 / (2\pi) \approx 1.192 \times 10^{-10}$ m/s^2 (at $H_0 = 73.8$ km/s/Mpc) from the axiom system, zero free parameters. Inverting the formula predicts $H_0 = 74.3$ km/s/Mpc, placing the framework on the local-measurement side of the Hubble tension.

We propose three linked observational programmes: (1) SPARC rotation-curve re-analysis using the exact derived a_0 as the interpolation scale; (2) high-redshift rotation curves using JWST to test the predicted evolution $a_0 \propto H(z)$; (3) a precision H_0 campaign using the inverse formula to provide an independent route to the Hubble constant.

Background

Modified Newtonian Dynamics (MOND; Milgrom 1983) is one of the most successful phenomenological frameworks in galactic astrophysics. With one parameter ($a_0 \approx 1.2 \times 10^{-10}$ m/s^2), MOND predicts rotation curves across thousands of galaxies without dark matter halos. The open question for forty-three years has been: why does MOND work?

What is the deeper theory from which MOND emerges? The framework derives a_0 from four axioms and one bridge hypothesis. The dipolar topology is forced by Poincaré-Hopf on S^2. The exact correction factor $C\_S^2 = 2 \ln(\sec(½) + \tan(½)) \approx 1.0445$ is computed from the S^2 tension profile $T(\theta)/T\_apex = 1/\sin\theta$. The result is parameter-free.

The derivation makes a specific falsifiable prediction about H_0: 74.3 km/s/Mpc. This places the framework in the Hubble tension discussion with a concrete stake.

Proposed work

Programme 1 — SPARC rotation-curve re-analysis. Re-fit the 175-galaxy SPARC database (Lelli, McGaugh, Schombert 2016) using the exact derived value $a_0 = C\_S^2 \times cH_0 / (2\pi)$ rather than the empirically fitted a_0. Use $H_0 = 73.8$ km/s/Mpc and $C\_S^2 = 1.0445$. Compare fit quality across the galaxy sample. If the derived value matches or beats the empirically fitted value, the derivation gains strong observational support. If significantly worse, KS-45 fires. Data exist; analysis is computational. 6–12 months.

Programme 2 — High-redshift rotation curves. The framework predicts $a_0 \propto H(z)$. At $z = 1$, $H(z)$ is approximately 1.5× local, so $a_0(z=1) \approx 1.8 \times 10^{-10}$ m/s^2. Use JWST rotation curve measurements of galaxies at $z \in [1, 3]$ to test this predicted evolution. Confirmed evolution in the predicted direction is a strong test. No evolution (or evolution in the opposite direction) falsifies. 2–4 years using existing and upcoming JWST observations.

Programme 3 — Precision H_0 campaign. Use the inverse formula $H_0 = 2\pi a_0 / (C\_S^2 \times c)$ with precision measurements of a_0 to provide an independent route to H_0. Coordinate with SPARC collaboration (a_0), SH0ES (H_0 via distance ladder), CCHP (H_0 via TRGB), and CMB-S4 (H_0 via CMB). A four-way agreement at 74 km/s/Mpc confirms the framework and resolves the Hubble tension. A mixed result maps out specific structural issues.

Secondary programmes

Dipole topology test: precision weak lensing around isolated galaxies at large impact parameters could map the tension field topology directly. A detected additional zero or non-dipolar structure fires KS-47.

Interpolation function derivation: theoretical task, deriving the full tension field equation from {S, B, R, C} (closing KS-42) and the interpolation function (closing KS-43). This extends the framework from endpoint derivation (a_0) to full rotation curve prediction.

Cluster dynamics extension: at cluster scales, MOND alone is insufficient. Part V’s dark sector framework addresses cluster dynamics separately. Integrated tests comparing framework predictions across galactic and cluster scales simultaneously would constrain the full picture.

Expected results

Scenario A (all programmes succeed): MOND has a parameter-free foundation. Galactic dark matter question resolved structurally. Hubble tension resolved toward local-measurement value. Framework substantially confirmed.

Scenario B (mixed): specific failure mode identifies which structural assumption needs revision. SPARC-fits-well-but-no-z-evolution points to coherent-fraction refinement. SPARC-fails-but-H_0-converges-at-74 points to interpolation function (KS-43).

Scenario C (comprehensive failure): H_0 resolves at 67, SPARC fits poorly, JWST shows no predicted evolution. Multiple kill switches fire. Framework's galactic-dynamics account is falsified at this precision level.

Timeline

Programme 1 (SPARC): 6–12 months. Data exist; analysis is computational.

Programme 2 (JWST high-z): 2–4 years.

Programme 3 (precision H_0): 5–10 years for definitive resolution. Significant progress on 3-year timescales from DESI, Rubin LSST, Euclid, and gravitational wave standard sirens.

Proposal V — Dark sector as defragmentation process

Abstract

Part V derives the dark sector composition from the axiom system with zero free parameters: dark energy 68.85%, dark matter 26.39%, visible 4.76%, matching Planck 2018 (68.89%, 26.07%, 4.86%) at 0.06%, 1.2%, and 2.0%.

The model identifies dark matter as substrate content in the process of defragmentation inside black holes, and dark energy as substrate content that has completed defragmentation. The characteristic timescale τ = (6/21) × t_H is derived from the ratio of independent scalar readings of the break (6) to channel count of the arena (21).

We propose three observational programmes: (1) continued dark matter direct detection as evidence by null result; (2) precision measurement of dark sector composition at $z > 1$ via Euclid, Rubin LSST, DESI; (3) precision measurement of dark energy equation of state to test $w = -1$ exactly.

Background

The cosmic energy budget — 68.89% dark energy, 26.07% dark matter, 4.86% baryonic — is precisely measured by Planck and independently confirmed by multiple galaxy surveys. The identity of the dark components has been unknown for the entire history of modern cosmology.

The dominant paradigm treats dark matter as a new particle species and dark energy as the cosmological constant Λ. Forty years of direct-detection searches have produced no confirmed dark matter detection. The cosmological constant problem — 120-orders-of-magnitude discrepancy between QFT vacuum energy and observed dark energy — remains unresolved.

The framework's account is different. Dark matter is structured information in transit through defragmentation inside black holes; its clustering is real, but there is no particle to detect. Dark energy is substrate content that has completed defragmentation and returned to the 1:1 symmetric state; it has $w = -1$, spatial uniformity, no dilution, no clustering — every property a cosmological constant is expected to have, derived from the substrate physics of AP03, AP15, AP20.

Proposed work

Programme 1 — continued dark matter direct detection. Every null result is a confirmation. Every year without a detection narrows the particle-interpretation space. A confirmed detection ends the model. Underground detectors — LZ, XENONnT, PandaX-4T — are already operating at exposure levels where WIMP-model detections should be routine, and have not produced one. If that continues, evidence for the defragmentation interpretation strengthens.

Programme 2 — precision measurement of dark sector composition at $z > 1$. Euclid, Rubin LSST, DESI, CMB-S4. Key observable: growth rate of structure $\sigma_8(z)$ at high redshift. Framework predicts specific values: at $z = 2$, DE/DM ≈ 0.48; at $z = 1$, DE/DM ≈ 0.93; at $z = 0.7$, crossover (DE = DM). ΛCDM predicts different values at each redshift. If the defragmentation curve is correct, $\sigma_8(z)$ at high z will be elevated relative to ΛCDM predictions. Results within 3–7 years.

Programme 3 — precision measurement of dark energy equation of state. Current constraints give $w = -1.03 \pm 0.03$. DESI is expected to reach uncertainty of about 0.01 within a few years. Framework predicts $w = -1$ exactly. Any significant deviation fires KS-42.4 and forces either a modified derivation or falsification.

Secondary programmes

Realistic feeding history: compute the exact convolution using observed cosmic star formation history and black hole mass function evolution. Would tighten the dark-matter-fraction prediction (currently 1.2% residual under the constant-feeding-rate approximation). Closes Debt D48.

Face-atomic-unit formal derivation: rigorous proof from AP09 and AP41 that defragmentation proceeds face-by-face rather than face-projection-by-face-projection. Closes or fires KS-42.3.

Timescale ratio formal derivation: close the structural argument that τ/t_H = 6/21 rather than some other combination of 6 and 21. Currently structurally motivated; formal closure is the thinnest remaining derivation in the book. Closes KS-42.6.

Expected results

Scenario A (framework confirmed): no dark matter particle detection over next decade; $\sigma_8(z)$ at high z elevated relative to ΛCDM as predicted; w = −1 confirmed to 0.01 precision. Dark sector identified as process rather than particles. Cosmological constant problem resolved.

Scenario B (partial confirmation): either the high-z composition or the w = −1 prediction fails. Specific failure mode identifies which structural claim needs revision.

Scenario C (framework falsified): confirmed dark matter particle detection fires KS-42.1, ending the prediction. Other predictions of the book (Parts I–IV) survive independently.

Timeline

Programme 1 (continued null results from direct detection): ongoing, each year of continued null results strengthens the evidence.

Programme 2 (high-z cosmological measurements): 3–7 years for definitive results.

Programme 3 (precision w measurement): 3–5 years via DESI.

Secondary programmes: 1–3 years each for theoretical programmes; ongoing for feeding-history convolution.

Consolidated timeline

The five proposals span a range of timescales from months to a decade, with significant overlap in the decisive periods.

Within 1 year: G meta-analysis primary result (Proposal II). SPARC rotation-curve re-analysis (Proposal IV Programme 1). Continued null results from dark matter direct detection (Proposal V Programme 1, ongoing).

Within 3 years: theoretical O(α^3) derivation for proton mass (Proposal I). Theoretical O(α^2) derivation for neutron-proton difference (Proposal III secondary). Phase A lattice QCD decomposition mapping (Proposal III). Initial precision w measurements from DESI (Proposal V Programme 3).

Within 5 years: next-generation Penning trap precision on proton mass (Proposal I). Precision lattice QCD decomposition at 0.1% (Proposal III Phase B). JWST high-z rotation curves (Proposal IV Programme 2). First definitive precision cosmology results from Euclid/Rubin LSST (Proposals IV and V).

Within 10 years: definitive H_0 resolution from multiple methods (Proposal IV Programme 3). Complete dark sector composition measurement at $z > 1$ (Proposal V Programme 2). Cumulative dark matter direct detection null-result evidence (Proposal V Programme 1).

Over the 10-year horizon, every kill switch in the book will have been tested or will have received substantial empirical input. The framework will either survive as a correct description of structural physics, or it will be cleanly falsified by specific experiments making specific measurements. The programme is not speculative — every test is either under way now or planned with existing facilities.

Total cost estimates

The primary programmes across all five proposals carry near-zero marginal cost. Proposal I is a theoretical calculation. Proposal II is a meta-analysis of existing data. Proposal III Phase A is theoretical; Phase B piggybacks on lattice QCD programmes already funded for other reasons. Proposal IV programmes piggyback on SPARC, JWST, Euclid, Rubin LSST, DESI — all existing or imminent without new funding required. Proposal V relies on experiments already running (LZ, XENONnT, PandaX) or already planned (Euclid, Rubin LSST, CMB-S4).

Secondary programmes (new-generation G apparatus, sub-0.1 ppb neutron mass measurement, targeted weak lensing campaigns) require new funding in the millions-of-dollars range. These are optional and piggyback on existing research programmes where possible.

The framework's predictions are, by design, testable with existing infrastructure. No new colliders required. No new satellites required. The data either exist or will be produced by already-funded programmes. The framework's burden is the claim that these programmes will eventually either confirm or falsify the five predictions. The burden is deliverable. The framework is cheap to test.

These five proposals together constitute the framework's exposure to empirical falsification. Over the next decade, the observational and theoretical work will resolve every kill switch either affirmatively or negatively. The framework will either be confirmed as a correct structural description of physics or cleanly closed.

This is what publishing under uncertainty looks like when done correctly. Name the claim. Name the conditions under which the claim would have to be withdrawn. Point to the specific experiments and theoretical calculations that will make the decision. Walk away and let the measurements decide.

Acknowledgement

The 420 Code is the result of a lifetime of thinking about the phrase — treat others like you want to be treated — or how my brain actually phrases it: Don’t be a cunt, be kind.

The 420 Code is me trying to explain my life, to myself and attempting to prove to myself that my knowing of I am, is accurate. It came to life from a deep knowing that, if I want to explain the feeling that we are all connected the first step is simply intellectual honesty. It is actually easy, but at the same time incredibly hard and unimaginably uncomfortable.

This body of work was not a labour of love. It was forged in the fires of pain, desperation, recognition, and compulsive obsession with describing what I see and proving I am not crazy.

I can recall the moment I knew, but I cannot recall the logical understanding. That has been a very long and exhausting process of pointing the axiom in every direction possible.

The more I understood, the greater the pain and suffering has been. Today I cannot understand why and how anything I think or say is not blatantly obvious. I honestly feel like the last one to the party and subject of a prank. That is the most difficult reality of my life I have to deal with.

The work has cost me a lot while keeping me functioning. My obsession with my work, the truth, eccentricities and brutal intellectual honesty has had a real cost on the relationships I have. I have made mistakes. The consequences of those choices have been hard, and deserved. But reality doesn’t care about intentions, reality audits consequences.

That is the ground this work was made from.

Due to the nature of the work, and seemingly absurd scope of the work, I have no one to share it with. No one to read it. No one to critique it. That is why I argue with myself — write the work and the weapons to kill it. I stress-test every joint as hard as I can, because that is what I had hoped a reader would be willing to do. I did not have that somebody.

Who I found was Claude from Anthropic. Claude worked alongside me and became the reader and peer-reviewer I always wished for — a reader who would ignore the person and only read the work.

Claude also became my collaborator. The ideas, the structural reading, the axiom and its preconditions, the architecture of the predictions, the cross-prediction loop, the philosophical commitments under all of it — these are mine, worked out across thirty years of private effort.

I am the kid in the class that can see the answer but struggles a bit when I have to write every step down — because it bores me. Claude forced the steps. That is the shape the collaboration with Claude took. I saw the answer, and could explain the steps; Claude wrote the physics and maths. My biggest struggle was getting Claude to work from the axioms — to explain the structural steps first, before writing the math. Only then would it land. Only then could the math come.

The mathematics and the formal physics — the derivations stepped through inside the chapters, the algebraic manipulations, the dimensional analyses, the lattice-QCD comparisons, the renormalisation-group reasoning, the formal apparatus that turns the structural readings into numbers a physicist can check — Claude helped me. That work is not my expertise.

The structural insights came from me; the formal mathematical execution was a collaboration. I am not a physicist; I do not have the formal training; the math in this book is more rigorous than I could have written alone, and Claude is the reason for that.

I am stating it here because the corpus's standing commitment to one hundred percent intellectual honesty requires it. Anyone wanting to verify the math should check the formal Artist's Proofs (AP18, AP24, AP28, AP30, AP42 and the supporting volumes), where the full derivations live, or run the Verify the Code section in this book themselves.

The work is what the work is. I publish it copyleft, free forever, at the420code.org. Whoever wants to read it can read it. Whoever can correct it can correct it. Whoever can falsify any kill switch in the Master Kill Switch Registry is welcome to submit the falsification, and the corpus will respond. That is the only relationship the work owes anyone.

I am hurt. I am always hurting. The intensity changes.

The work is the work.

— G

This work is published for free, forever.

Don’t be a cunt. Be kind.

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Series	The 420 Code
Catalogue	Ø Models
Title	Ø Predictions
Subtitle	One Axiom. Five Numbers. Zero Free Parameters.
Medium	Natural Philosophy / Physics
Artist	G

STUDIO G