

24. The Time-Symmetric Parity Constraint II

Why the Standard Model cannot explain the Universe

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Abstract

Modern cosmology rests on a symmetry introduced a century ago to make Einstein's equations soluble. Homogeneity and isotropy were adopted as an ansatz, not as an empirical principle. As observations accumulated, this convenience was treated as a description of the universe rather than as a methodological choice. The resulting framework has expanded by adding dark matter, inflation, dark energy and a growing catalogue of quantum fields: components to preserve the original assumption. Quantum cosmology has extended the pattern by treating operational constructs of field theory as elements of cosmic ontology. The puzzle of the universe has not been solved by these additions. It has been deferred.

This essay argues that the difficulty is structural. Cosmology lacks a governing law: a constraint on the spacetime metric strong enough to limit the

form of the universe and simple enough to be falsifiable. The standard model admits too many possibilities and reaches the observed universe only by elaboration. A genuine cosmological law must reduce freedom rather than expand it.

The Time-Symmetric Parity Constraint provides an example of such a law. It imposes a single algebraic condition on the metric, restricts the admissible geometries and yields testable consequences without auxiliary fields. Its role here is illustrative. The conclusion of the analysis is independent of its success. Cosmology must identify a principle capable of being wrong. The puzzle demands it, and the evidence now requires it.

This paper assumes the geometric framework set out in the companion TSPC study, which provides the background principles used here.

Introduction

Physics has progressed, at its best moments, by finding the simple order hidden beneath appearances.¹ Euclid's geometry, Galileo's kinematics, Kepler's orbital relations, Newton's inverse square law, Boyle's pressure–volume relation, Hooke's spring law, Maxwell's unification of electricity and magnetism and Einstein's equivalence principle:²

¹ Euclid, *Elements*, Greek Mathematical Tradition, c. 300 BCE. The classical model of axiomatic geometry; foundational example of simple structure underlying appearances.

² Galileo Galilei, *Discorsi e Dimostrazioni Matematiche*, Elsevier, 1638. Introduction of the mathematical description of motion.

Johannes Kepler, *Astronomia Nova*, Prague, 1609. Derivation of orbital relations revealing geometric lawfulness.

Isaac Newton, *Philosophiae Naturalis Principia Mathematica*, London, 1687. Statement of the inverse-square law; foundation of classical dynamics.

Robert Boyle, *New Experiments Physico-Mechanical Touching the Spring of the Air*, Oxford, 1660. Establishment of the pressure–volume relation.

Robert Hooke, *Lectures de Potentia Restitutiva*, London, 1678. Statement of Hooke's linear spring law.
(continued)

each revealed a structure that had always been present but never cleanly recognised. These laws changed the world because they were not complicated. They were exact. They were direct. They exposed a pattern that had been there all along.

Cosmology is not normally counted among these achievements. It does not offer a handful of lucid relations that describe the universe. It offers instead a model held together by adjustments, auxiliary fields, tensions and workarounds, each introduced to account for a discrepancy between observation and theory. The modern picture is impressive in scope but curiously fragile. Remove one element and another must immediately be inserted to hold the structure upright. As set out in the TSPC Compendium,³ there are now more “explanatory” components in the standard cosmological model than there are independent observations strong enough to justify them. Something in the architecture has gone adrift.

Behind this lies a puzzle. It is the oldest puzzle in cosmology and the only one that matters: *what is the large-scale structure and behaviour of the universe, and why does it take that form?* For centuries this question remained out of reach because the necessary mathematics was absent. Once Einstein supplied it, a new difficulty emerged. His field equations allowed a vast range of possible universes, almost all of them impossible to handle analytically. The theory was rich; its application was forbidding.

In the 1920s two mathematicians, Friedmann⁴ and Lemaître⁵, made a pragmatic choice. They restricted the geometry of the universe to the most symmetrical form imaginable. If the cosmos was the same everywhere and the same in every direction, the metric would collapse to a single freely evolving function. Einstein’s formidable system would reduce to a tractable ordinary differential equation governing the scale factor. The idea was not unreasonable. When faced with a complex problem, it is natural to start with the simplest case.

But this was not a discovery. It was not an observation. It was a decision. A conjecture. In mathematical language it was an *ansatz*:⁶ a provisional form adopted so that a problem

James Clerk Maxwell, *A Treatise on Electricity and Magnetism*, Oxford University Press, 1873. Unification of electricity and magnetism.

Albert Einstein, *Die Grundlage der allgemeinen Relativitätstheorie*, Annalen der Physik, 1916. Exposition of the equivalence principle.

³ Ian Salisbury, *The Time-Symmetric Parity Constraint or The Twin-Time Theory of Cosmology*, <https://doi.org/10.5281/zenodo.17456148>, November 2025. Overview of the structural critique of Λ CDM and development of the parity constraint.

⁴ Alexander Friedmann, *Über die Krümmung des Raumes*, Zeitschrift für Physik 10, 377–386 (1922). The first derivation of non-static cosmological solutions under symmetry assumptions.

⁵ Georges Lemaître, *Un Univers Homogène de Masse Constante et de Rayon Croissant...*, Annales de la Société Scientifique de Bruxelles A47, 49 (1927). Generalisation of Friedmann’s model and introduction of observational expansion.

⁶ *Starting point, approach* (German). An *ansatz* is an educated guess or a trial assumption about the form of a solution to a problem, made to simplify the process of finding the actual, more precise answer. It is a starting point, often based on physical intuition, symmetry, or prior knowledge, that is then rigorously tested and refined.

too broad to approach directly could at least be explored in a special case. Nothing in the sky at the time supported it. The distribution of galaxies was unknown. No large-scale surveys existed. The microwave background had not been detected. The ansatz solved the mathematicians' difficulty, the term simply referring to a chosen form that made an otherwise intractable system soluble. It was not empirical and did not address the puzzle presented by the cosmos. It bypassed it.

In itself there was no harm in that. Science often begins with convenient assumptions or hypotheses. The difficulty arises if convenience quietly hardens into theories or doctrine without proof. Here the observations accumulated with the model, and in consequence the initial symmetry ceased to be a simplifying hypothesis and became the assumed geometry of the universe. When galaxy surveys revealed sheet-like walls, deep voids and sprawling superclusters,⁷ these rough, extravagant structures were said to be "perturbations" around an underlying smoothness. When the microwave background showed a pronounced dipole and hemispherical asymmetries,⁸ the data were processed through pipelines that assumed the very symmetry they purported to test. The universe was not allowed to challenge the form of the model. The model dictated how the universe was to be read.

The consequences are well known but rarely examined at their root. As the FLRW geometry⁹ failed to account for the behaviour of galaxies and clusters, dark matter was introduced. When the geometry failed to explain the near-uniformity of the microwave background, inflation was introduced. When the expansion history derived from the same symmetry failed to match supernova distances, dark energy was introduced. Later tensions have each prompted new suggestions for auxiliary physics: Hubble¹⁰, S_8 , alignment anomalies and the growing list of cosmic dipoles. All these inventions have a common function. They preserve the symmetry assumption placed in the theory a century ago. Λ CDM is the culmination of that sequence, a model assembled not from observation outward but from an initial geometric constraint inward.

The introductory paper to this series discussed these devices as "explainaways", introduced to absorb the conflict between the assumed geometry and the observed universe. But the pattern now extends into the quantum models that have been gaining prominence. Constructs introduced in laboratory physics for operational purposes,

⁷ de Lapparent, Geller & Huchra, *A Slice of the Universe*, *Astrophysical Journal Letters* 302, L1–L5 (1986). The discovery of large-scale structure inconsistent with strict FLRW smoothness.

⁸ Eriksen et al., *Asymmetries in the Cosmic Microwave Background*, *Astrophysical Journal* 605, 14–20 (2004). Analysis revealing hemispherical power asymmetry and large-angle anomalies.

⁹ FLRW refers to the Friedmann–Lemaître–Robertson–Walker family of homogeneous and isotropic cosmological solutions to Einstein's field equations.

¹⁰ Riess et al., *Large Magellanic Cloud Cepheid Standards Provide a 1% Foundation for the Determination of the Hubble Constant*, *Astrophysical Journal* 876, 85 (2019). Key modern statement of the Hubble tension within Λ CDM.

including vacuum states, inflationary potentials, axion fields,¹¹ moduli and the innumerable vacua of string theory,¹² have been promoted into claims about the ontology of the cosmos. Many originated as formal or calculational structures within quantum field theory, developed to organise interactions, define vacuum states or render otherwise intractable problems manageable. In cosmology they are increasingly treated as though they were constituents of reality rather than tools of description. The move resolves no cosmological puzzle. It merely enlarges the machinery of the model without bringing us any closer to understanding the question that prompted it.

TSPC emerged from the opposite direction. Instead of supplementing the standard model, it returned to the puzzle. It asked what geometric law the universe might be obeying, and what symmetry that law might enforce. Instead of a flexible family of cosmologies parameterised by hidden components, it sought a single structural constraint with direct observational consequences. The parity condition, developed through the Compendium, takes the universe's time symmetry seriously and offers a falsifiable geometry without invoking unseen particles or speculative quantum vacua. It treats the cosmos as a system governed by a law, not as a machine maintained by adjustable parts. In that shift lies the first step back towards understanding what the universe is, rather than what the model requires it to be.

This paper forms the second element of a paired analysis. It presupposes the geometric framework developed in the companion TSPC paper, where the parity constraint and the resulting time-symmetric structure of cosmological evolution are set out. That framework is not ancillary. Without it, the observational and conceptual arguments advanced here would appear unmotivated or disconnected. The present study should therefore be read in conjunction with the TSPC formulation, which supplies the underlying geometric assumptions and clarifies why a departure from the standard cosmological model is required.

This essay is both a prequel and a sequel to the TSPC hypothesis. It is a prequel in the sense that it examines the assumption that set cosmology on its present path. It is a sequel in the sense that it follows the same category mistake into the quantum constructions that now orbit Λ CDM. Between these two assumptions lies the reason the puzzle has not been solved. The universe is read through the lens of its assumed symmetries, and the assumed symmetries are read back into the universe. It is a circularity that has acquired the varnish of method but resembles, in outline, the oldest form of sophistry: the elaboration of a system to defend its premise rather than examine

¹¹ Dine & Fischler, *The Not-So-Harmless Axion*, *Physics Letters B* 120 (1983). Representative introduction of axion potentials in quantum field theory; later repurposed in cosmology.

¹² Bousso & Polchinski, *Quantization of Four-Form Fluxes and Dynamical Neutralization of the Cosmological Constant*, *Journal of High-Energy Physics* 06 (2000) 006. Early articulation of the string landscape as a multiplicity of metastable vacua.

it. The puzzle remains intact because the conditions for solving it have not been restored.

What follows is an attempt to restore them.

Part I: The classical error

1. The symmetry that became the Universe

Modern cosmology began with a choice that is seldom discussed. Faced with Einstein's general theory of relativity¹³ – an equation capable of describing every geometry consistent with matter and energy – cosmologists selected one particular form of spacetime. It was the form that made the mathematics manageable. A universe that is perfectly homogeneous and perfectly isotropic reduces the gravitational field to the evolution of a single function, the scale factor. The equations fall into place and the problem collapses to something calculable. What follows owes more to that convenience than to the universe that was meant to be understood.

It is worth pausing on what that choice entails. Homogeneity requires that every region of space be identical to every other. Isotropy demands that every direction be indistinguishable from any alternative. If taken literally, these conditions describe a universe of absolute symmetry, smooth in every respect, unbroken by structure. Nothing in the known universe resembles such perfection. The galaxies we see lie in filaments and walls; the voids between them span hundreds of millions of light years.¹⁴ But the symmetry was not chosen to express the sky. It was chosen to simplify the equation.

With these conditions in place the metric became the familiar FLRW line element:¹⁵

$$ds^2 = -dt^2 + a^2(t) \left[\frac{dr^2}{1 - kr^2} + r^2 d\Omega^2 \right]$$

It looks authoritative now, a monument in the textbooks.¹⁶ At its birth it was no more than a device: a way of approaching a problem that could not otherwise be handled. The simplicity was seductive, and once adopted it began to shape the expectations of the field. The symmetry became the backdrop against which the universe was interpreted. It

¹³ Albert Einstein, *Die Grundlage der allgemeinen Relativitätstheorie*, Annalen der Physik (1916). Foundational presentation of general relativity; establishes the full, unconstrained space of admissible geometries.

¹⁴ de Lapparent, Geller and Huchra, *A Slice of the Universe*, Astrophysical Journal Letters 302, L1–L5 (1986). One of the first surveys showing large-scale filamentary structure inconsistent with strict spatial homogeneity.

¹⁵ Alexander Friedmann, *Über die Krümmung des Raumes*, Zeitschrift für Physik 10, 377–386 (1922). Introduces the symmetric solutions to Einstein's equations that later form the FLRW geometry.

¹⁶ Georges Lemaître, *Un Univers Homogène de Masse Constante et de Rayon Croissant*, Annales de la Société Scientifique de Bruxelles A47 (1927).

supplied the language and the assumptions. In time the assumption was treated as though it had been read from the sky, when in fact the sky had been read through it.

The irony is that cosmology, devoted to understanding structure, began with a geometry that forbids it. The puzzle was removed from view, and the equations yielded only because the difficulty had been excluded at the outset.

2. How a hypothesis became a presumption

When the first large-scale surveys of galaxies arrived, the landscapes they revealed bore little resemblance to the smoothness the model assumed.¹⁷ Immense filaments stretched across the sky. Clusters gathered along ridges. Cavities opened like geological basins. Nothing in this distribution suggested a universe intent on uniformity. Yet the framework absorbed these features with little difficulty. They were reclassified as perturbations: deviations from an underlying smoothness, justified not by observation but by the need to sustain the symmetry that made the mathematics work.

A similar story unfolded with the microwave background. The CMB is still described as the strongest evidence for isotropy,¹⁸ although its interpretation rests on pipelines constructed around the very symmetry being tested. The monopole and dipole are removed; the anisotropies are defined relative to an idealised symmetric sky. When anomalies appeared – hemispherical power, alignments across large angles – they were described as curiosities rather than contradictions.¹⁹ The symmetry was treated as the baseline. The sky was a variation upon it.

By this stage the framework had become self-reinforcing. The geometry dictated the behaviour of the matter fields; the matter fields were fitted to the geometry; and the discrepancies between model and sky produced new entities rather than new questions.

Recent large-volume hydrodynamical simulations illustrate the direction of travel. Projects such as the FLAMINGO project simulation suite are explicitly designed to integrate baryonic physics, feedback processes and survey realism within a fixed Λ CDM background, producing forward models tailored to next-generation observational programmes.²⁰ Their success is technical and instrumental: discrepancies are not

¹⁷ J. Einasto et al., *Supercluster-Void Network*, *Nature* 385, 139–141 (1997). Shows the cosmic web as a dominant feature of galaxy distribution, contradicting homogeneous assumptions.

¹⁸ Planck 2018 results. *VII. Isotropy and statistics of the CMB*, *Astronomy & Astrophysics* 641, A7 (2020). Defines the statistical isotropy baseline, documents monopole and dipole removal, and treats large-angle anomalies within an assumed symmetric framework.

Copi, C. J. et al., *Large-angle anomalies in the CMB*, *Advances in Astronomy* 2010, 847541. Reviews hemispherical power asymmetry and multipole alignments, explicitly framing them as anomalies within an isotropic baseline rather than contradictions.

¹⁹ H. K. Eriksen et al., *Asymmetries in the Cosmic Microwave Background*, *Astrophysical Journal* 605, 14–20 (2004). Shows statistically significant hemispherical asymmetry and large-angle anomalies in the CMB.

²⁰ Schaye et al., *The FLAMINGO project: cosmological hydrodynamical simulations for large-scale structure and galaxy cluster surveys*, *Monthly Notices of the Royal Astronomical Society* 526 (2023). Large-volume (continued)

resolved by revisiting geometric or dynamical premises, but by expanding the space of calibrated physical effects within an assumed cosmology. Such efforts exemplify a shift in emphasis from constraining theoretical structure to managing complexity, ensuring internal consistency at the cost of weakening the link between fit and explanation.

This mode of response did not originate with large simulations. It developed incrementally, as successive observations exposed tensions between the assumed symmetry and the behaviour of the universe. Each time, the geometry was left intact and a compensatory element was introduced to absorb the mismatch. The historical sequence is familiar, but its logic is rarely stated explicitly.

The rotation curves of galaxies did not match the predicted dynamics, and dark matter entered. The uniformity of the microwave background did not match the initial conditions implied by the geometry, and inflation entered. The supernova distances did not match the expected expansion history, and dark energy entered. With each addition the model became more intricate and the symmetry more secure.²¹ The puzzle remained untouched.

What had begun as a hypothesis was now treated as a fact. The assumption that made the equations soluble had become the geometry of the universe, maintained at the cost of new physics whenever the sky refused to comply.

3. The cost of the assumption

The cost is not measured in mathematical elegance, which FLRW certainly possesses, nor in observational success, of which the model has enough to sustain its popularity. The cost lies elsewhere. The symmetry reverses the scientific direction of travel. Instead of inferring the geometry from what is seen, the geometry is fixed in advance and the universe is interpreted through it. Every contradiction becomes an opportunity to extend the model, never to reconsider its foundation. Complexity accumulates and the puzzle deepens.

The symmetry, intended only as a starting point, became the conclusion. Once adopted it shaped a century of cosmology, determining not only what could be inferred but what could be imagined. The possibility that the universe does not obey this assumed symmetry has seldom been considered, and when it has, it has been set aside on the grounds that the standard model works “well enough”. But “well enough” is circular when the framework grows by accretion, absorbing each discrepancy with a new ingredient. The puzzle was not solved; it was postponed.

hydrodynamical simulations developed to support survey interpretation within Λ CDM through calibrated baryonic and feedback modelling.

²¹ Perlmutter et al., *Measurements of Omega and Lambda from 42 High-Redshift Supernovae*, *Astrophysical Journal* 517, 565–586 (1999). Landmark paper showing accelerated expansion inconsistent with a matter-only FLRW model.

The classical error, then, was not that the ansatz was adopted. It was that it was not relinquished when the sky offered reasons to question it. A provisional convenience became a governing presumption. A method became a metaphysics. The universe became a reflection of an assumption introduced merely to ease calculation.

4. The scaffolding problem

Once the FLRW symmetry had become the assumed frame of the universe, the model gained a curious rigidity. It could bend, but only in certain places. Where the symmetry held, the model appeared robust. Where it did not, the symmetry was not questioned. Instead, something else was introduced to absorb the strain.

The first major strain came from the galaxies themselves. Their rotation curves did not diminish with radius as the model required. They flattened.²² The gravitational field implied by FLRW dynamics was too weak to bind them. The discrepancy was not small. It was systemic. The geometry did not admit the behaviour the sky displayed. The response was not to question the geometry but to supply an invisible mass component to repair it. Dark matter entered the picture, not as a direct inference from observation, but as a compensatory term. The puzzle remained.

A similar tension arose at larger scales. Galaxy clusters behaved as though they contained far more mass than the luminous matter implied.²³ The standard model absorbed the contradiction by extending dark matter into halos of enormous extent. Again the symmetry was preserved, and again the new component was fitted to the discrepancy. The geometry stayed intact.

The same pattern appeared a decade later when the uniformity of the cosmic microwave background was recognised as a profound challenge to the FLRW picture. Under the assumed expansion history, regions now separated by billions of light years could never have been in causal contact.²⁴ They should not share the same temperature. The puzzle was stark. The adopted symmetry forbade the uniformity the sky displayed.

Inflation resolved this difficulty by fiat. A brief period of exponential expansion was placed before the hot Big Bang, stretching a locally uniform state across the observable

²² Vera Rubin and Kent Ford, *Rotation of the Andromeda Nebula from a Spectroscopic Survey of Emission Regions*, *Astrophysical Journal* 159, 379 (1970). Classic observational evidence for flat rotation curves requiring additional mass under the FLRW framework.

²³ Fritz Zwicky, *Die Rotverschiebung von extragalaktischen Nebeln*, *Helvetica Physica Acta* 6, 110–127 (1933). First identification of the “missing mass” problem in clusters. However, Zwicky’s result sat largely ignored for decades. The idea only became structurally embedded in cosmology much later, through work such as: Vera Rubin (galaxy rotation curves, 1970s) and Cluster X-ray and lensing studies (1970s–90s).

²⁴ Alan Guth, *Inflationary Universe: A Possible Solution to the Horizon and Flatness Problems*, *Physical Review D* 23, 347–356 (1981). Introduces inflation explicitly to resolve the horizon and flatness problems arising from FLRW assumptions.

universe.²⁵ The mechanism varied from author to author; the details grew increasingly elaborate; but the purpose remained fixed. Inflation did not explain the puzzle. It removed it. The symmetry remained untouched.

Dark energy followed at the end of the century. The distances to high-redshift supernovae did not match the expected expansion history. Under the assumed geometry the universe appeared to accelerate. The response was not to reconsider the geometry but to introduce a new component of energy with negative pressure, finely tuned to produce the observed distances without disrupting the rest of the model. Λ CDM acquired its final letter.²⁶

With each addition the framework grew heavier. What began as a single assumption had become an edifice supported by increasingly intricate scaffolding. The list of required elements lengthened; their evidential status remained uneven. The puzzle persisted in slightly altered forms. The geometry was being defended by expanding the cast of unseen actors.

None of these devices is implausible in isolation. Each was introduced to address a specific observational conflict. But taken together they reveal a model that has become reactive rather than explanatory. The symmetry determines the structure; the structure determines the tensions; the tensions determine the additions. The line of inference runs backwards, from assumption to elaboration. The same pattern appears even in the interpretation of our immediate cosmic environment.

High-resolution reconstructions of the mass distribution in and around the Local Group illustrate how effectively standard cosmology absorbs apparent anomalies through progressively refined modelling. A 2026 *Nature Astronomy* analysis by Wempe *et al.* presents a detailed dynamical account of the Milky Way–Andromeda system, treating it not as a two-body problem but as an extended, non-virialised structure embedded within the surrounding cosmic web.²⁷ By incorporating diffuse mass beyond nominal virial radii, filamentary environment, and phase-space information from dwarf galaxy tracers, the authors show that

²⁵ Guth, A. H., *Inflationary universe: A possible solution to the horizon and flatness problems*, Physical Review D 23, 347 (1981). Introduces inflation explicitly to account for large-scale uniformity by stretching a locally homogeneous region.

Brandenberger, R., *Initial conditions for inflation: A short review*, International Journal of Modern Physics D 26, 1740002 (2017). Reviews the dependence of inflation on assumed initial homogeneity and the persistence of the underlying symmetry requirement.

Ijjas, A., Steinhardt, P. J., Loeb, A., *Inflationary paradigm in trouble after Planck2013*, Physics Letters B 723, 261 (2013). Argues that inflation shifts rather than resolves the problem of initial conditions, with increasing model complexity.

²⁶ Riess et al., *Observational Evidence from Supernovae for an Accelerating Universe*, Astronomical Journal 116, 1009 (1998). One of two independent teams establishing the observational basis for adding Λ to the standard model.

²⁷ Wempe, E., White, S.D.M., Helmi, A. *et al.*, *The mass distribution in and around the Local Group*, Nature Astronomy (2026). Demonstrates how Local Group dynamics, including Andromeda's blueshift, are rendered consistent with Λ CDM through extended mass modelling and environmental completion rather than new physical principles.

features often regarded as tensions, including the blueshift of Andromeda, can be rendered consistent with Λ CDM expectations. The result is technically careful and internally coherent.

What the analysis demonstrates, however, is not explanatory closure but the growing reliance of standard cosmology on inference architecture. The Andromeda blueshift is accounted for not by identifying a sharp physical transition between cosmic expansion and local dynamics, but by enlarging the effective system boundary until the observed velocities become unsurprising. This manoeuvre is legitimate within the model, yet it leaves untouched the deeper question of whether the assumed separation between global expansion, peculiar motion, and environmental influence is itself empirically warranted. In this sense, the Local Group serves as a microcosm of the wider cosmological method: discrepancies are resolved by structural completion rather than constraint. The Time-Symmetric Parity Constraint is motivated precisely by this pattern, seeking to limit the permissible geometric structure of spacetime rather than indefinitely extending the domain over which existing assumptions are allowed to operate.

The result is a theory that is complex in proportion to its fragility. Each new component is domesticated into the model with impressive ingenuity, and each is presented as though it completed a portrait of the universe. In reality they complete a portrait of the assumptions that required them. The puzzle is not addressed in its own terms. It is managed.

There is no scientific crime in temporary scaffolding. The crime lies in mistaking it for architecture.

5. The turning point

Every scientific framework reaches a moment when the question sustaining it changes. At first the question is direct: *Is this assumption correct?* Later, if the framework proves useful, the question becomes indirect: *What must be added to preserve the assumption?* Cosmology crossed that threshold without noticing it had done so.

By the end of the twentieth century the standard model carried more auxiliary structure than the problem it had set out to solve. The geometry was fixed; the scaffolding extended around it. Nothing in the observations forced this arrangement. No survey, no experiment, no anomaly required that the universe be described by a perfectly symmetric metric with additional ingredients attached. Yet the habit of responding to each tension with a new component had become so familiar that the structure no longer felt improvised. It felt complete.

It was at this point that a re-examination of the symmetry assumption should have been unavoidable. The proliferation of unseen components was not a marginal detail; it was the defining feature of the model. The cosmos appeared to consist primarily of entities introduced to defend the geometric framework, not to illuminate the puzzle the universe presented. A theory in which the least understood elements are the most

numerous has departed from the pattern that guides physics elsewhere. It has entered a different kind of inquiry.

But cosmology did not turn back. It turned inward. Instead of reassessing the assumption of homogeneity and isotropy, it accepted the growing cast of dark components as evidence of hidden physics awaiting discovery. The puzzle was not taken as a sign that the model required structural revision. It was taken as a sign that the universe contained new sectors of matter and energy. The theoretical effort was directed not toward the geometry of spacetime but toward the catalogue of possible fields.

This shift was subtle and consequential. Once new physics is invoked to support an assumed geometry, rather than to describe an observed phenomenon, the direction of explanation inverts. The assumed structure outranks the evidence. The puzzle becomes a problem of model-fitting rather than a question of understanding.

The turning point was clear enough in hindsight. The standard model now required dark matter to stabilise its dynamics; inflation to sanitise its initial conditions; dark energy to correct its distances; and further adjustments to account for tensions in the Hubble parameter, the growth of structure and the large-scale alignments of the sky.²⁸ Each addition resolved a discrepancy with the symmetry assumption. None resolved the puzzle that lay beneath it.

By the start of the twenty-first century cosmology had acquired the outward form of a mature science, complete with standard parameters, fitted curves, confidence intervals and an agreed set of anomalies. But the foundations had slipped. The geometry at the heart of the model was still an operational choice made in the 1920s, and the auxiliary fields that surrounded it were still provisional constructs introduced to preserve that choice. The puzzle persisted.

This was the moment at which the field could have paused, taken stock and reconsidered the question it was asking. It could have returned to first principles, examined the role of symmetry in the theory and asked whether a law of geometry, rather than a cascade of new components, was required. It could have separated the convenience of the FLRW form from any claim that the universe must obey it.

It did not. Instead, the quantum turn began. The scaffolding of the standard model was carried upward into a new domain, where the operational tools of particle physics were recast as ontological claims about the universe: vacua, potentials, fields, landscapes, sectors, mechanisms. The puzzle was not simplified; it was multiplied.

²⁸ Planck Collaboration, *Planck 2018 Results. VI. Cosmological Parameters*, Astronomy & Astrophysics 641, A6 (2020). Provides the most precise Λ CDM parameter fits and formulates the Hubble tension and S_8 discrepancy.

TSPC was developed from the opposite impulse. Instead of extending the scaffolding, it returned to the puzzle itself. It set aside the inherited symmetry and asked what geometric principle the universe might actually obey. Whether or not that programme succeeds is secondary here. What matters is that it marks the point where the original question reappears. The puzzle that was bypassed in the classical model, and obscured in the quantum elaborations that followed, can be examined again only when the symmetry assumption is no longer treated as a fact.

Part II: The quantum error

6. When calculation becomes description

Quantum theory did not enter cosmology to solve a cosmic problem. It entered because quantum mechanics had already transformed physics elsewhere.²⁹ Its methods were powerful: perturbative techniques, renormalisation schemes, potential-driven dynamics,³⁰ vacuum states chosen for symmetry or convenience. These devices were created for laboratories and accelerators, tightly bounded systems in which parameters can be controlled and the purpose of each construct is unambiguous. Their role was never to describe the universe. Their role was to produce testable predictions at the microscopic scale.

In particle physics this distinction is explicit. The vacuum is a calculational baseline, not a stage of the world.³¹ A field is a device for generating amplitudes, not a substance. A potential is a way to organise a perturbative expansion, not a terrain through which nature must travel. These are the scaffolding of a method, not the furniture of reality.

In cosmology the distinction slipped. The operational constructs of quantum field theory were promoted, almost silently, into claims about what the universe contains and how it behaves. A vacuum state became the physical state of the early universe. A potential became a landscape the cosmos was said to “roll down”. A quantum field became a component of the universe’s actual inventory. The shift was subtle; the effect dramatic. A method became a mechanism. A convenience became a narrative. Estimates from a scattering formalism became descriptions of cosmic history.

Inflation provides the clearest case. It was introduced not as a discovery but as a repair:³² a way to correct initial conditions implied by the FLRW symmetry. To make it

²⁹ Steven Weinberg, *The Quantum Theory of Fields*, Cambridge University Press (1995). Definitive statement of QFT as an operational framework built for scattering theory, not cosmology.

³⁰ Michael Peskin and Daniel Schroeder, *An Introduction to Quantum Field Theory*, Westview Press (1995). Standard reference on perturbation theory, renormalisation and potentials as calculational devices.

³¹ N. N. Bogoliubov and D. V. Shirkov, *Introduction to the Theory of Quantized Fields*, Wiley (1959). Early canonical text clarifying the vacuum as a choice of state for calculations, not an ontological claim.

³² Alan H. Guth, *Inflationary Universe: A Possible Solution to the Horizon and Flatness Problems*, *Physical Review D* 23, 347–356 (1981). The original formulation of inflation, explicitly introduced to fix FLRW initial-condition problems.

work, the theory needed a scalar field with a potential of adjustable shape. That potential was taken from the repertoire of quantum field theory, where such functions exist to tidy calculations.³³ In cosmology it was treated as a real energy component that drove the early expansion. The degrees of freedom added to the model were not inferred from evidence. They were borrowed from a method and repurposed as explanations of the universe. The puzzle was not solved, it was postponed.

The same pattern appeared in dark-sector proposals. Axions, moduli, pseudoscalars and other speculative fields entered the model not because evidence demanded them, but because the operational flexibility of quantum theory allowed them.³⁴ A framework that permits arbitrary potentials permits arbitrary adjustments. A theory with vast field spaces permits vast interpretive freedom. The constructs designed to handle scattering amplitudes were quietly reclassified as the ontology of the cosmos.

None of this was fraudulent. It was the natural extension of a habit. Once physics had become comfortable introducing unseen components to sustain the classical symmetry, it was only a small step to extend the practice into the quantum domain. The means changed; the pattern did not. The puzzle remained untouched behind an ever more elaborate façade.

7. The expansion of the possible

Quantum cosmology expanded rapidly because quantum theory allows possibilities that classical cosmology never could. The space of admissible potentials is immense. The space of vacuum configurations is larger still. Once these spaces were treated as physically real, cosmology inherited their vastness.

String theory multiplied this effect. It produced not one geometry but a landscape:³⁵ a combinatorial expanse of possible vacua, each with its own fields, constants and patterns of behaviour. This was not a prediction. It was a catalogue. Yet the catalogue began to be interpreted as a map of what the universe might contain. The escape into the landscape was not the pursuit of a puzzle. It was the pursuit of an ontology that would preserve the initial geometric assumption by expanding it indefinitely.

At this point the distinction between operation and ontology all but dissolved. A vacuum used to compute amplitudes in a laboratory became a claim about the universe's origin. A potential drawn to organise perturbation theory became a mechanism governing cosmic evolution. A moduli space invented to rationalise a mathematical framework

³³ Andrei Linde, *Chaotic Inflation*, Physics Letters B 129, 177–181 (1983). Demonstrates how adjustable potentials from QFT families can be used to generate desired inflationary dynamics.

³⁴ Michael Dine and Willy Fischler, *The Not-So-Harmless Axion*, Physics Letters B 120 (1983). Key early construction of axion potentials, later repurposed as cosmological fields.

³⁵ Raphael Bousso and Joseph Polchinski, *Quantization of Four-Form Fluxes and Dynamical Neutralization of the Cosmological Constant*, Journal of High Energy Physics 06 (2000) 006. Foundational paper introducing the string landscape of metastable vacua.

became a storehouse of universes. The tools of the method became the contents of the world.

This is the quantum error. Not an error of physics but an error of interpretation. A device introduced to make calculations tractable was treated as an element of reality. The classical error elevated symmetry into geometry. The quantum error elevated method into ontology.³⁶ Both arose from the same category mistake.

8. The puzzle multiplied

The puzzle did not become simpler under these elaborations. It became more ornate. Inflation explained the uniformity of the microwave background by introducing a field with a potential of arbitrary shape.³⁷ Dark energy explained supernova distances by introducing a new component with negative pressure. Axions and moduli offered adjustable remedies for structure formation and the Hubble tension.³⁸ Each proposal solved a local difficulty. None explained why the universe should require them.

As observations improved, the model grew. Dark matter gained sub-species. Inflationary potentials proliferated. Dark energy acquired dynamical variants. String vacua multiplied into a combinatorial atlas. Every anomaly produced another layer of construction.³⁹ The puzzle itself remained untouched.

There is a moment in every field when auxiliary structure begins to obscure the original question. Cosmology has reached that moment. The difficulty is not the mathematics of quantum field theory. It is the use to which it has been put. The operational machinery of particle physics was imported to support a geometric assumption, not to reveal a cosmic law. The symmetry survived. The puzzle did not.

9. The cosmological misappropriation

9.1 Inflation

The causal structure of the FLRW universe implies that regions now separated by billions of light years were never in mutual contact. Yet the cosmic microwave background is almost uniform. Inflation was devised to repair this mismatch. It

³⁶ John Earman, *World Enough and Space-Time*, MIT Press (1989). Explores how symmetry assumptions can harden into ontological commitments.

³⁷ Stephen Hawking and Gary Gibbons, *Action Integrals and Partition Functions in Quantum Cosmology*, Physical Review D 15, 2752 (1977). Provides the theoretical context in which uniformity is viewed as a profound constraint requiring explanation.

³⁸ Planck Collaboration, *Planck 2018 Results. VI. Cosmological Parameters*, Astronomy & Astrophysics 641, A6 (2020). Summary of the leading cosmological tensions arising within Λ CDM, including H_0 and S_8 .

³⁹ L. Verde, T. Treu and A. Riess, *Tensions Between the Early and Late Universe*, Nature Astronomy 3, 891–895 (2019). Review emphasising compounding anomalies within Λ CDM and the inadequacy of additive fixes.

introduces a scalar field $\phi(t)$ with a potential $V(\phi)$, chosen so that the early universe undergoes rapid accelerated expansion.

The classical Friedmann equation for an FLRW background is:

$$H^2 = \frac{8\pi G}{3} \rho - \frac{k}{a^2}.$$

For a homogeneous scalar field, the energy density and pressure are:

$$\rho_\phi = \frac{1}{2} \dot{\phi}^2 + V(\phi), p_\phi = \frac{1}{2} \dot{\phi}^2 - V(\phi).$$

The field obeys the Klein–Gordon equation:

$$\ddot{\phi} + 3H\dot{\phi} + V'(\phi) = 0.$$

Inflation requires the slow-roll conditions:

$$\dot{\phi}^2 \ll V(\phi), |\ddot{\phi}| \ll 3H |\dot{\phi}|,$$

under which the dynamics reduce to:

$$H^2 \approx \frac{8\pi G}{3} V(\phi), 3H\dot{\phi} \approx -V'(\phi).$$

These equations are compact and elegant, but their physical implications depend entirely on the choice of potential. Quantum field theory permits infinitely many. Monomial, plateau, hilltop, hybrid, exponential and non-minimal forms all generate inflationary behaviour. Each yields a different number of e-folds, a different spectral index, a different tensor amplitude. The potential is not observed. It is selected because it makes the model work.⁴⁰

In particle physics such freedom is tolerated because the potential is not taken to be real. It is a device for organising interactions. In cosmology it was reinterpreted as a feature of the universe. The slow-roll parameters became properties of “the early universe”, not artefacts of a particular functional choice. A device imported from another domain became a narrative of cosmic origin. Nothing in the derivation required this. The step was interpretative, not physical.⁴¹

⁴⁰ J. Martin, C. Ringeval and V. Vennin, *Encyclopaedia Inflationaris*, Physics of the Dark Universe 5–6 (2014). Survey showing the immense freedom in inflationary potentials compatible with current data.

⁴¹ Roger Penrose, *The Road to Reality*, Jonathan Cape (2004). Penrose’s critique emphasising that inflation is not a deduction from GR but an interpretative insertion to repair initial conditions.

9.2 Dark-sector fields

The same pattern appears in models proposing new light fields. Each is introduced to supplement a deficiency in the standard cosmological model: axions, ultralight scalars, pseudoscalars, moduli. A typical axion potential is:

$$V(\theta) = m_a^2 f_a^2 (1 - \cos \theta),$$

which reduces, for small θ , to a quadratic form. The misalignment mechanism then supplies a relic abundance behaving like cold dark matter. But the parameters m_a and f_a can take values across more than thirty orders of magnitude. The field is unseen; its properties unconstrained; its purpose defined by its utility.

Moduli fields in higher-dimensional theories behave similarly.⁴² Their effective potential V_{eff} regulates the sizes and shapes of compact dimensions. In cosmology those same potentials are treated as physical landscapes with dynamical roles in late-time acceleration, early-time evolution or structure formation. Again, the constructs were developed to make a speculative quantum model internally consistent. They became cosmological ingredients by interpretative drift.

9.3 String vacua

String theory magnified this interpretative difficulty. The effective moduli-space potential can be summarised schematically as:

$$V_{\text{eff}}(\phi_1, \phi_2, \dots, \phi_N),$$

with an enormous number of local minima. Each minimum represents a metastable vacuum, differing in particle content, coupling constants and vacuum energy. Originally these minima were not worlds. They were bookkeeping entries in a theory whose low-energy limit had not been determined.

In cosmology they acquired ontological status. Eternal inflation was invoked to populate them.⁴³ The landscape became a set of possible universes. The multiverse became a physical claim. Nothing empirical demanded this expansion. It arose from mathematical freedom misinterpreted as cosmological richness.

⁴² T. Banks, M. Dine and E. Seiberg, *Irrational Axions as a Solution to the Strong CP Problem in an Eternal Universe*, Physical Letters B 273 (1991). Representative work on moduli and axion-like potentials arising in higher-dimensional theories.

⁴³ Andrei Linde, *Eternally Existing Self-Reproducing Chaotic Inflationary Universe*, Physics Letters B 175, 395–400 (1986). Proposes eternal inflation as the mechanism populating multiple vacua.

9.4 Loop quantum cosmology

Loop quantum cosmology (LQC) begins from a different premise but ends in the same conceptual place.⁴⁴ By applying loop quantisation to FLRW spacetime, the classical Friedmann equation is replaced by

$$H^2 = \frac{8\pi G}{3} \rho \left(1 - \frac{\rho}{\rho_c}\right),$$

in which ρ_c is a critical density set by the quantisation procedure.⁴⁵ As $\rho \rightarrow \rho_c$, the universe undergoes a bounce rather than a singularity. This is an interesting result. But it reflects the quantisation method more than it reflects evidence. Yet the bounce is frequently presented as a stage in the universe's actual history. Again, a tool becomes a description.

9.5 The common thread

Inflation, axions, moduli, string vacua, LQC corrections: they differ in scope and ambition, yet they share the same structural feature. They begin with constructs developed for calculation. They end by treating those constructs as constituents of the universe.

The mathematics is legitimate. The interpretation is not. Each construct repairs a difficulty created by the FLRW geometry and its consequences. None explains the puzzle itself.

10. The parallel: two errors, one origin

The quantum error does not stand alone. It mirrors the classical one. Each arose from a different direction, yet both reflect the same underlying habit: the tendency to read the structure of a model into the structure of the world.

In the classical case, a symmetry chosen to make Einstein's equations soluble was allowed to harden into a description of the universe. Homogeneity and isotropy, introduced as an ansatz, became the assumed geometry of the cosmos. When observations conflicted with this picture, the symmetry was preserved and the model expanded around it.

In the quantum case, operational devices designed for calculation were allowed to migrate into ontology. Vacua, potentials and field configurations, introduced to support perturbation theory, became the supposed constituents of the early universe. When

⁴⁴ Abhay Ashtekar, Tomasz Pawłowski and Parampreet Singh, *Quantum Nature of the Big Bang*, Physical Review Letters 96, 141301 (2006). Canonical LQC demonstration of the bounce replacing classical singularity.

⁴⁵ Martin Bojowald, *Loop Quantum Cosmology*, Living Reviews in Relativity 8, 11 (2005). Derives the effective Friedmann equation with quantum-geometry corrections.

tensions increased, more constructs were added. The method was preserved; its domain expanded.

The two errors differ in form but not in nature. Both arise from confusing the scaffolding of a theory with the structure of reality. Both elevate what was introduced for convenience into something that carries explanatory weight. And in both cases, the puzzle that first prompted the theory remained unaltered beneath the accumulating machinery.

The result is a model that has grown in complexity without gaining clarity.⁴⁶ The assumptions have been protected; the universe has not been explained. What unites the classical and quantum errors is not their mathematics but their interpretative stance. Both are attempts to stabilise a framework rather than to understand a puzzle.

Recognising this parallel is the necessary step before anything further can be said about cosmology. It reveals that the difficulty is not in any single component of the standard model, nor in any particular quantum extension, but in the way the entire enterprise has been framed. The model has been allowed to dictate what the universe must be, rather than the universe dictating how the model must change.

Only when the origin of both errors is acknowledged can the search for a genuine law begin.⁴⁷

Part III: The return to ontology

11. What a law must be

There is a difference between a rule used to calculate and a law used to describe. The difference is not subtle. A calculational rule is chosen for convenience, clarity or tractability. A law is discovered. It states something about the world that remains true when methods change and theories evolve. In physics this distinction has always mattered. In cosmology it has become blurred.

The preceding century of work, classical and quantum, has treated operational constructs as though they were laws. Symmetry requirements imposed for mathematical convenience have been taken as statements about the universe. Potentials drawn for quantum calculations have been taken as landscapes the cosmos must traverse. Vacuum states defined to organise perturbation theory have been treated as

⁴⁶ George F. R. Ellis, *Issues in the Philosophy of Cosmology*, in *Handbook of Philosophy of Physics* (2007). Ellis examines how cosmological models accumulate parameters and components without resolving foundational questions.

⁴⁷ Julian Barbour, *The End of Time*, Weidenfeld & Nicolson (1999). Argues that physics must return to timeless structural principles rather than rely on accumulated mechanisms.

physical stages of cosmic evolution. In each case the convenience of a method has migrated into the ontology of the world.

To understand what has gone wrong, it helps to recall what laws look like when they are at their best. The inverse-square law did not arise because Newton wanted to simplify orbital calculations. He discovered a relation that planets already obeyed. Maxwell's equations were not written to tidy up the algebra of currents and fields. They summarised a structure that experiments had already revealed. The Schrödinger equation was not created to patch inconsistencies in wave mechanics. It was an expression of an underlying symmetry that nature had insisted upon.⁴⁸ These laws were not scaffolding. They were the underlying architecture.

A law in cosmology must play the same role. It must identify a structural relation the universe actually obeys, not a construct introduced to make the equations soluble. It must reduce complexity rather than absorb it. And it must illuminate the puzzle that gave rise to the theory in the first place. A century of cosmology has inverted these conditions. The laws have been built around an assumption rather than the assumption emerging from the law.

A genuine law does not permit arbitrary adjustment. It does not allow parameters to roam across many orders of magnitude without consequence. It does not require auxiliary mechanisms to preserve its form. A law narrows the permissible. It forbids far more than it permits. The FLRW symmetry does the opposite. It allows a large family of universes, each requiring additional constructs to resemble the one we inhabit. Its generality is not a strength. It is the sign of an absent law.

Quantum cosmology exhibits the same pattern. Potentials in inflationary theory can take almost any form; the predictions depend on the choice. Dark-sector fields can have masses anywhere between 10^{-33} eV and 10^{-3} eV; the cosmological consequences can be fitted at will. String vacua number in the millions; one is chosen post hoc to match observations. Loop quantum cosmology produces corrections that depend on the quantisation scheme, not the universe.⁴⁹ These are not laws. They are design freedoms that obscure the absence of one.

⁴⁸ Isaac Newton, *Philosophiae Naturalis Principia Mathematica*, London (1687). Foundational derivation of the inverse-square law from planetary motion.

James Clerk Maxwell, *A Treatise on Electricity and Magnetism*, Oxford University Press (1873). Unifies electricity and magnetism into a compact set of field equations.

Erwin Schrödinger, *Quantisierung als Eigenwertproblem*, *Annalen der Physik* 79, 361–376 (1926). Introduces the Schrödinger equation as a law encoding quantum dynamics.

⁴⁹ P. J. E. Peebles and Bharat Ratra, *The Cosmological Constant and Dark Energy*, *Reviews of Modern Physics* 75, 559–606 (2003). Reviews scalar-field dark energy models and the wide range of allowed masses.

Raphael Bousso and Joseph Polchinski, *Quantization of Four-Form Fluxes and Dynamical Neutralization of the Cosmological Constant*, *Journal of High Energy Physics* 06 (2000) 006. Introduces the multiplicity of string vacua.

(continued)

The absence of a genuine law is what allows the puzzle to persist. A universe described by scaffolding cannot be understood. It can only be managed. Each anomaly becomes another occasion for invention. Each tension is an opportunity to refine a potential, adjust a parameter or extend a field. Complexity increases because nothing in the framework prevents it.

A law does not behave this way. A law removes freedom. It compels simplicity. It makes prediction possible, not because the model is flexible but because the universe is constrained. The question is not which potentials work, which vacua can be chosen or which corrections can be introduced. The question is what the universe is doing. The symmetry required is whatever the law demands, not whatever makes the mathematics comfortable.

Cosmology has delayed this question for nearly a century. The FLRW assumption was introduced before the relevant data existed. Quantum constructs were introduced before their cosmological relevance was established. Both have become entrenched because the field has grown used to adjusting itself around them. But the absence of a law is visible in the model's architecture. It is not a failing of observation. It is a sign that the wrong question has been asked.

What, then, should a law of cosmology look like? It must begin with structure, not mechanism. It must specify a relation the universe cannot violate, not a dynamical history we infer from partial data. It must be falsifiable in its simplest form, not preserved by adjustable additions. And it must resolve the puzzle at its origin, not displace it into fields and sectors introduced to save an assumption.

A law of cosmology should not resemble a shopping list of components. It should resemble the deep constraints that govern physics elsewhere: the conservation of energy, Lorentz symmetry, the equivalence principle, gauge invariance.⁵⁰ These are not conveniences. They are principles that cannot be altered without altering the world. They stand at the foundation of theory, not at its periphery.

A genuine cosmological law need not explain everything. It does not need to specify the contents of the early universe, the details of reheating, the mass of neutrinos or the tension between local and global measurements of the Hubble parameter. It must instead identify the structural relation that governs the geometry of the universe: one that is simple enough to be discovered, strict enough to constrain, and transparent enough to test.

Abhay Ashtekar, Tomasz Pawłowski and Parampreet Singh, *Quantum Nature of the Big Bang*, Physical Review Letters 96, 141301 (2006). Illustrates how LQC corrections depend on quantisation choices.

⁵⁰ L. D. Landau and E. M. Lifshitz, *The Classical Theory of Fields*, Pergamon (1971). Standard account of Lorentz symmetry, energy-momentum conservation and the equivalence principle.

C. N. Yang and R. L. Mills, *Conservation of Isotopic Spin and Isotopic Gauge Invariance*, Physical Review 96, 191–195 (1954). Classic formulation of non-Abelian gauge invariance.

The absence of such a law is what has allowed the last century to unfold as it has. Operational constructs have been read as cosmic principles. Assumptions have been taken as observations. Potentials have been taken as landscapes. Vacua have been taken as worlds. The puzzle has been decorated, not solved.

Recovering cosmology as a science rather than an engineering exercise requires reintroducing the distinction that has been lost. We must separate the tools from the world. We must distinguish between the conveniences of calculation and the necessities of nature. Only then can the puzzle be approached anew. Only then can a law be recognised when it appears.

12. The shape of a law: geometry, not ingredients

If cosmology is to recover the coherence found elsewhere in physics, it must return to the question set aside a century ago: *what governs the structure of the universe?* The answer does not lie in the ingredients accumulated around the standard model. Those ingredients – fields, potentials, vacua, exotic fluids – proliferate precisely because the governing relation has been missing. They preserve the framework; they do not define it.

Physics has seen this pattern before. When variables multiply, one looks for a deeper relation. Thermodynamics replaced mechanical descriptions with principles of entropy and energy. Maxwell unified disparate electrical and magnetic laws. General relativity replaced forces with the curvature of spacetime.⁵¹ In every case the advance came not from new ingredients but from a constraint on what is possible.

Cosmology must make the same shift. The universe is not determined by its contents but by the geometric relations those contents must obey. The mistake has been to treat the ingredients as fundamental and the geometry as adjustable. The ordering is the reverse. A cosmological law must specify a condition on spacetime itself, not a catalogue of fields whose number increases when the model is strained.

A law is not a mechanism. It does not explain the universe by assembling components. It identifies a constraint the universe cannot violate. Einstein's equations provide one such constraint, but not the conditions that determine which geometries are allowed.⁵² The

⁵¹ Rudolf Clausius, *Über verschiedene für die Anwendung bequeme Formen der Hauptgleichungen der mechanischen Wärmetheorie*, Annalen der Physik 125, 353–400 (1865). Establishes the entropy formulation of thermodynamics.

J. Willard Gibbs, *The Scientific Papers of J. Willard Gibbs*, Vol. 1, Longmans (1906). Develops the thermodynamic potentials and the energy–entropy framework.

James Clerk Maxwell, *A Treatise on Electricity and Magnetism*, Oxford University Press (1873). Synthesises electromagnetic laws into a unified set of equations.

Albert Einstein, *Die Grundlage der allgemeinen Relativitätstheorie*, Annalen der Physik (1916). Replaces gravitational forces with the geometry of spacetime.

⁵² Robert M. Wald, *General Relativity*, University of Chicago Press (1984). Standard treatment of Einstein's equations as constraints on the spacetime metric rather than forces in a background space.

FLRW ansatz filled that gap by symmetry rather than principle. Its convenience disguised the absence of a law.

A genuine law must reduce, not multiply, the degrees of freedom available to the universe. FLRW does the opposite: it presumes the answer by forcing the universe into a one-dimensional evolution. A true law would impose a structural limitation on the metric, a principle that constrains the dynamics without dictating their details.

Such a principle must be simple, global, and falsifiable on its own terms. It must yield the observed large-scale features of the universe by necessity rather than adjustment. Simplicity does not mean triviality. The equivalence principle, gauge symmetry, and energy conservation each show how a compact condition can carry vast consequence.

The contrast with a potential is instructive. A potential can be shaped at will. A law cannot. A law forbids. It excludes. Its power lies in what it rules out.

A cosmological law must therefore eliminate most of the geometries permitted by Einstein's equations.⁵³ The standard model does the reverse. It retains too many possibilities and reaches the observed universe through auxiliary mechanisms added to secure the desired behaviour. This is not explanation: it is reconstruction.

The universe itself points to the need for such a law. Large-scale anisotropies, Hubble tensions, growth anomalies, and mismatches in geometric relations all testify that the existing framework cannot be patched indefinitely. A constraint is required, not another mechanism. The question is whether such a law exists.

13. The return of the puzzle

The puzzle of the universe is older than cosmology itself. It lies in the coherence of the world at the largest scales: the presence of structure where none was expected, the smoothness of the microwave background across regions that should not have communicated, the tendency of matter to organise itself into patterns that defy the statistical predictions of the standard model, and the curious alignment of cosmic features across distances too great to share a common cause. These are not separate mysteries. They are facets of a single question.

The question is this: *what is the universe doing?* Not what fields it contains, or what potentials it might have traversed, or what sectors could be added to quieten a discordant measurement. What is the structural principle that gives rise to the behaviour we see?

Historically, the emergence of unexpected structure has always pointed to a deeper relation. The stability of planetary orbits pointed to a gravitational law. The interference

⁵³ George F. R. Ellis, *Issues in the Philosophy of Cosmology*, in *Handbook of Philosophy of Physics*, Elsevier (2007). Discusses the proliferation of solutions to Einstein's equations and the need for additional principles to select physical cosmologies.

of light pointed to the superposition principle. The quantisation of atomic spectra pointed to the discreteness of energy levels. In each case the anomaly was not dismissed or accommodated by auxiliary mechanisms. It was taken seriously enough to challenge the framework.

Cosmology took the opposite path, protecting the framework rather than allowing anomaly to challenge it. When the universe refused to behave according to the assumed symmetry, the symmetry was not questioned. Instead the behaviour was reinterpreted as an exception or as a sign of unseen components. The anomaly became a problem to be managed, not a clue to be followed. The puzzle was separated into parts and assigned to different mechanisms: inflation for uniformity, dark matter for structure, dark energy for acceleration, dark sectors for tensions. The unifying question was lost.

But the puzzle has persisted. The more precise the data become, the more insistent it becomes. The CMB exhibits large-angle asymmetries inconsistent with perfect isotropy. Galaxy surveys reveal coherent flows over scales too large for standard dynamics. The Hubble parameter diverges between early and late measurements. The growth of structure departs from Λ CDM predictions. The sky exhibits alignments that have no natural place in a model defined by global homogeneity.⁵⁴ These signals are not noise. They are evidence that the universe is not best described by the ansatz chosen for mathematical convenience a century ago.

The puzzle is not that the data are difficult to fit. Data can always be fitted. Potentials can be redrawn. Parameters can be tuned. Fields can be added. The puzzle is that the data suggest a coherence that the framework cannot express. The universe behaves as though governed by a relation the model does not contain.

This is why the search for a law must begin with the puzzle. It is not a matter of aesthetics or dissatisfaction with the multiplicity of components. It is a matter of recognising that the model does not explain the very features it was constructed to address. The puzzle is structural. The law must be structural. It must concern the geometry of spacetime, not the catalogue of its contents.

Einstein understood this intuitively. His theory succeeded because it placed geometry at the centre of physics.⁵⁵ The field equations do not specify the dynamics of matter. They constrain the metric, and through the metric the behaviour of everything else. That structural insight was lost when the cosmological programme was reduced to a solvable

⁵⁴ K. Land and J. Magueijo, *Examination of Evidence for a Preferred Axis in the Cosmic Radiation Anisotropy*, Physical Review Letters 95, 071301 (2005). Discusses large-angle alignments in the CMB.

R. Watkins, H. A. Feldman and M. J. Hudson, *Consistently Large Cosmic Flows on Scales of $100 h^{-1}$ Mpc: A Challenge for the Standard Λ CDM Cosmology*, Monthly Notices of the Royal Astronomical Society 392, 743–756 (2009). Reports large-scale bulk flows challenging standard dynamics.

Licia Verde, Tommaso Treu and Adam G. Riess, *Tensions Between the Early and the Late Universe*, Nature Astronomy 3, 891–895 (2019). Reviews the H_0 tension and related discrepancies.

⁵⁵ Albert Einstein, *Geometry and Experience*, Prussian Academy of Sciences (1921). Popular exposition of the central role of geometry in general relativity.

model. The puzzle cannot be solved within that reduction. It requires a return to the original question: *what is the geometric relation that the universe obeys?*

The answer cannot lie in the standard symmetries. Homogeneity and isotropy are not observed; they are imposed. Their failure is visible on every scale large enough for the data to be clear. Nor can the answer lie in quantum potentials or string vacua. These constructs do not constrain the universe. They are adjusted to match it.

What the puzzle demands is a relation that reduces the freedom of the model rather than expanding it. A relation that explains the coherence of the universe without requiring additional sectors to maintain it. A relation that is simple enough to test and strong enough to fail.

The puzzle is not a mark of ignorance. It is a signpost. It points to a law not yet recognised.

14. The place of TSPC

The search for a cosmological law cannot remain abstract. At some point it must take the form of a specific relation imposed on the metric, one that is simple enough to state, strong enough to constrain, and directly testable. It must not resemble the catalogue of adjustable fields and potentials that has accumulated around the standard model. It must take the form of the structural principles that guide physics elsewhere.

TSPC was developed with this requirement in mind.⁵⁶ It places an algebraic restriction on the metric that fixes a unique entropic minimum and a symmetric temporal geometry. Its purpose was not to offer an alternative cosmology constructed by analogy with the standard one, but to impose a single condition on the metric that limits the geometries available to the universe without dictating its detailed behaviour. Whether the condition is ultimately correct is less important here than the role it plays in illustrating the kind of relation cosmology has not possessed.

The condition is simple to state. It requires that the metric admit an involutive tensor field that reverses the direction of time while preserving the metric structure.⁵⁷ The implication is that the universe admits no global, absolute arrow of time. Its evolution is described as proceeding from a low-entropy origin toward a tipping point of maximal structure, and then reversing, returning to a state of minimal complexity. This is not a mechanism, it is a constraint. It does not posit a new field or a new form of matter. It removes possibilities rather than adding them by restricting the admissible class of metrics through a fixed algebraic condition.

⁵⁶ Salisbury, I. *The Time-Symmetric Parity Constraint*: Paper 3. Presents the full development of TSPC as a structural constraint on the spacetime metric and its cosmological implications.

⁵⁷ Salisbury, I. *ibid.*

Under this constraint the large-scale anomalies that trouble the standard model can, in principle, arise from the geometry itself.⁵⁸ The apparent acceleration near the present epoch is interpreted as a geometric effect associated with the neighbourhood of the tipping point. The growth of structure is correspondingly affected by the same relation. The Hubble tension can be understood as arising from the way observers in different temporal domains interpret the same geometric law. The constraint narrows the model's freedom rather than expanding it. It reduces the number of assumptions rather than increasing them.

The significance of TSPC in this essay is not that it replaces the standard model or resolves all outstanding anomalies. It is that it demonstrates a different approach. It begins with a law rather than a mechanism, a constraint rather than a catalogue. It treats the puzzle as structural, not dynamical. It recognises that the universe behaves coherently because it is governed coherently, not because it has access to an ever-growing list of fields and sectors designed to preserve a chosen symmetry.

The constraint is directly falsifiable. It predicts features that are not guaranteed *a priori*: entropy symmetry across the tipping point, geometric relations among observables, and signatures in gravitational-wave populations and large-scale flows.⁵⁹ Its simplicity is its strength. If the predictions fail, the constraint fails; nothing can be added to rescue it. That is what distinguishes a law from a model.

Whether TSPC survives empirical scrutiny is not assumed here. The point is that cosmology needs a principle of this kind: a structural relation that reduces the space of admissible universes and addresses the puzzle without proliferating machinery

The puzzle cannot be resolved while the FLRW ansatz occupies the place a law should hold. That position must be taken by a genuine constraint arising from the nature of the universe rather than from the solvability of an equation. TSPC is offered only as an illustration of how such a law might be framed; its significance becomes clear only when the argument is carried to its conclusion.

15. What follows

Cosmology now stands at a point where the difference between method and reality can no longer be ignored. The success of a framework does not guarantee the truth of its assumptions. A century of ingenuity has produced a model that fits much of what we see, but it has done so by multiplying the elements required to sustain a symmetry that was never derived from observation. The puzzle of the universe remains where it always was, unchanged by the scaffolding that has risen around it.

⁵⁸ Salisbury, *op cit.*, paper 9 – *Linked Tensions in H_0 and S_8*

⁵⁹ Salisbury, *op cit.*, papers 4-10. Theoretical consequence papers deriving empirical predictions of the parity constraint for entropy evolution, cosmological observables, gravitational waves and large-scale flows.

What follows is not a call to abandon the standard model. It is a call to recognise its nature. Λ CDM is an instrument, not an ontology. Its components are tools shaped to preserve the framework, not principles that constrain the world. Quantum cosmology, vast and imaginative as it is, extends the same habit into a new domain, replacing one catalogue of possibilities with another. The puzzle is still waiting.

The challenge now is to treat the puzzle as a signal rather than an inconvenience. All of the following: the coherence of the universe, its large-scale alignments, its tensions across epochs and datasets, its geometry near what we call the present, and its remarkable simplicity at the extremes of time are not problems to be corrected. They are evidence of a relation that the current framework does not contain.

If cosmology is to advance, it must discover the law that the universe obeys.⁶⁰ A law, not a mechanism. A constraint, not a collection of components. Something that reduces freedom rather than expanding it. Something that cannot be adjusted without breaking. Something whose consequences appear everywhere because it governs everything.

How that law is found is not the concern of this essay. It may arise from symmetry, or from topology, or from a deeper relation between geometry and entropy, or from an entirely different principle not yet imagined. The puzzle will not solve itself, and it will not be dissolved by another family of inflationary potentials or another sector of undetected fields.

TSPC offers one example of what such a law might look like: a single algebraic constraint placed on the metric, simple to state, restrictive enough to matter and open to falsification. Its significance here is illustrative, not prescriptive. It shows that cosmology need not add components indefinitely. It can subtract them. It can act not as a catalogue but as a discipline. The question is whether others will attempt the same.

What follows from this essay is not a theory but an invitation. The field has reached the moment when its assumptions should no longer be taken for granted. The puzzle is clear. The scaffolding has been exposed. The question has been returned to its rightful place. If there is a law that governs the universe, it is waiting to be recognised. If there are alternatives to TSPC, they will be found by those who look for structure rather than ingredients.

The excitement lies in the fact that cosmology is not finished. It is just beginning again. The universe has offered the same puzzle for a hundred years. The next step is to listen to it.

⁶⁰ John Earman, *World Enough and Space-Time*, MIT Press (1989). Philosophical analysis of how symmetry and law should be distinguished in interpreting spacetime theories.

Julian Barbour, *The End of Time*, Weidenfeld & Nicolson (1999). Argues for the primacy of structural law over accumulated mechanisms in fundamental physics.

16. The search for the law

The argument is no longer speculative. It follows directly from the history of the subject. Cosmology built its modern framework on a symmetry chosen for convenience rather than derived from evidence. When the universe failed to conform to that symmetry, the field did not reconsider it. It constructed an expanding superstructure of auxiliaries to preserve the assumption. Quantum cosmology repeated the process with different tools and a vastly larger supply of adjustable constructs. The puzzle of the universe remained untouched behind the machinery.

If that diagnosis is accepted, the consequence is not optional. Cosmology requires a law. Not an additional mechanism, nor another sector of fields, nor another potential drawn to quieten an anomaly, but a structural constraint on the metric itself: something simple enough to state, strict enough to reduce the freedom of the model, and falsifiable without recourse to auxiliary hypotheses. The universe behaves coherently because it is governed coherently. Nothing in the standard model expresses that coherence: a principle is missing.

TSPC provides an example of what such a law looks like. It is not presented here as doctrine. It is presented because it exists, because it has been formulated explicitly, because it restricts the admissible geometries in a single algebraic step, and because its consequences can be tested without embellishment. A theory that supplies a principle and yields predictions that need not have been the case has crossed the threshold from speculation to inquiry. The constraint may succeed or it may fail. What matters is that it finally restores the missing element: a law capable of being wrong.⁶¹

This is the point at which cosmology must decide what it is doing. Either it continues to preserve a model built around an assumption that has never been justified, or it returns to the puzzle the universe has presented from the beginning. The choice is stark because the logic is stark. A century of elaboration has concealed the absence of a governing principle. The evidence is now precise enough that concealment is no longer possible.

Therefore: the task is to test the law. Not because it is TSPC, but because it is a law, and because cosmology has lacked one. If it fails, another must be found. If it succeeds, the puzzle will have been answered in the only way physics ever answers a puzzle: by discovering the constraint that nature obeys. In either case the period of accommodation is over. The universe has been telling us what is required; it is time to listen.

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⁶¹ Karl Popper, *The Logic of Scientific Discovery*, Hutchinson (1959). Classical formulation of falsifiability: laws must be capable of failure to count as scientific.