

3 – The Time-Symmetric Parity Constraint

On the loss and recovery of constraint in modern cosmology

Ian Salisbury, Oxford, August 2025

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Abstract

This paper proposes a new direction for cosmology, not by adding dynamical fields or invoking speculative particles, but by removing possibilities. At its heart lies a single algebraic constraint on the spacetime metric, imposed by a fixed, non-dynamical tensor field. This constraint carves the manifold into two mirrored temporal domains, evolving in perfect symmetry from a shared minimum of entropy and complexity. It does not rely on inflation, dark energy, or initial fine-tuning. Instead, it restricts the universe to geometries that forbid an absolute direction of time and allow structure to emerge symmetrically in both halves.

The resulting modification to the Einstein field equations introduces no new degrees of freedom, only a subtle structural correction to gravitational coupling. This correction is governed by a single parameter, not freely chosen, but tightly constrained. Its predicted effects on expansion, structure growth, and lensing are coherent, testable, and falsifiable with current and forthcoming data. A

finite, peaked acceleration inference, as supported by progenitor-age-corrected supernova analyses and by geometric consistency tests of the redshift-time relation, is shown to be naturally accommodated within a parity-constrained geometry. Within this framework, a parity-induced clock-skew mechanism produces a peak in apparent late-time acceleration at moderate cosmic distances, without invoking dark energy.

What emerges is not a new mechanism, but a structural alternative: one that reframes cosmic asymmetries, gravitational anomalies, and the arrow of time as consequences of a geometric constraint. By narrowing the space of admissible metrics, the theory offers a unified and intelligible account of expansion, entropy, and structure, not as outcomes of arbitrary initial conditions or hypothetical fields, but as expressions of a globally symmetric spacetime. The theory is precise, economical, and explicitly falsifiable with current and forthcoming observations.

1. Introduction

This paper defines and analyses an algebraic admissibility constraint on spacetime geometry, termed the Time-Symmetric Parity Constraint (TSPC). The constraint restricts the class of admissible spacetime metrics to those that satisfy a fixed global symmetry condition under time reversal.

TSPC is not a modification of gravitational dynamics and does not introduce new propagating fields. It acts as a structural restriction on the solution space of the Einstein field equations. The constraint is imposed directly on the spacetime metric and operates independently of matter content or initial conditions.

The constraint is formulated as an admissibility condition on the spacetime metric and implemented at the level of the action. Its enforcement employs standard variational methods involving a fixed algebraic structure and an auxiliary enforcing field. Specifically, the constraint is imposed by a fixed involutive tensor $\Pi_{\mu\nu}$ and enforced

pointwise by a symmetric Lagrange multiplier $\lambda_{\mu\nu}$. The tensor $\Pi_{\mu\nu}$ is treated as non-dynamical background structure and enters the action only algebraically. The Lagrange multiplier enforces the admissibility condition without introducing independent equations of motion.

This paper proceeds as follows. Section 2 defines the algebraic structure of the Time-Symmetric Parity Constraint. Section 3 characterises the associated symmetry restrictions and invariant quantities. Section 4 identifies the resulting class of admissible metrics. Subsequent sections examine the consequences of the constraint and its empirical exposure.

2. Algebraic foundations of the Parity Constraint

This section defines the algebraic structure of the Time-Symmetric Parity Constraint and the class of admissible metrics it selects.

Let Π^μ_ν be a fixed tensor field of type (1,1) on the spacetime manifold, satisfying the involution condition

$$\Pi^\mu_\rho \Pi^\rho_\nu = \delta^\mu_\nu$$

The tensor is treated as fixed background structure and is not varied in the action. Index positions on Π^μ_ν are adjusted using the spacetime metric $g_{\mu\nu}$ when forming contractions; the involutive structure itself is defined independently of the metric.

The dynamical sector is taken to be that of general relativity. A spacetime metric $g_{\mu\nu}$ is said to be admissible if it satisfies the algebraic invariance condition. The starting point is the Einstein–Hilbert action:

$$S_{\text{EH}} = \frac{1}{2\kappa} \int d^4x \sqrt{-g} R + S_{\text{matter}}[g_{\mu\nu}, \psi]$$

The metric is then constrained to satisfy:

$$g_{\mu\nu}(x) = \Pi^\alpha_\mu \Pi^\beta_\nu g_{\alpha\beta}(x)$$

This algebraic condition defines the class of admissible metrics.

To express this constraint within the action, a symmetric Lagrange-multiplier field $\lambda^{\mu\nu}(x)$ is introduced.

The action is then augmented:

$$S_{\text{constraint}} = \left(\frac{1}{2}\right) \int d^4x \sqrt{-g} \lambda^{\mu\nu}(x) [g_{\mu\nu}(x) - \Pi^\alpha_\mu(x) \Pi^\beta_\nu(x) g_{\alpha\beta}(x)]$$

Variation of the total action with respect to $\lambda^{\mu\nu}$ yields the same admissibility condition

$$g_{\mu\nu}(x) = \Pi^\alpha_\mu \Pi^\beta_\nu g_{\alpha\beta}(x)$$

Variation with respect to the metric $g_{\mu\nu}$ yields Einstein field equations supplemented by an additional algebraic contribution arising from the constraint sector. This contribution enforces the admissibility condition pointwise and introduces no

independent dynamical degrees of freedom. Its explicit form is derived in subsequent sections.

Example: Robertson–Walker metric

Consider

$$ds^2 = -dT^2 + a^2(T) [dr^2 + S_k^2(r) d\Omega^2]$$

Let Π act as time reflection on the tangent space at each point, while leaving the spatial coordinates fixed.

In this symmetric background Π can be represented in a comoving orthonormal frame by

$$\Pi^\mu_\nu = \text{diag}(-1, 1, 1, 1)$$

Then $\Pi^2 = \delta$ and the invariance condition

$$\Pi^\rho_\mu \Pi^\sigma_\nu g_{\rho\sigma} = g_{\mu\nu}$$

is satisfied precisely when the scale factor is an even function of the symmetric time coordinate,

$$a(T) = a(-T).$$

This example shows that Π -even FLRW backgrounds remain fully admissible, confirming that the constraint restricts but does not empty the space of solutions.

3. Consistency and non-dynamical character of the constraint sector

3.1 Metric variation and constraint-sector contribution

This subsection establishes how TSPC enters the field equations and clarifies the character of the resulting modification. The aim is limited and technical: to identify what arises from variation with respect to the spacetime metric, and to show that the contribution introduced by the constraint sector is algebraic rather than dynamical.

Variation of the total action with respect to the metric $g_{\mu\nu}$ yields the Einstein field equations supplemented by an additional term sourced by the Lagrange multiplier sector. This term arises entirely from the constraint contribution to the action and reflects the enforcement of the admissibility condition on the metric. No derivatives of the multiplier field appear in the action, and correspondingly no derivatives arise in the resulting field equations.

The modification therefore does not introduce a new propagating field or an independent stress–energy component in the usual sense. The multiplier field enters the equations pointwise, adjusting algebraically to enforce the Π -invariance condition on admissible metrics. The effect is to restrict the solution space of the Einstein equations rather than to alter their dynamical content.

It is important to distinguish this construction from models in which additional fields contribute kinetic terms or evolve according to independent equations of motion. Here, the constraint sector supplies no such dynamics. The resulting field equations retain the differential order of general relativity, and all time evolution remains governed by the metric and matter fields within the admissible Π -even sector.

The explicit form of the constraint-sector contribution, and its behaviour under symmetry reduction, are deferred to later sections where specific classes of solutions are examined. At this stage, the essential result is simply that metric variation produces an algebraic enforcement term, consistent with the interpretation of the constraint as a restriction on admissible geometries rather than as a new source of gravitational dynamics.

3.2 Absence of propagating degrees of freedom

This subsection establishes that the constraint sector introduces no additional dynamical degrees of freedom. The point is structural rather than interpretive: the Time-Symmetric Parity Constraint is enforced without enlarging the phase space of the theory.

The Lagrange multiplier field $\lambda^{\mu\nu}$ enters the action without derivatives and appears only algebraically. As a consequence, it possesses no kinetic term and no associated wave equation. Variation with respect to $\lambda^{\mu\nu}$ yields the admissibility condition on the metric, while variation with respect to $g_{\mu\nu}$ introduces an algebraic contribution that enforces this condition pointwise. At no stage does $\lambda^{\mu\nu}$ acquire independent equations of motion.

Because the multiplier field carries no derivatives, it introduces no initial data and no propagating modes. Its role is exhausted by the enforcement of the algebraic constraint. The number of physical degrees of freedom remains that of general relativity coupled to matter, with the additional restriction that only Π -even metrics are admissible.

This distinguishes the present construction from modified gravity models that introduce new scalar, vector, or tensor fields with their own dynamics. In such models, additional degrees of freedom typically arise through kinetic terms or higher-derivative couplings. No such structures appear here. The constraint sector reduces the space of admissible solutions but does not add to the dynamical content of the theory.

The absence of new degrees of freedom is therefore not an assumption but a direct consequence of the algebraic form of the constraint and the manner in which it is imposed at the level of the action.

3.3 Conservation and compatibility with general relativity

This subsection addresses the consistency of the constraint-sector modification with the geometric and conservation structure of general relativity. In particular, it clarifies how

the augmented field equations remain compatible with diffeomorphism invariance and the contracted Bianchi identities.

The total action, consisting of the Einstein–Hilbert term, the matter action, and the algebraic constraint term, is diffeomorphism invariant. No background coordinate structure is introduced, and the fixed tensor Π enters only through algebraic contractions. As a result, the variational principle preserves the geometric identities underlying general relativity.

Variation with respect to the metric yields field equations of Einstein form supplemented by an algebraic contribution arising from the constraint sector. Because the Einstein tensor satisfies the contracted Bianchi identities identically, the total source term appearing on the right-hand side of the field equations must be covariantly conserved. This requirement is not imposed separately; it follows directly from diffeomorphism invariance of the action.

The constraint-sector contribution therefore satisfies the necessary conservation condition as a consequence of the admissibility restriction it enforces. It does not represent an independently conserved stress–energy tensor associated with new physical degrees of freedom. Rather, it reflects the algebraic restriction placed on the metric itself, ensuring that only Π -even geometries appear as solutions.

In this sense, the construction modifies the space of admissible solutions without altering the underlying conservation laws or differential structure of general relativity. The field equations remain second order in the metric, and the usual geometric identities continue to hold within the restricted solution space.

A more explicit analysis of the constraint-sector contribution under symmetry reduction, including its role in homogeneous and isotropic backgrounds, is deferred to later sections. At this stage, it is sufficient to note that the algebraic enforcement of the parity constraint is fully compatible with the conservation structure of general relativity and introduces no inconsistency at the level of the field equations.

3.4 Scope and limits of the constraint-sector analysis

This subsection clarifies the scope of the preceding analysis and delineates what has, and has not, been established at this stage. Its purpose is to prevent over-interpretation and to fix the logical role of the constraint-sector discussion within the overall structure of the paper.

Sections 2 and 3 have defined the Time-Symmetric Parity Constraint, shown how it is implemented at the level of the action, and established its algebraic and non-dynamical character. It has been demonstrated that the constraint restricts the admissible class of spacetime metrics without introducing new propagating degrees of freedom, without altering the differential order of the field equations, and without violating the conservation structure of general relativity.

No claims have yet been made concerning specific cosmological solutions, parameter values, or observational consequences. In particular, no symmetry reductions, background specialisations, or phenomenological interpretations have been introduced. The analysis to this point is structural and formal, concerned solely with the admissibility and consistency of the constraint mechanism itself.

The role of the constraint sector is therefore limited but decisive. It establishes a fixed geometric restriction that all subsequent solutions must satisfy. Questions of cosmological dynamics, effective parameters, and empirical exposure arise only after this restriction has been imposed and are addressed in later sections of the paper.

By separating the definition and consistency of the constraint from its applications, the framework avoids conflating structural assumptions with phenomenological outcomes. This separation is essential to the interpretability and falsifiability of the construction and fixes the logical order in which subsequent results are to be understood.

3.5 Transition to admissible geometries

The preceding analysis has established TSPC as a consistent, algebraic restriction on the spacetime metric, enforced without introducing new dynamical fields or violating the conservation structure of general relativity. What remains is to characterise the geometric consequences of this restriction.

The constraint does not specify a unique spacetime geometry. Instead, it defines a class of admissible metrics: those that are invariant under the involutive action of the fixed parity tensor Π . The physical content of the framework therefore lies not in the introduction of new equations of motion, but in the geometric structure of the solution space selected by the constraint.

In the sections that follow, attention shifts from the formal properties of the constraint sector to the geometry of admissible spacetimes. This includes the identification of permitted symmetry classes, the structure of invariant foliations where they exist, and the consequences of Π -invariance for curvature, expansion histories, and global temporal structure.

All subsequent results are to be understood as consequences of the admissibility restriction defined in Sections 2 and 3. No additional assumptions are introduced beyond those already stated. The task is therefore not to modify general relativity further, but to explore the geometric and physical implications of restricting it to the Π -even sector.

4. Symmetry groups and algebraic invariants

The algebraic constraint imposed by the parity tensor does more than enforce time symmetry at each point: it also shapes the set of allowable transformations and conserved structures across the manifold. The Π -odd sector does not survive the

constraint in the cosmological background, while local departures from perfect symmetry remain admissible within the allowed diffeomorphism subgroup. This prevents over-constraint while preserving the large-scale symmetry implied by Π . In particular, the presence of a fixed tensor field reduces the full symmetry group of general relativity, the diffeomorphism group, to a smaller group of transformations that preserve the parity structure. In simple terms, general relativity normally allows any smooth relabelling of spacetime coordinates, but once a fixed tensor field is present, only those relabellings that leave this field unchanged remain admissible, just as a painted stripe on a sphere reduces its full rotational symmetry to the subset that preserves the stripe.

The fixed tensor field $\Pi_{\mu\nu}$ is not required to be covariantly constant. In geometries admitting a timelike eigenvector field associated with the +1 eigenspace, derivatives of Π reflect properties of the admissible metric, such as the embedding of reflection hypersurfaces. These relations are consequences of admissibility and of the chosen geometric structure, and are examined when specific metric classes are introduced; they do not define Π itself.

In this sense, the algebraic constraint plays a dual role. It excludes incompatible geometries while selecting conserved structures that shape the physical evolution. The resulting theory is more rigid than general relativity but also more predictive, precisely because it allows fewer degrees of freedom.

In standard general relativity, the symmetry group is the full diffeomorphism group:

$$\text{Diff}(M)$$

which represents all smooth coordinate transformations on the spacetime manifold M . However, the presence of a fixed tensor field $\Pi_{\mu\nu}$ breaks this full symmetry.

The full diffeomorphism group is reduced to the parity-preserving subgroup:

$$\text{Diff}_{\Pi}(M) = \{\varphi \in \text{Diff}(M) \mid \varphi^* \Pi_{\mu\nu} = \Pi_{\mu\nu}\}$$

That is, only those diffeomorphisms φ are permitted which preserve the parity structure: they must pull back the parity tensor to itself. This subgroup governs all admissible coordinate transformations.

The algebraic constraint also gives rise to invariant scalar quantities constructed from contractions of the fundamental tensors. For example:

- $I_1 = \Pi^{\mu\nu} g_{\mu\nu}$
- $I_2 = \lambda^{\mu\nu} \Pi_{\mu\nu}$
- $I_3 = \Pi^{\mu\alpha} \Pi^{\nu\beta} R_{\alpha\beta\mu\nu}$

Each of these remains unchanged under $\text{Diff}_{\Pi}(M)$ and therefore serves as a geometric invariant of the parity-constrained manifold.

These invariants can be used to classify solutions or to define observational quantities that characterise deviations from standard cosmology. In particular, scalar

invariants involving $\lambda_{\mu\nu}$ enter into the effective stress-energy tensor, providing a link between geometric structure and observational predictions.

5. Geometry emerging from algebraic constraints

As developed in Section 2, the algebraic constraint imposed by the parity tensor does more than define a symmetry: it shapes the geometry of spacetime itself. Because the constraint acts pointwise and independently of time evolution, it does not generate dynamics but operates as a selection principle: only those metric configurations that satisfy the symmetry condition are permitted. All others are excluded from the solution space.

This selection carves out a subspace of allowable geometries from the full solution space of general relativity. The permitted metrics are not generic; they possess a structure determined by the involutive nature of the parity tensor. At each point in spacetime, the tangent space is partitioned into two sectors, determined by the involutive nature of the parity tensor. This ensures that even local features of curvature remain compatible with the global time-reversal symmetry.

The constraint therefore bridges global and local behaviour. While local variations and anisotropies are allowed, they are embedded in a manifold that remains symmetric in its large-scale structure. The algebraic constraint serves as a scaffold: it supports local complexity while ensuring that the overall geometry remains coherent and symmetric across the temporal domains.

The defining involutive condition of the parity tensor is:

$$\Pi_\rho^\mu \Pi_\nu^\rho = \delta_\nu^\mu$$

This implies that Π_ν^μ has eigenvalues ± 1 and defines a decomposition of the tangent space into two eigenspaces:

- E^+ with eigenvalue +1
- E^- with eigenvalue -1

The parity constraint on the metric is expressed as:

$$g_{\mu\nu}(x) = \Pi_\mu^\alpha(x) \Pi_\nu^\beta(x) g_{\alpha\beta}(x)$$

This enforces that the metric is invariant under the transformation induced by the parity tensor. The set of all such allowed metrics defines a subspace:

$$\mathcal{G}_\Pi = \left\{ g_{\mu\nu} \mid g_{\mu\nu} = \Pi_\mu^\alpha \Pi_\nu^\beta g_{\alpha\beta} \right\}$$

All curvature tensors constructed from metrics in $\mathcal{G}_\Pi$ inherit the same symmetry. For admissible metrics, one has the Riemann tensor:

$$R_{\mu\nu\rho\sigma}(x) = \Pi_\mu^\alpha \Pi_\nu^\beta \Pi_\rho^\gamma \Pi_\sigma^\delta R_{\alpha\beta\gamma\delta}(x)$$

Similar relations hold for the Ricci tensor and scalar curvature. These constraints ensure that geodesics, curvature, and causal structure evolve within a globally consistent, symmetry-preserving framework.

6. Cosmological consequences and observables

The algebraic constraint imposed by the parity tensor modifies the Einstein field equations without introducing any new fields or dynamical degrees of freedom. Its effect is structural rather than causal: it limits the class of permissible geometries and, in doing so, alters the relationship between curvature and matter. This manifests observationally as a small but measurable enhancement in gravitational interaction across cosmic scales.

The modification is expressed through a correction term in the field equations that depends algebraically on the Lagrange multiplier $\lambda_{\mu\nu}$. This correction is purely algebraic: it does not propagate, carry energy, or generate new degrees of freedom. Instead, it acts as an instantaneous algebraic response to the constraint. The result is a geometric adjustment to the effective gravitational coupling, which can be characterised phenomenologically by a single dimensionless parameter introduced below.

This single parameter, arising directly from the parity constraint, produces coherent and testable effects across multiple cosmological observables:

- *Hubble expansion:* The Friedmann equation includes a fractional enhancement in gravitational strength, resulting in a slight increase in $H(z)$;
- *Structure formation:* The linear growth rate $f\sigma_8(z)$ is modestly elevated due to enhanced gravitational clustering;
- *Weak lensing:* Voids and low-mass halos show increased lensing convergence, reflecting the geometric amplification of curvature.

Recent modelling sharpens this morphological test. Using constrained Milky Way-like simulations (Hestia), Muru et al. show that if the GeV excess were due to WIMP annihilation its brightness would be triaxial and non-spherical, reflecting the merger-imprinted inner halo rather than the boxy/peanut bulge traced by old stars.¹ For TSPC, a bulge/bar-aligned excess remains compatible with curvature-coupled baryonic processes and geometric emission within the constraint; a halo-aligned morphology would weigh against the “no new fields” stance and favour a particle-DM interpretation.

¹ M. M. Muru; J. Silk; N. I. Libeskind; S. Göttlöber; Y. Hoffman, *Fermi-LAT Galactic Center Excess morphology of dark matter in simulations of the Milky Way galaxy*, arXiv:2508.06314 (2025). Predicts a triaxial inner-halo γ -ray morphology for a WIMP origin of the GCE (via Hestia simulations), providing a clean morphology test against bulge-aligned baryonic scenarios.

These effects mimic observational signatures attributed to the dark sector in Λ CDM but arise here from purely geometric constraints, with no need for dark energy, scalar fields, or exotic particles.

The entropy slope introduced in the text is defined mathematically as:

$$\sigma(T) = \frac{1}{S_*} \cdot \frac{dS}{d \ln a}$$

The modified Einstein field equations take the form:

$$G_{\mu\nu} = \kappa \left(T_{\mu\nu} + T_{\mu\nu}^{\lambda}(x) \right)$$

Here, $T_{\mu\nu}^{\lambda}(x)$ is the contribution from the algebraic constraint. It depends on the Lagrange multiplier but does not introduce any dynamical degrees of freedom.

Its leading-order form is:

$$T_{\mu\nu}^{(\lambda)}(x) = -\frac{1}{2} \lambda_{\mu\nu}(x) + (\text{terms involving } \Pi)$$

In the homogeneous and isotropic sector, the algebraic term can be collected into an effective renormalisation of the gravitational coupling, expressible at background level as

$$\kappa_{\text{eff}} \equiv \kappa(1 + \alpha_{\lambda}).$$

In this phenomenological reduction the Friedmann equation takes the form

$$H^2 = \frac{8\pi G}{3} \rho (1 + \alpha_{\lambda}),$$

where α_{λ} summarises the net effect of the constraint on large-scale dynamics..

Order-of-magnitude considerations suggest that α_{λ} must lie near 10^{-7} in order to remain compatible with solar-system limits on $|\Delta G/G|$, with CMB-lensing residuals, and with per-cent level departures in expansion and structure growth. A full global fit is possible within the framework, but is unnecessary for establishing the scale of the effect. The order-of-magnitude bound is sufficient to evaluate observational viability.

These effects are not adjustable responses to anomalies. They arise directly from the structure of the constraint and constitute a falsifiable signature of the TSPC framework.

A further observational effect arises from a small, parity-induced clock skew – a systematic shift in the elapsed time measured by an observer’s clock compared with the idealised cosmic time along a photon’s path – that accumulates along null geodesics. The strength and redshift profile of this skew follow directly from the dimensionless entropy slope.

In TSPC, $S(T)$ is minimal at $T = 0^-$ and $T = 0^+$, maximal at the tipping epoch T^{tip} ; hence $|\sigma|$ is small near the endpoints and largest near the tip. When the skew couples to this slope, rather than to comoving distance itself, the accumulated bias is negligible for emission times far from the tip but reaches a single broad maximum for light emitted

when the Universe was near T^{tip} , corresponding to intermediate redshifts. This produces the observed mid- z “hump” naturally, without ad-hoc redshift dependence.

The accumulated clock skew as a function of redshift is given by

$$\Delta t_{\text{obs}}(z) = \alpha_{\lambda} \int_0^{\chi(z)} W(\chi') \sigma(T(\chi')) d\chi'$$

Its derivative with respect to redshift links the skew to the weighting function and entropy slope at the emission time

$$\frac{d}{dz} \Delta t_{\text{obs}}(z) \propto W(\chi(z)) \sigma(T_{\text{emit}}(z)) \frac{d\chi}{dz}$$

This enters the observed redshift relation and, via the growth rate definition

$$1 + z_{\text{obs}} = (1 + z_{\text{true}}) [1 + \varepsilon f(z_{\text{true}})]$$

The same relation then defines the bias term $f(z)$

$$f(z) \approx \left(\frac{d \ln D_L}{dz} \right)^{-1} \frac{d}{dz} (\Delta t_{\text{obs}}(z) H(z))$$

When the clock skew couples to this slope, rather than to comoving distance itself, the accumulated bias is negligible for emission times far from the tip but rises to a single broad maximum for light emitted when the Universe was near T^{tip} , corresponding to intermediate redshifts. The resulting peak in the apparent acceleration signal at moderate cosmic distances follows directly from the geometry, without any need for ad-hoc redshift adjustments. Once the single amplitude α_{λ} is fixed, the shape of the signal is determined entirely by the entropy-slope profile. That shape must match supernova residuals,² produce consistent biases in both radial and transverse BAO measurements³, and appear in cosmic-chronometer determinations of $H(z)$ without further tuning⁴. It should also predict a small, correlated shift in strong-lensing time-delay distances. Conversely, if the reconstructed bias profile shows multiple peaks or oscillations inconsistent with a single symmetric driver, the hypothesis would be falsified.

6.1 Context and related observational literature

The cosmological effects derived above do not arise in isolation. A substantial body of observational and theoretical work has shown that apparent acceleration, when

² Riess A.G. *et al.*, *Observational evidence from supernovae for an accelerating universe and a cosmological constant*, *Astronomical Journal* 116, 1009 (1998). First robust detection of cosmic acceleration from Type Ia supernova luminosity distances, establishing them as a primary probe of the expansion history.

³ Eisenstein D.J. *et al.*, *Detection of the baryon acoustic peak in the large-scale correlation function of SDSS luminous red galaxies*, *Astrophysical Journal* 633, 560 (2005). First clear detection of the BAO feature, providing a standard ruler for measuring angular diameter distance and Hubble parameter as a function of redshift.

⁴ Jimenez R., Loeb A., *Constraining cosmological parameters based on relative galaxy ages*, *Astrophysical Journal* 573, 37 (2002). Introduced the cosmic-chronometer method, using differential galaxy ages to derive the Hubble parameter independently of other probes.

inferred from distance–redshift relations, need not be monotonic and need not reflect a fundamental dynamical driver. In particular, several independent analyses combining cosmic chronometer data with baryon acoustic oscillation measurements have reconstructed an apparent acceleration signal that peaks at intermediate redshifts rather than increasing indefinitely.⁵ Such reconstructions demonstrate that the observational signature often attributed to late-time acceleration can exhibit a finite, non-asymptotic profile without internal inconsistency.

Another line of investigation considers whether early-universe plasma physics might alter the calibration of the cosmic distance scale itself. Jedamzik, Pogosian and Abel have proposed that primordial magnetic fields present during recombination could accelerate recombination through small-scale baryonic inhomogeneities, thereby reducing the inferred sound horizon and permitting a higher CMB-inferred value of H_0 without modifying late-time gravitational dynamics.⁶

Related work on null geodesics and observational cosmology has further shown that averaging, inhomogeneity, and path-dependent effects along photon trajectories can bias luminosity-distance and redshift relations in a systematic manner. These studies establish that distance measures inferred along null geodesics are sensitive to geometric structure and to how time is operationally defined for observers, even in the absence of new dynamical fields.⁷ Inhomogeneous or symmetry-restricted geometries can therefore generate apparent acceleration-like effects through geometric rather than dynamical mechanisms.

More broadly, it is experimentally established that elapsed time measured by physical clocks can differ systematically from idealised background time in relativistic settings. While such experiments are local and terrestrial in scale, they demonstrate in principle that observer-measured time need not coincide with a fiducial global time parameter when geometry and motion are non-trivial.⁸ The relevance of this observation in

⁵ R. Rezaei, *Eur. Phys. J. C* 82, 861 (2022), which combines cosmic chronometer and BAO measurements to recover the observed peak in apparent acceleration at intermediate redshifts.

⁶ Karsten Jedamzik, Levon Pogosian and Tom Abel, *Hints of primordial magnetic fields at recombination and implications for the Hubble tension*, *Nature Astronomy* (2025). Investigates whether primordial magnetic fields can accelerate recombination and thereby reduce the sound horizon, allowing a higher CMB-inferred value of H_0 while leaving late-time gravity unchanged.

⁷ A. A. Coley, *Null Geodesics and Observational Cosmology* (2008), which analyses how averaging and inhomogeneities along photon paths can systematically bias luminosity-distance vs. redshift relations;

M. A. Breton, *Theoretical and numerical perspectives on cosmic distance ...* (2021), reviewing how inhomogeneity may distort cosmological distance measures;

A. E. Romano & M. Sasaki, *Spatial averaging and apparent acceleration in inhomogeneous spaces* (2009), demonstrating non-monotonic apparent acceleration from null-geodesic averaging;

G. F. R. Ellis, *Inhomogeneity effects in Cosmology* (2011), discussing how inhomogeneity and averaging can mimic dark-energy phenomena.

⁸ J. C. Hafele and R. E. Keating, *Around-the-World Atomic Clocks: Observed Relativistic Time Gains*, *Science*, Vol. 177, No. 4044, 14 July 1972, pp. 168–170. Used circumnavigating atomic clocks to demonstrate how observer-measured elapsed time systematically shifts relative to idealised cosmic time under relativistic

cosmology lies not in scale but in kind: it underlines that time measurement is operational and can acquire systematic offsets in curved spacetime.

The Time-Symmetric Parity Constraint does not rely on these works for its derivation. Rather, they provide contextual support for the admissibility of geometric mechanisms that produce finite, non-monotonic apparent acceleration and observer-dependent time offsets without invoking additional dynamical degrees of freedom. In this sense, the framework presented here offers a specific and falsifiable realisation of effects whose qualitative possibility has already been established across a range of independent studies.

7. Falsifiability through constrained α_λ : observational tests and limits

The TSPC framework departs from many cosmological alternatives by limiting itself to a single, structurally derived parameter: α_λ . This parameter arises from the algebraic enforcement of time symmetry. Its role is not auxiliary but foundational: it governs the magnitude of the parity-induced correction to gravitational interaction across the spacetime manifold.

The predictive power of the framework lies in the fact that α_λ is not a free fitting parameter. Its magnitude is tightly constrained by both theoretical structure and empirical sufficiency. The allowable range is dictated by the need to simultaneously explain subtle enhancements in cosmic expansion, structure growth and lensing, while avoiding violations of precision tests within the solar system and the CMB.

This constraint enables a sharp forecast: if the TSPC framework is valid, then certain correlated observational signatures must appear, all consistent with a narrow parameter band. These include:

- A $\sim 1\%$ elevation in the Hubble expansion rate $H(z)$;
- A mild but coherent increase in the amplitude of structure formation $f\sigma_8(z)$;
- Slightly stronger weak lensing convergence, particularly in underdense regions;
- Predictable redshift-dependent offsets in distance–redshift observables.

These predictions are not retrofitted to match *post hoc* anomalies. Rather, they emerge geometrically from the constraint and manifest consistently across observables. This gives the framework both coherence and falsifiability.

effects. (Caesium-beam atomic clocks flown eastward lost $\sim 59 \pm 10$ ns; flown westward gained $\sim 273 \pm 7$ ns – matching theoretical predictions combining special and general relativistic effects.)

Large-scale observational campaigns including DESI⁹, Euclid¹⁰, LSST¹¹, and the SKA¹² are designed to probe these same quantities with percent-level precision. Their results will either confirm the predicted pattern or exclude it. In this sense, the viability of TSPC hinges not on theoretical elegance alone, but on its alignment with empirical reality.

The structural correction to the Friedmann equation takes the form:

$$H^2 = \frac{8\pi G}{3} \rho (1 + \alpha_\lambda)$$

This expression represents the background-level phenomenological reduction of the constraint sector.

The allowed parameter range is sharply bounded:

$$\alpha_\lambda \in [1 \times 10^{-7}, 2 \times 10^{-7}]$$

The bounds quoted here reflect order-of-magnitude consistency requirements rather than a completed global fit.

This range is consistent with:

- Solar system precision tests: $|\Delta G/G| < 10^{-5}$
- CMB lensing residuals: $\lesssim 10^{-6}$
- Expected fractional effects: $\sim 1\text{--}2\%$

These bounds define a falsifiable window: if α_λ lies within this window, consistency across all correlated observables becomes mandatory rather than optional.

8. Symmetric entropy and scale factor evolution under algebraic constraints

The algebraic constraint imposed by the parity tensor governs not only the geometry of spacetime but also its thermodynamic and kinematic evolution. In the TSPC framework, the universe unfolds in two mirrored temporal domains, $+T$ and $-T$, joined at a shared point of minimum entropy. The evolution of entropy and the cosmic scale factor is symmetric about this midpoint and emerges from their global constraint, not from dynamical boundary conditions or fine-tuned potentials.

Entropy increases away from the minimum in both temporal directions. This is not imposed by hand, nor driven by a specific mechanism; it arises naturally from restricting the metric to forms consistent with the parity symmetry. The entropic arc is

⁹ DESI Collaboration, *The DESI Experiment Part I: Science, Targeting, and Survey Design*, arXiv:1611.00036. Measures $H(z)$ through baryon acoustic oscillations, directly testing the expansion correction induced by α_λ .

¹⁰ Euclid Collaboration, *Living Rev. Relativ.* 21, 2 (2018).

Will test α_λ through weak lensing shear, especially in underdense regions.

¹¹ LSST Science Collaboration, *LSST Science Book*, v2.0 (arXiv:0912.0201).

Constrains structure growth rates ($f\sigma_8$) across redshift, probing the constraint's effect on clustering.

¹² Braun, R. et al., *Anticipated SKA1 Science Performance*, SKA-TEL-SKO-0000818 (2019).

Probes large-scale lensing and high-redshift structure, testing late-time predictions of TSPC.

algebraically coupled to the scale factor, which expands from the minimum, reaches a maximum at the tipping point, and then contracts in a mirrored profile.

This evolution implies that time asymmetry as manifested in the thermodynamic arrow emerges locally, while the global structure remains perfectly time-reversal symmetric. Memory, causality, and irreversibility all appear within each temporal domain; but the total manifold respects a higher symmetry enforced by the constraint.

The evolution of the scale factor is similarly governed. The constraint ensures that expansion and contraction are paired across temporal domains. There is no bounce, reversal, or dynamical redirection; instead, the geometry is configured to evolve symmetrically. This preserves the coherence of geodesics and curvature while enabling entropy to evolve asymmetrically in each half.

The resulting cosmology explains time's arrow and expansion history as consequences of a deeper structural condition, not as emergent features of initial states.

A convenient schematic representation of the symmetric background evolution is to model the scale factor near the tipping epoch by a smooth even function of the symmetric time coordinate:

$$a(T) \approx a_{\max} \left(1 - (T/T^{\text{tip}})^2 \right)$$

The constraint does not impose a unique analytic form, only the structural requirement of an even background evolution with a single maximum at T^{tip} and matched minima at $T = 0^-$ and $T = 0^+$. Entropy follows the same qualitative pattern: rising from zero at the minimum to a maximum at the tip, and returning symmetrically.

Under this constraint the parity condition selects cosmological geometries whose background evolution is an even function of T about the tipping epoch. The key point is structural: the global constraint mandates a mirrored evolution of scale, entropy and curvature across the two temporal domains.

Together, these expressions describe a universe whose geometry, entropy, and expansion all evolve in a globally symmetric pattern, with local arrows of time arising from a shared structural origin.

9. The contraction phase and temporal symmetry

The TSPC framework predicts a cosmology in which the contraction phase is not a distinct or dynamically initiated epoch, but the time-reflected continuation of the expansion enforced by the parity constraint. As described earlier, the universe evolves in two mirrored temporal domains, expanding away from a shared low-entropy origin at $T = 0^-$, reaching maximum expansion and entropy at the tipping point T^{tip} , and contracting symmetrically toward a terminal low-entropy state at $T = 0^+$.

This behaviour is not the result of a dynamical reversal or exotic stress–energy component. It follows algebraically from restricting the metric to the Π -even sector. The constraint acts globally and pointwise, selecting time-symmetric geometries from the outset rather than inducing transitions between dynamical regimes. The contraction is therefore not a bounce, collapse, or reversal, but the continuation of a geodesically complete, parity-constrained evolution.

Within each temporal domain, the thermodynamic arrow points away from the entropy minimum. Entropy and complexity increase from $T = 0^-$ toward T^{tip} and then decrease symmetrically toward $T = 0^+$, while local irreversibility is preserved within each branch. The global manifold remains time-symmetric even as local arrows of time persist.

The background scale factor is required only to be an even function of the symmetric time variable about the tipping point T^{tip} . The constraint does not impose any explicit functional relation such as inversion or exponential form.

The entropy evolves symmetrically:

$$S(-T) = S(T)$$

Any Π -even background scalar that evolves under the constraint satisfies:

$$X(-T) = X(T)$$

For dynamical quantities with odd parity, such as time derivatives of these scalars, one then has:

$$\dot{X}(-T) = -\dot{X}(T)$$

Scalar quantities built from the Π -even sector of the metric inherit the same parity structure as the background evolution: even functions of the symmetric time coordinate have odd derivatives, and vice versa. This ensures that entropy gradients, local expansion quantities and any Π -even scalar evolve in mirrored form across the two temporal domains. No stronger claim is made about the full curvature tensor beyond its restriction to the Π -even sector selected by the constraint.

10. Local complexity within global algebraic constraints

While the algebraic constraint imposed by the parity tensor governs the global structure of spacetime, it does not eliminate local complexity. The constraint determines the allowable form of the metric and restricts its evolution to a symmetry-preserving subspace, but it does not suppress perturbations, anisotropies, or non-linear structure formation within that space.

Near the tipping point, where scale and entropy are maximised, local dynamics become highly non-linear. Gravitational collapse, tidal shearing, and turbulent flows emerge from the self-interaction of matter and curvature. These phenomena are well described by general relativity and are not impeded by the constraint, provided they remain embedded within an admissible metric. The constraint limits the class of geometries, not the richness of the dynamics they may support.

This distinction is central. The global parity condition ensures time symmetry and suppresses singularities, but it does not require homogeneity or simplicity. Within each temporal domain, the metric may exhibit sharp gradients, caustics, and chaotic flows. These structures are observable as galaxy clusters, voids, and anisotropic filamentary distributions. What the constraint enforces is that these features arise symmetrically in both temporal branches and that the geometry evolves within the permitted invariant class.

Gravitational wave solutions of general relativity remain admissible within this subspace. These waves cannot dislodge or undermine the imposed constraint. Their existence demonstrates that local excitations of curvature remain fully compatible with the parity condition, but they do not weaken its enforcement. This points to a deeper structural unity: the same algebraic law governs the persistence of global symmetry, the propagation of gravitational disturbances, and the generation of matter distributions. In this sense, matter, gravity, and time appear as distinct manifestations of a single organising principle. Each is permitted to vary locally, producing the rich phenomena of collapse, turbulence, and radiation, but none is able to overturn the global exclusion imposed by the constraint. Their programme is unaltered though the background geometry within which they operate is subject to the same small fractional enhancement governed by α_λ .

The Lagrange multiplier $\lambda_{\mu\nu}$, which enforces the constraint, introduces no new propagating fields. It contributes algebraically to the field equations but does not carry energy or momentum. As a result, the constrained geometry remains free from pathologies often associated with modified gravity theories such as ghost modes, instability under perturbation, or violation of the Bianchi identities¹³.

The theory thus allows for a universe that is globally symmetric but locally rich. The structure we observe, from black holes to baryonic filaments, need not be reduced or smoothed to preserve time symmetry. On the contrary, it is precisely this richness, appearing in mirrored temporal sectors, that the constraint permits and anticipates.

The algebraic constraint applies globally to the metric:

$$T_{\mu\nu}^\lambda(x) = -\frac{1}{2}\lambda_{\mu\nu}(x) + \dots$$

but introduces no evolution equation of its own. It adjusts instantaneously to maintain the constraint, without altering the degrees of freedom or the causal structure of the theory.

¹³ See, for example, S. Nojiri and S. D. Odintsov, *Phys. Rept.* 505, 59–144 (2011), reviewing ghost modes and stability in modified gravity; A. De Felice and S. Tsujikawa, *Living Rev. Relativity* 13, 3 (2010), discussing stability and Bianchi identity consistency in metric theories.

11. Speculative extensions: quantum and topological considerations

Although the TSPC framework is formulated as a classical algebraic constraint on the spacetime metric, its structure suggests limited points of contact with constraint-based approaches to quantum gravity and with topological formulations of spacetime. These connections are speculative and no quantisation scheme is proposed. The purpose of this section is limited to identifying structural compatibility, not to asserting derivation or unification.

In several approaches to quantum gravity, physical states are defined not solely by initial data but by satisfaction of global or algebraic constraints preserved under diffeomorphism-invariant evolution. In this respect, the parity constraint in TSPC plays a formally analogous role: it restricts the admissible configuration space of metrics without generating dynamics of its own. The similarity lies in functional role rather than in formalism or interpretation.

The fixed parity tensor $\Pi_{\mu\nu}$ acts as an involutive operator that selects a symmetry-preserving sector of the metric configuration space. Its role is not to fluctuate or propagate, but to impose a global restriction that remains intact under local dynamics. This is structurally comparable to non-dynamical constraints encountered in canonical formulations, where auxiliary fields enforce identities without contributing independent degrees of freedom. The Lagrange multiplier $\lambda_{\mu\nu}$ serves this enforcing role, without acquiring dynamical status or independent degrees of freedom.

The existence of two mirrored temporal domains raises the possibility that the spacetime manifold admits a non-trivial global identification. In particular, the parity constraint may be interpreted as enforcing a reflection symmetry that effectively pairs regions of the manifold across a distinguished hypersurface. No specific topological classification is assumed, but the possibility that the constrained spacetime admits a double-cover or involutive identification is noted as a question for future analysis.

These remarks are not offered as evidence for quantisation, topological unification, or any specific microscopic completion. They indicate only that a fixed algebraic restriction on admissible geometries can reproduce features often sought through more elaborate dynamical constructions, while remaining free of additional degrees of freedom or instability. If the parity constraint reflects a deeper organising principle, it would likely manifest first as a structural limitation on configuration space rather than as a new interaction or field.

12. Evaluation, comparison, and theoretical economy

The TSPC framework offers an alternative to conventional cosmology that is structurally coherent and observationally constrained. Its distinguishing feature is that it does not introduce new dynamical fields, arbitrary initial conditions, or inflationary mechanisms. Instead, it imposes a fixed algebraic condition on the spacetime metric, enforced pointwise across the manifold by a non-dynamical tensor field. The condition

is postulated directly as an algebraic restriction on the spacetime metric, limiting the solution space to geometries that exhibit global temporal symmetry and excluding configurations that support an absolute direction of time.

Internally, the theory is self-contained. The parity tensor $\Pi_{\mu\nu}$ defines an involution on the tangent space at each point, partitioning the manifold into mirrored temporal domains. The Lagrange multiplier $\lambda_{\mu\nu}$ enforces the constraint algebraically, without propagating or introducing energy–momentum contributions of its own. The resulting field equations are modified but not enlarged: the theory retains the causal and geometric structure of general relativity while narrowing its solution space to metrics that respect the imposed symmetry.

Unlike cosmological constructions in which temporal symmetry is extended to charge conjugation,¹⁴ the TSPC framework imposes no corresponding requirement on particle identity. The constraint acts solely on the spacetime metric and does not distinguish matter from antimatter or assign them different gravitational couplings. No mechanism of gravitational repulsion between matter and antimatter is therefore required. This is consistent with the ALPHA-g measurement of antihydrogen free fall, which found its acceleration to be directed towards the Earth and consistent, within current experimental uncertainty, with the gravitational acceleration of ordinary matter.¹⁵

As has been described, the universe evolves symmetrically from the point of minimum entropy at $T = 0^-$ toward the tipping point, the moment of maximum expansion and entropy. From there, it recontracts toward the return state at $T = 0^+$, which is structurally identical to the origin but causally disjoint. The evolution is governed not by dynamical laws alone but by a global constraint that ensures time-symmetric development across mirrored domains. This structure allows for complexity to grow within each temporal domain while remaining consistent with the parity condition imposed on the metric.

When compared to other cosmological models, the differences are clear. Inflationary cosmology offers an explanation of flatness and homogeneity but relies on finely tuned scalar fields and assumes a thermodynamic arrow without explanation. Bouncing models invoke energy condition violations and dynamical reversal mechanisms that often introduce singularities or pathologies. Cyclic cosmologies propose recurrent behaviour but typically do not address entropy reset or symmetry enforcement. Λ CDM,

¹⁴ For CPT-symmetric cosmology, see Boyle, Latham; Kieran Finn; Neil Turok. *CPT-Symmetric Universe*. Physical Review Letters 121, 251301 (2018). Introduces the proposal that the universe before the Big Bang is the CPT mirror of the universe after.

¹⁵ ALPHA Collaboration. *Observation of the effect of gravity on the motion of antimatter*. Nature 621, 716–722 (2023). Finds antihydrogen free fall to be consistent with ordinary attractive gravity within experimental uncertainty.

for all its empirical success, requires the postulation of dark energy and dark matter as unexplained components.¹⁶

TSPC avoids these additions. It accounts for the arrow of time, the emergence of structure, and the observed matter distribution as consequences of a single, fixed constraint. It modifies gravity without new degrees of freedom, and it predicts deviations from Λ CDM that are coherent across observables: a slight enhancement in expansion rate, a small elevation in structure growth, and an increase in weak lensing strength in underdense regions.

Critically, the theory is falsifiable. The structural parameter α_λ is not a free fitting term; it is bounded by the constraint structure itself and lies within a narrow window fixed by solar system dynamics, CMB lensing, and structure formation data. The values required to account for observed departures from Λ CDM lie within the same range permitted by independent tests. If α_λ lies outside this window, or if the predicted observational pattern is not borne out by surveys such as DESI, Euclid, LSST or SKA, the theory is excluded. If the pattern is confirmed, the theory stands as a purely geometric account of dark-sector phenomena, entropy evolution, and cosmic symmetry.

In this respect, TSPC does more with less. It offers a unified explanation of time, structure, and gravity through an algebraic condition that reshapes the geometry without invoking new physics. Its simplicity is not one of ignorance or omission, but of structural parsimony: a reduction in theoretical complexity that increases explanatory reach.

13. Concluding remarks

This paper has presented a cosmological framework grounded not in new dynamical fields or quantum-scale speculation, but in a single algebraic constraint imposed on the spacetime metric. The Time-Symmetric Parity Constraint requires that the geometry of the universe respects a fixed parity structure, enforced pointwise across the manifold by an involutive tensor field. The consequence is a cosmology that is globally symmetric in time, geodesically complete, and observationally distinguishable.

Rather than deriving this constraint from deeper physical principles, the theory postulates it directly. It is not a boundary condition in the Cauchy sense. Rather, it functions as a global restriction on admissible metrics, eliminating geometries that permit an absolute direction of time. The field equations are modified algebraically, but no new degrees of freedom are introduced. The Lagrange multiplier enforces the constraint pointwise without propagating or contributing independent energy-momentum.

¹⁶ For representative discussions of these classes, see: *Guth, A. (1981)* for inflation; *Ijjas et al. (2013)* for bouncing cosmologies; *Steinhardt & Turok (2002)* for cyclic models, and *Planck Collaboration (2020)* for Λ CDM parameterisation.

The involutive tensor Π_ν^μ introduced in this framework is not an independent physical field. In backgrounds that admit a unit normal n_μ to a reflection hypersurface, Π_ν^μ may be represented as

$$\Pi_\nu^\mu = \delta_\nu^\mu - 2 n^\mu n_\nu$$

where n_μ is the unit normal to the hypersurface $T = 0$, with index lowering defined by the spacetime metric so that $n_\mu = g_{\mu\nu} n^\nu$, satisfying $n^\mu n_\mu = 1$ and $n^\mu \partial_\mu T > 0$. This construction fixes Π uniquely (up to the discrete reversal $T \rightarrow -T$) and ensures that $g_{\mu\nu} = \Pi_\mu^\alpha \Pi_\nu^\beta g_{\alpha\beta}$ holds identically. It does not define Π . The involution is postulated as primitive structure and restricts the admissible class of metrics; the normal n_μ is derived from Π when such a foliation exists.

Π therefore introduces no new continuous freedom: it serves only as a geometric reflection operator that enforces the global parity symmetry of spacetime. The thermodynamic, kinematic, and observational consequences of this restriction, including entropy evolution and the appearance of a finite, peaked acceleration signal, follow from the constrained geometry rather than from additional dynamical ingredients.

The predictive scope of the theory is narrow but clear. A single parameter, α_λ , governs the strength of the gravitational correction introduced by the constraint. Its value is sharply bounded by theoretical consistency and observational limits. It must lie within a narrow window sufficient to account for observed deviations from Λ CDM, but small enough to satisfy solar system and CMB constraints. This parameter enters the Friedmann equation, modifies the growth rate of structure, and amplifies weak lensing in void regions. Its effects are coherent across these domains and lie within reach of current and forthcoming surveys, including DESI, Euclid, LSST, and SKA, each targeting a different observable through which the theory may stand or fall.

This constraint-based cosmology is not just predictive: it is falsifiable. The narrowness of α_λ 's permitted range ensures that forthcoming observations will either confirm the predicted pattern or exclude it. If excluded, the framework fails. If confirmed, it will stand as a structural explanation of the dark sector: one that attributes cosmic asymmetry and gravitational anomalies not to unseen matter or energy, but to a geometric restriction on what the universe is allowed to be.

And yet, this strength rests on a striking philosophical choice. The defining constraint of TSPC is postulated rather than derived. It is postulated directly as an algebraic condition on the spacetime metric, enforced by a fixed involutive tensor field. As demonstrated in Section 2, the same condition admits all Π -even Robertson-Walker geometries, including the standard homogeneous and isotropic cosmological form when the scale factor is an even function of the symmetric time coordinate, ensuring that the standard cosmological form remains encompassed within the framework. Section 3 shows that only the Π -even component of $R_{\mu\nu}$ is constrained, maintaining compatibility with

ordinary curvature evolution. Its role is to limit the solution space to geometries that exhibit global temporal symmetry and exclude configurations that would support an absolute direction of time. This is not an appeal to final causes, but an assertion of structural preference: that the universe is symmetric not because it began that way, but because the structural form of spacetime forbids it from being otherwise.

That this postulate is testable, and possibly false, is no weakness. The history of physics includes many such moments where symmetry was conjectured before it was justified. Here too, the hypothesis of a time-symmetric manifold, defined by a single algebraic constraint, may or may not survive contact with data. But it provides a path of enquiry in which gravitational structure, thermodynamic evolution, and cosmic coherence arise from a single postulate, and where falsification is possible in the near term.

Whether confirmed or not, the framework illustrates an alternative mode of explanation in cosmology: one in which global structure need not be traced to initial conditions or dynamical additions, but can arise from explicit constraints on admissible geometry.

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