

9 – Linked Tensions in H_0 and S_8

Consequences of the Time-Symmetric Parity Constraint

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Abstract

Discrepancies between early- and late-universe inferences of the Hubble constant H_0 and the structure-growth parameter S_8 have persisted despite exhaustive systematic checks. Supernova calibration drift, Malmquist bias, and host-galaxy mass steps have been modelled and corrected; weak-lensing surveys have tested shear calibration, photometric redshifts, and intrinsic alignments. Yet the H_0 excess and S_8 deficit remain at high statistical significance.

The Time-Symmetric Parity Constraint (TSPC) offers a structural alternative. By imposing a fixed algebraic condition on the spacetime metric, it modifies gravitational coupling through a single bounded parameter, α_λ , without introducing new fields or degrees of freedom. This correction produces a small increase in the expansion rate, contributing to the H_0 discrepancy, while simultaneously enhancing structure growth, easing the S_8 tension. Both anomalies emerge as linked

consequences of the same structural adjustment, not as independent puzzles.

This linkage is strengthened further by ACT DR6, which places substantially tighter constraints on many of the low-order modifications previously proposed to reconcile early- and late-universe measurements. Early-dark-energy models, excess relativistic species, and related extensions show no statistically compelling improvement in fit once the full DR6 data are applied, and most are now restricted to narrow, fine-tuned parameter ranges.

The framework is parsimonious, coherent, and sharply falsifiable: once α_λ is fixed, the amplitudes of expansion and growth deviations follow without further tuning. Current bounds are consistent with the narrow range of α_λ required by the framework. Forthcoming surveys, DESI, Euclid, LSST and SKA will determine whether the H_0 and S_8 tensions dissolve into geometry or persist as challenges to the hypothesis.

1. Introduction

Two of the most persistent anomalies in contemporary cosmology are the H_0 and S_8 tensions. Local determinations of the Hubble constant, using the Cepheid–supernova distance ladder and strong-lensing time delays, yield values significantly higher than those inferred from the cosmic microwave background under Λ CDM.¹ At the same time, low-redshift weak-lensing and clustering surveys consistently recover a suppressed value of the structure-growth parameter S_8 relative to the Planck prediction.² These

¹ Riess A.G. et al., ApJL 934, L7 (2022) *A Comprehensive Measurement of the Local Value of the Hubble Constant with $1 \text{ km s}^{-1} \text{ Mpc}^{-1}$ Uncertainty from the Hubble Space Telescope and the SH0ES Team* – Local distance-ladder determination of H_0 , in tension with Planck.

Millon et al., A&A 2020 – TDCOSMO strong-lens time-delay H_0 .

² Heymans et al., A&A 646, A140 (2021) – KiDS-1000 cosmic shear; low S_8 value.

Asgari et al., A&A 2021 – KiDS-1000 S_8 deficit relative to Planck.

discrepancies have reached high statistical significance and now define the leading challenges to the standard model.

Extensive effort has been devoted to testing whether they might arise from observational systematics. In the case of H_0 , supernova calibration drift, Malmquist bias, and host-galaxy mass steps have been modelled explicitly,³ while independent strong-lensing time-delay measurements confirm the elevated local value.⁴ For S_8 , weak-lensing surveys have applied stringent corrections for shear calibration, photometric redshift uncertainties, and intrinsic alignments.⁵ Yet in both domains the residual discrepancies remain, surviving successive refinements of analysis.

The ACT DR6 release intensifies this situation.⁶ Its independent CMB power spectra reproduce the low early-universe H_0 value with increased precision, while its polarisation data place increasingly tight constraints on a wide class of proposed ‘Hubble fixes’, leaving many viable only within relatively restricted regions of parameter space. The tension has therefore become more sharply defined, not alleviated.

Within Λ CDM, these anomalies are treated as independent puzzles: one suggesting excess expansion, the other suppressed growth. In the framework of TSPC, they are not separate but correlated. TSPC imposes a fixed algebraic condition on the spacetime metric, forbidding geometries that admit an absolute temporal direction and requiring evolution in two mirrored domains. This constraint modifies the effective strength of gravity through a single structural parameter, α_λ , without introducing new fields or degrees of freedom.

The correction slightly enhances the Hubble expansion rate $H(z)$, contributing to the H_0 discrepancy, while simultaneously enhancing the linear growth of structure $f\sigma_8(z)$, easing the S_8 tension. Both effects follow from the same geometric source. Once α_λ is fixed, the amplitudes of expansion and growth deviations are determined without further tuning. The anomalies are therefore reframed not as signs of hidden substances or neglected physics, but as linked expressions of one structural adjustment.

The present paper complements Papers 4 and 6 by examining two further observational anomalies whose apparent independence dissolves once the parity constraint is imposed. The following sections set out the algebraic framework, its observational consequences, and the empirical strategy by which forthcoming surveys, DESI, Euclid, LSST and SKA will determine whether the H_0 and S_8 tensions dissolve into geometry or persist as challenges to the hypothesis.

³ Brout et al., ApJ 938, 110 (2022) – Pantheon+ calibration and bias controls; supernova analysis; systematics checked.

⁴ TDCOSMO Collaboration, *op. cit.* Hierarchical inference.

⁵ DES Collaboration, *Phys. Rev. D* 2022 – DES Y3 shear, IA and photo-z systematics.

Abbott et al., *Phys. Rev. D* 105, 023520 (2022) – DES Y3 weak lensing; systematics controlled.

⁶ ACT Collaboration, DR6 Power Spectra (JCAP 2025) – Independent early-Universe H_0 .

2. Algebraic Framework

TSPC modifies general relativity not by adding content but by reducing freedom. A fixed symmetric tensor $\Pi_{\mu\nu}$ defines an involution, partitioning the tangent space into mirrored temporal sectors.⁷ The metric is required to remain invariant under this transformation. To impose the condition within the Einstein–Hilbert action, a symmetric Lagrange multiplier $\lambda_{\mu\nu}$ is introduced. This enforces the constraint algebraically at each point, introducing no new propagating degrees of freedom.

Variation of the action yields modified Einstein equations with a local correction term. At leading order, the effect is a fractional renormalisation of the gravitational coupling, governed by a single structural parameter α_λ . This parameter is not freely tunable: its value is dictated by the geometry of the constraint and tightly bounded by empirical limits.

The correction is algebraic and non-propagating. It alters no causal pathways, violates no conservation laws, and leaves the Bianchi identities intact. Its effect is to adjust the effective strength of curvature responses point by point, producing coherent but subtle deviations in cosmological observables.

The constraint is imposed through two algebraic objects: a fixed symmetric parity tensor $\Pi_{\mu\nu}$ and a Lagrange multiplier $\lambda_{\mu\nu}$.

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

Constraint on the metric:

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

Modified Einstein–Hilbert action:

$$S = \int d^4x \sqrt{-g} \left[\frac{1}{16\pi G} R + \lambda^{\mu\nu} \left(g_{\mu\nu} - \Pi_\mu^\alpha \Pi_\nu^\beta g_{\alpha\beta} \right) \right]$$

Field equations with algebraic correction:

$$G_{\mu\nu} = 8\pi G T_{\mu\nu} + \Delta_{\mu\nu}(\lambda, \Pi)$$

Effective gravitational coupling:

$$G_{\text{eff}} = G(1 + \alpha_\lambda)$$

3. Cosmological Consequences

The algebraic correction introduced by the parity constraint alters cosmic observables in a coherent way. Because the effective gravitational coupling is fractionally

⁷ For the formal definition of Π and proof of its Robertson–Walker admissibility, see Section 2 of Paper 3 *The Time-Symmetric Parity Constraint*.

strengthened, the Friedmann equation acquires a small elevation in $H(z)$, directly contributing to the H_0 discrepancy.⁸ At the same time, the enhanced coupling accelerates the growth of structure, modestly raising $f\sigma_8(z)$ and reducing the S_8 tension.⁹

These effects are not independent. Once α_λ is fixed, the amplitudes of both deviations follow without further adjustment. The anomalies that appear as separate puzzles in Λ CDM are reframed as linked consequences of the same structural correction.

The correlated departures can be expressed schematically as:

For the expansion history, the modified Friedmann equation gives:

$$H^2(z) = H_{\Lambda\text{CDM}}^2(z)[1 + \alpha_\lambda]$$

For structure growth, the linear growth rate inherits the same fractional enhancement through the effective coupling:

$$f\sigma_8(z) \propto G_{\text{eff}} \delta(z) = G(1 + \alpha_\lambda)\delta(z)$$

The same fractional enhancement thus drives both the Hubble and growth anomalies. In TSPC the H_0 and S_8 tensions are not clues to hidden matter or exotic energy but to a structural constraint on admissible geometries.

Recent ACT DR6 constraints underscore this coherence. Additive modifications to the expansion history that do not entail a corresponding shift in growth are increasingly disfavoured, strengthening the case for linked departures of $H(z)$ and $f\sigma_8(z)$ governed by a single structural parameter.¹⁰

A further class of proposals seeks to resolve the H_0 tension by modifying the early-time calibration rather than the late-time dynamics. Recent analyses of primordial magnetic fields at recombination, for example, argue that small-scale baryon inhomogeneities induced by non-helical magnetic fields can accelerate recombination and thereby reduce the inferred sound horizon. In such constructions the CMB angular scale is preserved while permitting a higher locally inferred H_0 . The primary adjustment is to the early-universe ruler r_s , not to the late-time gravitational response. Any shift in structure-growth observables then arises only indirectly through parameter degeneracies in global fits rather than as a necessary correlated prediction.

From the present perspective, this distinction is decisive. A recalibration of r_s can elevate H_0 while leaving the growth sector largely Λ CDM-like. By contrast, the Time-

⁸ Planck Collaboration, A&A 641, A6 (2020) – Baseline Λ CDM expansion curve.

Riess et al., *op. cit.* (2022) – Observed H_0 excess.

⁹ Asgari et al., *op. cit.* (2021) – Cosmic shear; constraints on structure growth; observed S_8 deficit.

¹⁰ ACT Collaboration, DR6 Extended Models (JCAP 2025) – Places strong constraints on many additive solutions proposed within Λ CDM.

Symmetric Parity Constraint admits no mechanism by which expansion and growth may decorrelate. Once $\alpha\lambda$ is fixed, the fractional departures in $H(z)$ and $f\sigma_8(z)$ are linked by construction. A joint fit that raises H_0 through early-time recalibration without a commensurate shift in growth would therefore favour primordial-field explanations over TSPC; conversely, a coherent correlated displacement in both sectors would disfavour early-ruler modifications and support a structural geometric origin.

A complementary response within the standard geometric framework has been to relax the assumption of a constant dark energy equation of state, allowing $w(z)$ to evolve with redshift while retaining the Friedmann–Robertson–Walker metric. Analyses employing flexible parametrisations of $w(z)$, combining supernovae, baryon acoustic oscillations, direct $H(z)$ measurements and CMB distance priors, report a statistical preference for mild evolution in the dark-energy sector. In such constructions the H_0 tension is absorbed into late-time expansion dynamics while the early-universe normalisation remains fixed. Any consequences for structure growth then arise indirectly and are typically treated separately.

A parallel class of proposals targets the S_8 tension directly through modifications confined to the growth sector. Models invoking weak interactions between neutrinos and dark matter, for example, suppress late-time structure formation without altering the expansion history. While such extensions can improve joint fits to selected datasets, they do so by introducing additional microphysical parameters whose values are constrained primarily by the observations they are designed to reconcile.

From the present perspective, these approaches share a common feature: the expansion history and the growth of structure remain independently adjustable. The Time-Symmetric Parity Constraint permits no such freedom. Expansion and growth shift together as consequences of a single algebraic restriction on admissible spacetime geometries. Any observational pattern in which $H(z)$ and $f\sigma_8(z)$ move independently would therefore falsify the hypothesis.

4. Observational Strategy

The predictive strength of TSPC lies in its parsimony. A single structural parameter, α_λ , governs both the elevation of $H(z)$ and the enhancement of $f\sigma_8(z)$. Its value is not freely tunable: it must lie within the narrow window simultaneously permitted by solar-system dynamics, CMB lensing, and large-scale structure.

Current bounds already indicate this coherence. Planetary ephemerides restrict fractional variations in Newton’s constant to less than one part in 10^5 .¹¹ Reconstructions of CMB lensing residuals constrain departures at the 10^{-6} level.¹² Cosmological surveys at intermediate redshift point to percent-level deviations. The

¹¹ Pitjeva & Pitjev, *Celest. Mech. Dyn. Astron.* 130, 57 (2018) – Solar-system ephemeris bounds on ΔG .

¹² Planck Collaboration, *A&A* 641, A8 (2020) – CMB lensing reconstruction; tight bounds on G_{eff} .

ranges permitted by these three domains substantially overlap the range required to account for the observed H_0 and S_8 tensions.

ACT DR6 places additional weight on this requirement. By constraining departures in both the expansion history and the growth of structure with high-resolution CMB data, it removes much of the freedom for explanations that alter one sector without the other.

Although not directly related to either the H_0 or S_8 tensions, observations of unexpectedly mature high-redshift structures illustrate the same progressive compression of the remaining Λ CDM parameter space. A recent example of pressure-based constraints at high redshift illustrates this broader compression of permissible growth histories.¹³ A Sunyaev–Zeldovich detection of ionised gas associated with a high-redshift overdense structure ($z \approx 4.3$) has been reported in *Nature*. The SZ effect probes integrated electron pressure and is insensitive to surface-brightness dimming, providing direct sensitivity to deep potential wells at early epochs.

Interpretation of the signal relies on extrapolated scaling relations for mass, temperature, and virialisation calibrated at substantially lower redshift. The result concerns a single object rather than a population. It therefore does not define a mass function, abundance constraint, or redshift-dependent trend. There is no decisive challenge to Λ CDM.

Nonetheless, even tentative evidence for hot gas at such early times further narrows the temporal margin available for structure assembly. As with the H_0 and S_8 tensions, the significance of such observations lies less in any one datum than in the cumulative restriction they impose on monotonic forward-growth narratives without introducing additional dynamical components.

The remaining viable space is one in which expansion and growth shift together, as required by a structural modification rather than an additive component.

Forthcoming surveys provide the decisive test. DESI, Euclid, LSST, and the SKA will measure expansion, structure growth, and lensing at percent-level precision across redshift. If the anomalies are linked by the structural correction, they will display a consistent correlated pattern within the same narrow band of α_λ . Any mismatch (for example, an enhanced Hubble rate without a corresponding shift in growth) would falsify the hypothesis outright.

Thus the empirical strategy is direct. The framework has no freedom to adjust one anomaly independently of the other. Either both dissolve into geometry, or the constraint fails.

¹³ Zhou, D., Chapman, S. C., Aravena, M., *et al.*, *Sunyaev–Zeldovich detection of hot intracluster gas at redshift 4.3*, *Nature* (2026), published 5 January 2026, doi:10.1038/s41586-025-09901-3. Reports a tentative SZ pressure signal associated with a system at $z \approx 4.3$. Although interpretation relies on extrapolated scaling relations and concerns a single object, it provides pressure-based evidence that further compresses the timeline available for structure assembly under Λ CDM.

Current limits on the structural parameter α_λ :

Solar-system dynamics:

$$\left| \frac{\Delta G}{G} \right| < 10^{-5}$$

CMB lensing residuals:

$$|\alpha_\lambda| \lesssim 10^{-6}$$

Cosmological deviations required:

$$\alpha_\lambda \sim 10^{-2}$$

Together these define the falsifiable window, now additionally circumscribed by ACT DR6 constraints:

$$10^{-6} \lesssim \alpha_\lambda \lesssim 10^{-2}$$

5. Concluding Remarks

The H_0 and S_8 tensions are among the sharpest empirical challenges to Λ CDM. Exhaustive checks for calibration drift, selection bias, and host correlations have not removed them; independent probes confirm their persistence.¹⁴ In the standard framework they appear as distinct anomalies, one suggesting excess expansion and the other suppressed growth.

Within TSPC they are understood as linked. A single algebraic correction to the Einstein field equations, governed by the structural parameter α_λ , produces a small increase in $H(z)$ while enhancing structure growth. The two tensions are therefore not separate puzzles but correlated consequences of the same geometric restriction on admissible spacetimes.

The framework is parsimonious and falsifiable. Its permitted window for α_λ is tightly bounded by solar-system tests, CMB lensing, and cosmological deviations. Forthcoming surveys, DESI, Euclid, LSST, and the SKA will determine whether the predicted correlated pattern is borne out. Recent ACT DR6 results sharpen this prospect: by further restricting additive solutions within Λ CDM, the DR6 data amplify the diagnostic power of any correlated pattern in $H(z)$ and $f\sigma_8$. If the pattern fails to appear, the hypothesis fails. If it is confirmed, two of the deepest anomalies in precision cosmology dissolve into geometry, and the H_0 and S_8 tensions would naturally be interpreted as evidence for a structural constraint on the metric rather than for new physics in the dark sector.

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¹⁴ TDCOSMO Collaboration, *op.cit.* – Strong-lensing time-delay determination of H_0 .