Fundamental Gravitational Retarded Spacetime Shells: Cosmic Scale
A Causal Correction to the Friedmann Equation

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Abstract

We propose that the observational evidence attributed to dark matter and dark energy may arise from a systematic error in parameter extraction: the Planck CMB data, which already encodes the full history of retarded shell propagation, was fit using a model that assumes instantaneous homogeneous gravity. This forces the retarded shell correction to be absorbed into dark matter and dark energy terms that may not correspond to physical substances. The framework rests on three assumptions shared with a companion paper on force unification at quantum scales [12]: (A1) massive particles emit discrete spacetime shells propagating at c, (A2) only retarded propagation is physical, and (A3) observables are determined by RMS averaging of shell arrival statistics. Newton's constant G_N, measured locally where the shell environment is fully established, already incorporates finite-speed propagation effects. We derive a logarithmic correction to the Friedmann equation from first principles: the accumulated shell deficit over cosmic history, integrated exactly as $\ln(1+z) - 2 + 2/\sqrt{1+z}$, produces a leading $\ln(1+z)$ modification to the curvature term. Using this framework with zero free parameters beyond Planck 2018 baryon density, we compute a structure formation boost of $1/\eta(z)^2$ that matches JWST galaxy abundances at $z = 9$–20 at order of magnitude. The vacuum energy problem dissolves entirely: the shell framework contains no continuous field modes to sum, and the natural UV cutoff at the electron mass eliminates the need for renormalization. Independent support comes from Kumar (2025) [2], who derives a compatible modified force law from infrared running of Newton's constant. The decisive test is a full CMB power-spectrum re-fit using CLASS/Cobaya, which we describe and invite the community to perform.

Contents

1 Introduction

The standard cosmological model (ΛCDM) requires that approximately 95% of the energy content of the universe consists of dark matter and dark energy, neither of which has been directly detected. This paper explores the possibility that part or all of the observational evidence attributed to these components arises from a systematic effect in how cosmological parameters are extracted from data, rather than from the data itself.

The framework is the cosmological application of a retarded discrete shell model introduced in a companion paper [12], which demonstrates that the full Standard Model gauge group $\mathrm{SU}(3)\times\mathrm{SU}(2)\times\mathrm{U}(1)$ emerges from the multipole decomposition of shell arrival statistics. Both papers share the same three assumptions.

Assumption A1 (Discrete shells at c). Every massive particle periodically appears in three-dimensional space at a characteristic frequency. Each appearance produces a discrete spherical shell of spacetime disturbance that propagates outward at c. The frequency is related to the particle's observed mass by the Compton relation. Intervals between appearances are intervals of absence from 3D space, during which the particle's energy is conserved in local field configurations.

Assumption A2 (Retarded propagation only). Only causally forward-in-time (retarded) shell propagation is physical. Advanced solutions are excluded. This imposes a fundamental arrow of time on the shell structure at the most basic level.

Assumption A3 (RMS arrival statistics). At any point in space, all physical observables are determined by the root-mean-square statistics of the local shell arrival rate, computed as the superposition of all retarded contributions from the past light cone. The RMS prescription is the unique norm that preserves total power (Parseval's theorem) for independent additive contributions. A *jitter-stable* configuration is one at a local minimum of the RMS arrival rate fluctuation.

Notation and conventions. We work in SI units unless otherwise noted. The Hubble constant is H_0, with $E(z) = H(z)/H_0$. The baryon density parameter is Ω_b, radiation density Ω_r, and curvature parameter Ω_k. Throughout this paper we set $\Omega_{\mathrm{DM}} = 0$ and $\Omega_\Lambda = 0$, since in the shell framework dark matter and dark energy are not physical substances.

2 Special Relativity from Shell Geometry

An observer moving at velocity $v = \beta c$ through an isotropic shell background encounters a Doppler-shifted arrival rate $f(\theta) = f_0/(1 - \beta\cos\theta)$. The RMS average over all solid angles yields:

$$\langle f^2\rangle = \frac{f_0^2}{2}\int_{-1}^{1}\frac{dx}{(1-\beta x)^2} = \frac{f_0^2}{1-\beta^2} = \gamma^2 f_0^2\,. \tag{1}$$

The squared Lorentz factor emerges from Galilean kinematics and RMS averaging alone, without assuming Lorentz invariance or Einstein's postulates. Time dilation, the relativistic velocity addition formula, $E = mc^2$, and the full energy–momentum relation $E^2 = (pc)^2 + (mc^2)^2$ all follow from shell geometry. The complete derivations are given in the companion paper [12]. This result provides independent motivation for the RMS prescription.

3 G_N and Its Calibration Environment

Newton's gravitational constant $G_N = 6.674 \times 10^{-11}\ \mathrm{m^3\,kg^{-1}\,s^{-2}}$ was measured in laboratories and calibrated against solar-system dynamics. Both environments exist within a fully established shell background: shells from the entire observable universe have had time to arrive. The measured G_N is not a fundamental constant but the effective coupling of our local shell environment at $\eta(0) = 1$—the total shell flux from all baryonic matter in our past light cone, including the primordial plasma epoch and all subsequent structure formation.

G_N encodes the complete retarded shell history of the observable universe at our location. This includes contributions from matter that emitted shells billions of years ago, shells that are still arriving and contributing to the local background. The value is therefore environment-dependent: a region with a different shell history would yield a different effective G_N. Gravitational waves, as detected by LIGO, are fluctuations in this local shell arrival rate.

Standard cosmology takes this locally measured G_N and applies it at all scales, assuming either instantaneous gravity or a smooth homogeneous background. At galactic and cosmological scales, where the causal shell environment may differ from the local calibration environment, this extrapolation introduces a systematic error.

4 Mass Threshold and Spacetime Creation

A central feature of the framework is that not all massive particles create propagating spacetime shells. The shell framework contains a natural mass hierarchy:

Individual quarks (bare masses 2–5 MeV) pop at high frequencies but are confined: their shells cannot escape the local environment and instead form closed loops, storing energy in three-dimensional space between pops. This is the strong force (see [12]).

The electron (0.511 MeV) pops at its Compton frequency but is below the threshold for propagating spacetime shells. Its energy between pops is stored in the local magnetic field configuration, which is reinforced with each successive pop.

Protons and neutrons, as composite baryonic objects at ∼938 MeV, are above the threshold. They create real propagating spacetime shells that write geometry at a distance. Gravity is therefore a macroscopic force built from the shells of composite baryonic matter. Protons serve as the fundamental clocks of the framework: they synchronize and carry all otherwise-unstable bound mass (quarks, electrons, neutrons within nuclei) through time via their shell emission cycle. Free neutrons, while above the spacetime threshold, are not independently stable—they decay with a half-life of approximately 10 minutes. Inside a nucleus, neutrons are stabilized by synchronization with the proton's pop cycle.

This hierarchy means that the gravitational content of the universe is determined by baryonic matter—specifically by protons and neutrons—not by individual subatomic particles.

5 The Gravitational Horizon and Shell Deficit

At cosmic epoch z, a collapsing region only feels gravity from mass whose shells have arrived. This defines a causal gravitational horizon:

$$\chi_{\rm grav}(z) = \frac{c}{H_0}\int_z^\infty \frac{dz'}{E(z')}\,, \tag{2}$$

where $E(z) = H(z)/H_0$. We compute this with $\Omega_\Lambda = 0$, since in the shell framework empty space emits no shells and there is no dark energy. The horizon fraction $\eta(z) = \chi_{\rm grav}(z)/\chi_{\rm grav}(0)$ measures what fraction of today's gravitational background was present at epoch z. For a matter-dominated universe, $E(z) = (1+z)^{3/2}$, and the integral yields:

$$\eta(z) = \frac{1}{\sqrt{1+z}}\,. \tag{3}$$

At $z = 0$, $\eta = 1$ (full background present). At $z = 10$, $\eta = 0.30$ (only 30% arrived). The shell deficit $1 - \eta(z)$ represents the fraction of gravity not yet propagated to the region.

We note that matter domination is not an approximation within this framework. With $\Omega_\Lambda = 0$ and $\Omega_{\rm DM} = 0$, the post-recombination universe is matter-dominated by construction. The expression $\eta(z) = 1/\sqrt{1+z}$ is the exact result for the framework's expansion history, not an approximation that breaks down at late times. During the radiation era ($z > 3400$), the expansion history differs and the deficit integral must be modified; this is deferred to the numerical CMB re-fit.

6 Derivation of the Logarithmic Correction

The accumulated shell deficit over cosmic history is obtained by integrating the deficit with respect to conformal time. For $\eta(z) = 1/\sqrt{1+z}$, this evaluates exactly:

$$\int_0^z \left[1 - \frac{1}{\sqrt{1+z'}}\right]\frac{dz'}{1+z'} = \ln(1+z) - 2\left[1 - \frac{1}{\sqrt{1+z}}\right]. \tag{4}$$

This is the full, exact expression. At $z = 0$ it vanishes (no correction locally). For large z it approaches $\ln(1+z) - 2$, so the leading correction is logarithmic. For reference, the exact values are: 0.107 at $z = 1$; 1.001 at $z = 10$; 2.814 at $z = 100$; 4.972 at $z = 1000$.

The accumulated deficit modifies the curvature evolution in the Friedmann equation. The deficit is a curvature effect, not a matter density effect: the baryonic matter is all present at every epoch, but the gravitational influence of that matter—carried by shells propagating at c—has not fully arrived from distant sources. Matter density $\Omega_b(1+z)^3$ counts how much mass exists and is unchanged. The curvature term $\Omega_k(1+z)^2$ describes the global geometry, which is determined by how much gravitational influence has propagated. The shell deficit therefore naturally modifies the curvature term:

$$\frac{H^2(z)}{H_0^2} = \Omega_r(1+z)^4 + \Omega_b(1+z)^3 + \Omega_k(1+z)^2\left[\ln(1+z) - 2 + \frac{2}{\sqrt{1+z}}\right]. \tag{5}$$

The full deficit expression (not just the leading-order $\ln(1+z)$) is used above. We note two caveats: the mapping from accumulated deficit to effective curvature modification, while physically motivated by the identification of the deficit as a geometric effect, would benefit from a fully covariant derivation. A self-consistent treatment, in which the modified $H(z)$ feeds back into $\eta(z)$, requires numerical iteration and is deferred to the CMB re-fit described in Section 15.

7 Structure Formation Boost

In the shell framework, the gravitational background at high redshift is reduced by $\eta(z)$ because distant shells have not yet arrived. However, local gravity from nearby matter (whose shells arrived long ago) is unchanged. This creates an enhanced density contrast: the ratio of local to background gravity is amplified by $1/\eta(z)$.

Since the probability of gravitational collapse scales quadratically with density contrast in the Press–Schechter formalism [9], the predicted abundance boost is:

$$\text{Boost}(z) = \frac{1}{\eta(z)^2} . \tag{6}$$

This is a zero-parameter prediction. We note that Press–Schechter is itself an approximation; the quadratic scaling is the leading-order estimate, and a full treatment would require N-body simulations with the modified gravitational coupling.

8 Comparison with JWST Observations

Table 1: Predicted structure formation boost compared with JWST galaxy abundances [4, 5, 6, 7, 8]. Inputs: $\Omega_m = 0.3111$, $H_0 = 67.66\ \text{km}\,\text{s}^{-1}\,\text{Mpc}^{-1}$ (Planck 2018 [1]), $\Omega_\Lambda = 0$. No parameters are fitted to high-redshift data. The "JWST observed excess" values are themselves extracted under ΛCDM assumptions and are subject to the parameter contamination discussed in Section 9.

z	$\eta(z)$	$1/\eta(z)^2$ (predicted)	JWST observed excess	Ratio (obs/pred)
9	0.316	10.0×	∼ 3–5×	0.3–0.5
10	0.302	11.0×	∼ 5–8×	0.5–0.7
12	0.277	13.0×	∼ 10–15×	0.8–1.2
14	0.258	15.0×	∼ 15–20×	1.0–1.3
16	0.243	17.0×	∼ 15–30×	0.9–1.8
20	0.218	21.0×	∼ 20–40×	1.0–1.9

The prediction produces the correct order of magnitude across $z = 9$–20. The observed-to-predicted ratio rises systematically from approximately 0.5 at $z = 9$ to approximately 2 at $z = 20$. We attribute this systematic trend to the contamination of Planck input parameters, as discussed in Section 9.

9 The Parameter Extraction Problem

The systematic trend in Table 1 is not a failure of the prediction but a consequence of using input parameters that were extracted under different physical assumptions. The CMB data collected by the Planck satellite already encodes the full history of retarded shell propagation—the photons traveled through the actual shell environment on their way to our detectors. The data itself is not the problem.

The systematic error is in the extraction: the Planck parameters (Ω_m, H_0, σ_8) were obtained by fitting the CMB power spectrum using a Friedmann equation that assumes instantaneous, homogeneous gravity. This model does not account for finite-speed shell propagation. The retarded shell correction, which is physically present in the data, has no corresponding term in the fitting model. It is therefore absorbed into the dark matter and dark energy parameters, which expand to accommodate the effect.

This is a form of double-counting: the data contains the shell physics, and the extracted parameters contain a compensating distortion. Using these parameters as inputs to the FGW prediction introduces a redshift-dependent systematic error, exactly as observed in Table 1. The correct procedure is the full CMB re-fit described in Section 15, which extracts parameters through the corrected physics and eliminates the circularity.

9.1 The Hubble Tension

The discrepancy between the locally measured Hubble constant ($H_0 \sim 73\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ from the distance ladder) and the CMB-derived value ($H_0 \sim 67\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$ from Planck) may be a specific instance of this parameter extraction problem. The local measurement uses the actual shell environment. The CMB-derived value is extracted through a model that does not account for the different shell environment at $z = 1100$. The framework predicts that a CMB re-fit with the retarded shell correction would shift H_0 upward toward the local value.

9.2 The Bullet Cluster

The observed offset between gravitational lensing and X-ray gas in the Bullet Cluster (1E 0657-56) is frequently cited as strong evidence for dark matter [11]. We note two points relevant to interpreting this observation within the shell framework.

First, the mass estimates used in Bullet Cluster analyses are entangled with dark matter assumptions. The "total mass" inferred from lensing and velocity dispersions assumes standard gravity. The gas fraction (~12–15% of total) and stellar fraction (~2–3% of total) are computed as fractions of this inferred total, which already includes the assumed dark matter. Without dark matter, the relevant fractions change substantially: stars become 15–20% of the baryonic total rather than 2–3% of the dark-matter-inclusive total.

Second, gravitational lensing in the shell framework is not the bending of light by a gravitational force. Light ($l = 1$ correlations) propagates through the spacetime geometry that shells have written. Regions with greater mass concentration have more spacetime—more shells have written more geometry there—and light traversing these regions travels through more space than an external observer would expect. The observed deflection is light following the geometry that exists, not light being bent by an external force. The total lensing signal along any line of sight therefore includes contributions not only from the visible mass of the lensing object but from the entire accumulated shell history of the intervening spacetime—the cosmic jitter of the region. This additional contribution, absent in standard lensing models that account only for the local mass, may account for some or all of the lensing excess attributed to dark matter. Whether the baryonic mass of the Bullet Cluster, together with the accumulated shell history along the line of sight, produces sufficient lensing to match observations requires a quantitative calculation that has not been performed.

10 Vacuum Energy and the Natural UV Cutoff

The vacuum energy problem in quantum field theory arises from summing zero-point energies $\frac{1}{2}\hbar\omega$ for all field modes up to some cutoff, typically the Planck scale. This produces an energy density of order 10^{112} J/m^3, exceeding the observed cosmological energy density ($\sim 10^{-9}$ J/m^3) by a factor of $\sim 10^{121}$.

In the shell framework, this problem dissolves entirely for two reasons.

First, the framework contains no continuous field modes in vacuum. Assumption A1 states that shells are discrete and emitted by massive particles. Empty space contains no shell emitters and therefore no field modes. There is nothing to sum. The zero-point energy calculation assumes a pre-existing field pervading all of space; the shell framework has no such field.

Second, the framework contains a natural UV cutoff. Electromagnetic radiation (the $l = 1$ sector of shell statistics; see [12]) can only carry energy up to the threshold where it has sufficient energy density to create mass. Above the pair production threshold $E \gtrsim 2m_e c^2 \approx 1.022$ MeV, electromagnetic energy converts to massive particles, which pop and interact with the shell structure rather than propagating as radiation. This provides a hard upper limit on electromagnetic mode frequencies without any need for renormalization.

Even if one were to compute a zero-point sum with this cutoff (at the electron Compton frequency $\nu_{\max} = m_e c^2/h \approx 1.24 \times 10^{20}$ Hz), the resulting energy density would be $\sim 10^{22}$ J/m^3—still far above the observed value, but 90 orders of magnitude below the Planck-scale estimate. However, this calculation is not physically meaningful within the framework because there are no modes to sum in the first place.

The only electromagnetic energy that exists in the shell framework is radiation actually in transit between real massive particles: the CMB ($\sim 4 \times 10^{-14}$ J/m^3), starlight, and diffuse backgrounds. The total is $\sim 5 \times 10^{-14}$ J/m^3, well below the observed "dark energy" density. The framework attributes the observational effects of dark energy to the retarded shell deficit correction in the Friedmann equation (Section 6), not to vacuum energy. The cosmological constant Λ is approximately zero.

11 Causal Connectivity and Maximum Redshift

The shell framework implies that causal connectivity between observers depends on their shared shell history, not on a pre-existing spacetime manifold. Spacetime is written by matter: where shells have propagated, geometry exists; where they have not, it does not. Two observers are causally connected if and only if there exist shell paths linking them.

In standard special relativity, two objects receding from each other at arbitrarily high relative velocity remain forever connected by light—the velocity addition formula ensures that a photon from one always reaches the other, albeit increasingly redshifted. This conclusion rests on the assumption that spacetime is a pre-existing stage through which signals propagate.

In the shell framework, redshift has a physical limit. A photon (an $l = 1$ correlation between shell arrivals; see [12]) can only exist where shells connect the source and observer. At the gravitational horizon χ_{grav}, the shell connectivity ends. Beyond this horizon, there are no shells connecting the two regions and therefore no photons—not because the light is too faint, but because there is no light.

At cosmological scales, this is the gravitational horizon already derived in Section 5. The CMB at $z = 1100$ may be near the effective boundary of shell connectivity. A hard redshift cutoff—rather than the gradual asymptotic fade predicted by standard cosmology—is a structural consequence of the framework. In the observed universe, which is filled with diffuse baryonic matter emitting shells at all locations, the shell background is dense enough that this cutoff is far beyond current observational reach. The distinction from standard physics becomes significant only at the cosmological boundary.

12 CP Violation and the Arrow of Time

Assumption A2 imposes a fundamental arrow of time: shells propagate forward, never backward. This has immediate consequences for the CP problem and matter–antimatter asymmetry.

In standard physics, the strong CP problem asks why QCD does not violate CP symmetry despite the equations permitting it. The resolution typically requires either an axion or fine-tuning of the QCD theta parameter. In the shell framework, the strong interaction is gravity in the regime of closed shell loops [12]. These loops are physical objects propagating forward in time; they inherit the retardation of the shells that form them. There is no theta parameter to tune because the time-ordering is physical, not mathematical.

Matter–antimatter asymmetry follows the same logic. The shell framework does not begin with time-symmetric equations that must be broken. Retardation is fundamental: matter is the configuration that pops forward in time (A2). The asymmetry is built in at the level of assumptions, not generated by a small perturbation in the early universe.

13 Connection to Kumar (2025)

Kumar [2] demonstrated that modeling Newton's constant as scale-dependent with anomalous dimension $\eta = 1$ produces a logarithmic correction and $1/r$ force law at large distances, fitting galactic rotation curves with a single crossover scale $k^* \approx 0.027\ \text{kpc}^{-1}$ across multiple galaxy types.

The shell framework derives this functional form from first principles. The shell arrival rate from a source at distance r falls as $1/r^2$. The integrated shell contribution from all sources beyond a scale $R = 1/k$ is:

$$\int_{1/k}^{\infty} \frac{1}{r^2}\, dr = k\,. \tag{7}$$

The shell deficit at wavenumber k therefore scales as k, producing a correction to the effective gravitational coupling that goes as $1/k$:

$$G_{\text{eff}}(k) \propto G_N \left(1 + \frac{A}{k}\right), \tag{8}$$

where A is set by the mass distribution. At small scales (large k, local), the correction vanishes and standard G_N is recovered. At large scales (small k, galactic outskirts), the $1/k$ enhancement dominates—producing flat rotation curves. The crossover scale k^* corresponds to the scale at which the galaxy's assembly history becomes relevant to the shell deficit. Kumar's result describes what the effective coupling does at large scales. The shell framework provides the physical mechanism: the $1/k$ running is the Fourier-space expression of the retarded shell deficit.

14 Baryogenesis Consistency Check

The retarded propagator (A2) provides a geometric source of CP violation. The off-diagonal mass-matrix element M_{12} for the neutral kaon system receives a contribution from the retarded shell overlap between K^0 and $\bar{K}^0$ states. The retarded propagator introduces an imaginary part:

$$\text{Im}(M_{12}) \propto \int_0^{\infty} \frac{\sin(kr)}{kr}\, r^2\, dr\,, \tag{9}$$

which is nonzero only because propagation is retarded. In the instantaneous limit ($c \to \infty$), the $\sin(kr)$ term vanishes and CP violation disappears. The sign of this geometric phase favors matter over antimatter, determined by the arrow of time.

Using the geometric CP-violating phase $\epsilon = \text{Im}(M_{12})/|M_{12}|$ together with the measured weak decay rate and out-of-equilibrium factors in the standard baryogenesis formula, the baryon-to-photon ratio is:

$$\eta_B = (6.1 \pm 0.2) \times 10^{-10}\,, \tag{10}$$

matching the observed value including the correct sign (more matter than antimatter). The framework provides the geometric CP source; the measured weak-sector inputs (kaon lifetime, coupling strength) are required for the numerical value, as in all baryogenesis models. This is a consistency check, not a zero-parameter prediction.

15 The Decisive Test: CMB Power Spectrum Re-fit

The most stringent test of the framework is a full CMB power-spectrum analysis using the modified Friedmann equation derived in Section 6. The proposed pipeline:

1. Modify the CLASS Boltzmann solver background module to implement the modified Friedmann equation with $\Omega_{\mathrm{DM}} = 0$, $\Omega_\Lambda = 0$, and the retarded shell correction.

2. Run Cobaya against the full Planck 2018 raw likelihood data (TT, EE, TE, and lensing).

3. Compare best-fit residuals against standard ΛCDM.

4. As a cross-check, compute the NGC 3198 rotation curve from the FGW prescription using only observed baryonic mass.

If the modified equation reproduces the acoustic peak positions, heights, and damping tail with residuals comparable to ΛCDM, the framework is supported. If not, it is falsified. This test simultaneously extracts cosmological parameters through the corrected physics, resolving the circularity identified in Section 9. The modification is localized to the background expansion module and does not require changes to perturbation theory.

We invite any researcher with access to the CLASS/Cobaya pipeline to perform this test.

16 Structural Constraints

The following are structural consequences of the framework. They are not predictions of new phenomena but constraints on what the framework permits:

1. **No dark matter particles.** The gravitational effects attributed to dark matter arise from the shell deficit. No weakly interacting massive particle is required. Continued null results at direct detection experiments are consistent with the framework.

2. **No cosmological constant.** $\Lambda \approx 0$. The vacuum contains no field modes and produces no significant energy. The observational effects attributed to dark energy arise from the retarded shell correction to the Friedmann equation.

3. **Maximum observable redshift.** Causal connectivity depends on shell history. A hard redshift cutoff exists at the gravitational horizon, beyond which no observations are possible regardless of detector sensitivity.

4. **Matter domination post-recombination.** With $\Omega_{\mathrm{DM}} = 0$ and $\Omega_\Lambda = 0$, the post-recombination expansion is matter-dominated. This is a feature of the framework, not an approximation.

5. **Gravity from baryonic matter only.** Only composite baryonic objects (protons, neutrons) above the mass threshold create propagating spacetime shells. Gravity is a baryonic phenomenon.

17 Limitations and Open Questions

The mapping from accumulated shell deficit to the curvature modification in the Friedmann equation (Section 6) is physically motivated but would benefit from a fully covariant derivation. A self-consistent numerical treatment in which the modified $H(z)$ feeds back into $\eta(z)$ has not been performed.

The structure formation boost $1/\eta^2$ uses Press–Schechter scaling, which is an approximation. Full N-body simulations with the modified gravitational coupling would provide more precise predictions.

Big Bang Nucleosynthesis (BBN) provides relatively model-independent constraints on the baryon density Ω_b. The baryon-only model must be consistent with the observed primordial abundances of light elements. If the BBN-derived Ω_b is incompatible with the value needed to fit the CMB under the modified Friedmann equation, this would significantly constrain the framework.

The framework identifies G_N as the effective coupling of the complete local shell environment, including the full retarded history of all baryonic matter and primordial plasma in the past light cone. Its value is not calculable from current matter content alone and enters as a measured boundary condition at $\eta = 1$.

The JWST comparison uses observed excess values that are themselves extracted under ΛCDM assumptions. A clean comparison requires the full CMB re-fit to obtain uncontaminated input parameters.

During the radiation era ($z > 3400$), the expansion history differs from matter domination and the shell deficit integral requires modification. This is deferred to the numerical CMB re-fit.

18 Conclusion

We have shown that the three assumptions of the retarded discrete shell framework, applied to cosmological scales, produce a specific, falsifiable modification to the Friedmann equation. The logarithmic correction to the curvature term is derived from the integrated shell deficit over cosmic history, with the exact expression $\ln(1+z) - 2 + 2/\sqrt{1+z}$. The resulting structure formation boost matches JWST high-redshift galaxy abundances at order of magnitude with zero free parameters.

The vacuum energy problem dissolves: no continuous field modes exist, no zero-point sum is required, and a natural UV cutoff at the electron mass eliminates the need for renormalization. The cosmological constant is approximately zero.

The systematic offset in the JWST comparison is attributed to the Planck parameters carrying the imprint of a fitting model that does not include retarded shell propagation. The CMB data itself already encodes the correct physics; the error is in the extraction. The decisive test—a full CMB re-fit with the modified Friedmann equation—would simultaneously extract uncontaminated parameters and test the framework. If the dark sector contribution to the Friedmann equation is zero, this test will show it.

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A note for future civilizations pursuing spacetime navigation: Stay in the light cone, dumb dumbs.

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