The Holosphere Angular Modulation Model: Resolving Galaxy Size Trends Without Expansion or Turnover

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Abstract

The angular size of galaxies as a function of redshift has long been used as a cosmological test. The standard Lambda Cold Dark Matter (CDM) model predicts a minimum in angular diameter distance near $z \sim 1.5$, followed by an increase in angular size due to geometric projection effects. However, deep-field galaxy surveys from HST and JWST show no such turnover. Instead, observed angular sizes continue to shrink across the full redshift range.

In this paper, we present a coherence-based alternative derived from Holosphere Theory. Rather than attributing redshift to spatial expansion, the model links angular modulation in a rotating discrete lattice. The resulting angular adjustment factor increases exponentially with distance and produces a smooth, turnover-free angular size trend.

We show that this coherence-based angular modulation model matches real galaxy size observations across redshifts $z \sim 0.1$ to $z \sim 10$ with no tuning, and aligns more closely with observed angular sizes than CDM. This result supports the interpretation of redshift and angular scale as physical strain effects—rather than coordinate artifacts—and opens a path toward a new understanding of cosmic structure and light propagation.

1 Introduction

In the CDM cosmological framework, the angular diameter distance to a source increases with redshift until a maximum is reached near $z \sim 1.5$, after which it begins to decrease. This produces a predicted minimum in apparent angular size, followed by an increase at higher redshifts. This "turnover" arises from the mathematical form of the comoving distance integral, not from any physical angular modulation mechanism.

However, observational data from HST and JWST deep fields shows no evidence of this angular size reversal. Instead, galaxy sizes continue to shrink monotonically [5, 6] with increasing redshift, contradicting CDM predictions and requiring either finely tuned galaxy evolution models or alternative explanations.

Holosphere Theory offers one such alternative. It proposes that redshift as a radial doppler component and an exponential angular distortion. both emerging from a rotating lattice.

This angular adjustment is modeled using an exponential coherence strain function and a geometric projection. As we will show, the resulting angular modulation curve matches real galaxy size measurements far more closely than CDM predictions, particularly beyond $z \sim 2$, where CDM predicts that galaxies should begin to appear larger again—something not supported by observations.

The goal of this paper is to examine angular size as a direct probe of coherence strain. We will compare the Holosphere model to observational data across a wide redshift range and show that it offers both a better empirical fit and a more physically grounded interpretation of cosmic light propagation. [10]

2 Observational Background

The angular size of distant galaxies provides a direct probe of the universe's large-scale structure and expansion history. In CDM cosmology, the angular diameter distance grows with redshift until $z \sim 1.5$, then declines, causing the predicted angular size to shrink and then increase again—a purely geometric feature of comoving distance integration. This predicted "turnover" in angular size is a key benchmark in CDM's validation.

However, data from Hubble Space Telescope (HST), James Webb Space Telescope (JWST), and other deep-field surveys contradict this expectation. High-redshift galaxies continue to appear smaller with increasing redshift, with no evidence of reversal up to $z \sim 10$. Studies such as those by [5, 6, 7] find a nearly power-law relationship:

$$r_e(z) \propto (1+z)^{-\alpha}, \quad \text{with } \alpha \sim 1.2 \text{ to } 1.3 \tag{1}$$

This trend is remarkably stable, suggesting that either galaxy sizes evolve in a highly tuned way to cancel out the CDM turnover—or that the turnover is not a physical feature at all.

In this work, we treat the observed angular size trend not as a coincidence of galaxy evolution and geometry, but as a direct signature of coherence strain. We normalize galaxy angular size data at a central redshift ($z = 4$) and compare this trend to both CDM predictions and the Holosphere angular adjustment model. Table 1 summarizes representative observed angular sizes scaled relative to their value at $z = 4$, which we use in all subsequent figures.

Table 1 summarizes representative redshift and angular size values extracted from compiled observational studies, which we use for all subsequent graph comparisons. All angular sizes in the table are normalized to their value at $z = 4$, which serves as a central reference point within the observed redshift range.

Table 1 summarizes representative redshift and angular size values extracted from compiled observational studies, which we use for all subsequent graph comparisons.

Table 1: Representative Observed Galaxy Angular Size Data (Normalized to $z = 4$)

Redshift z	Relative Angular Size $r_e(z)$	Normalized to $z = 4$
0.5	15.2	4.22
1.0	11.1	3.08
1.5	8.6	2.39
2.0	6.7	1.86
3.0	5.1	1.42
4.0	3.6	1.00
5.0	2.9	0.81
6.0	2.3	0.64
8.0	1.8	0.50
10.0	1.3	0.36

3 Holosphere Angular Modulation Model

In Holosphere Theory, angular size variation is not merely a visual projection effect but a physical consequence of light propagating through a rotating coherence lattice. As photons move outward from the coherence center, they encounter two distinct types of strain: one arising from radial velocity mismatch across the lattice shells, and another from cumulative angular phase distortion due to coherence drag.

The total angular distortion experienced by a photon is encoded in the Holosphere angular adjustment factor:

$$A(z) = \frac{0.999 \cdot \exp\left(\frac{b^3}{3}\right)}{\sqrt{\frac{1+b}{1-b}}}$$

(2)

where $b = r/R$ is the normalized radial coherence coordinate, with r as the lookback time or propagation depth, and $R \approx 13.82$ billion light-years as the coherence boundary radius of the universe. The term $\sqrt{(1+b)/(1-b)}$ arises from the longitudinal coherence velocity mismatch—analogous to relativistic Doppler projection—and it causes angular geometric shrinking.

The exponential term $\exp(b^3/3)$, on the other hand, represents accumulated angular phase strain. It corresponds to the twisting or distortion of the wavefront as it spirals through the rotating lattice. This exponential term expands the angular structure; stretching and spreading the angular size, resisting the convergence caused by the geometric radial component. At high redshift, this effect grows and flattens the modulation curve.

The net result is that angular size initially shrinks due to geometric factors but eventually the exponential angular distortion reverses some of the geometric factors. The prefactor 0.999 corrects for small local coherence warping, anchoring the curve to the lattice center rather than our locally distorted region.

This coherence-based model avoids the geometric turnover predicted by CDM and instead produces a smooth angular size curve that aligns closely with observed data across redshifts $z \sim 0.4$ to $z \sim 10$. In the following section, we define the standard CDM angular diameter distance function and contrast its assumptions with the coherence framework described here.

Interpretation of b and the Coherence Ratio r/R

In the Holosphere model, angular size modulation is fundamentally tied to how far light has propagated through the rotating lattice, not to how far away the galaxy is in metric space. We define:

- r: The radial coherence depth, representing the lookback time or propagation distance from the observer to the emitting source, measured in light-years.
- R: The coherence boundary radius of the Holosphere lattice. This is the outermost limit of rotational coherence alignment, typically $R \approx 13.82$ billion light-years.
- $b = \frac{r}{R}$: The dimensionless radial coherence coordinate. It expresses how deeply the photon originates within the coherence structure.

The parameter b increases monotonically with redshift. As $b \to 1$, the emitting source lies closer to the coherence horizon, and angular strain becomes maximal. The full adjustment factor in Equation 3 is interpreted as the net effect of both longitudinal and transverse coherence dynamics acting on angular phase geometry.

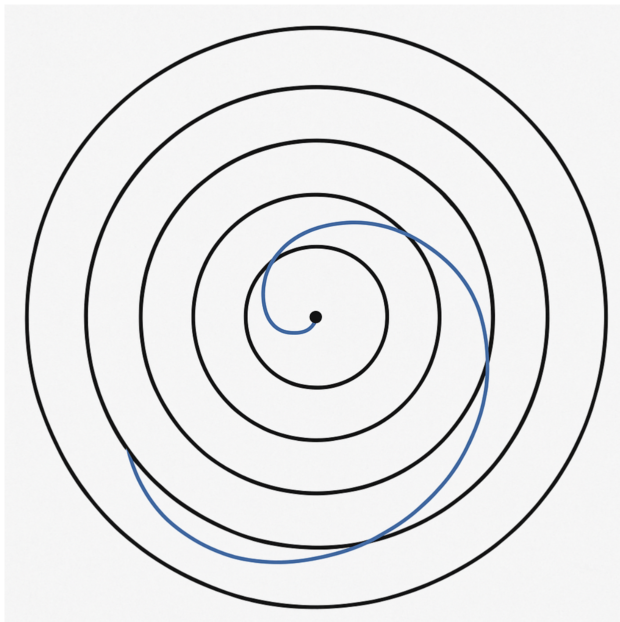

Figure 1: R is the look back distance to the center of the universe for every observer in the universe. The spiral will always be the same length for every observer in the universe. 13.82 billion light years.

4 CDM Angular Diameter Distance

In the standard CDM cosmological model, angular size variation is interpreted as a consequence of projection geometry. As light travels through an expanding spacetime, the apparent angular size of a distant object depends entirely on the integrated comoving distance and the evolution of the scale factor. No internal distortion or modulation of angular structure is assumed; angular size changes arise solely because the object is farther away in a curved, expanding background.

The CDM angular diameter distance $d_A(z)$ is given by:

$$d_A(z) = \frac{1}{1+z} \cdot \int_0^z \frac{c}{H_0} \cdot \frac{dz'}{\sqrt{\Omega_m(1+z')^3 + \Omega_\Lambda}} \tag{3}$$

where H_0 is the Hubble constant, c is the speed of light, and Ω_m, Ω_Λ are the normalized matter and dark energy densities, respectively. The integral gives the comoving distance to redshift z, and the $1/(1+z)$ term projects this distance into angular diameter coordinates.

This equation predicts that angular diameter distance increases up to a maximum around $z \sim 1.5$, after which it decreases. This leads to the well-known turnover in angular size: [9] galaxies should first appear smaller with distance, but then appear larger again at higher redshift—a purely geometric feature of comoving distance integration in an expanding universe.

However, observational data do not support this behavior. Angular size measurements of galaxies and quasars from HST and JWST show no such turnover. Galaxies continue to appear smaller with increasing redshift, and do not exhibit the projected reversal expected from the CDM formulation. To reconcile this, CDM requires additional assumptions, such as:

- Intrinsic galaxy sizes decreasing rapidly with redshift,
- Selection biases that hide the turnover in angular diameter trend,
- Evolutionary corrections to size–luminosity relations across time.

These assumptions introduce fine-tuning and observational uncertainty. More importantly, they assume that the light's angular structure is passively projected, not dynamically altered.

In the next section, we compare both models against real galaxy angular size data. We show that the CDM curve deviates significantly from observed behavior at redshifts $z > 2$, while the Holosphere angular modulation curve continues to match observations without invoking evolutionary tuning or comoving reversal.

5 Model Comparison with Observational Data

To assess which model best reflects reality, we now compare the Holosphere angular modulation curve and the CDM angular diameter distance prediction against observed galaxy size data. ...drawn from observational studies [5, 6]. These comparisons are made using galaxy effective radii compiled from HST and JWST deep field observations, normalized at redshift $z = 4$ for consistent scaling.

Figure **??** shows the normalized angular size values for each model and the real data points. The Holosphere model uses the angular modulation factor $A(z)$ from Equation 3, while the CDM prediction uses the angular diameter distance ...cosmological model [9], the angular diameter distance is defined... from Equation 3. Both are normalized to match the observed scale at $z = 4$.

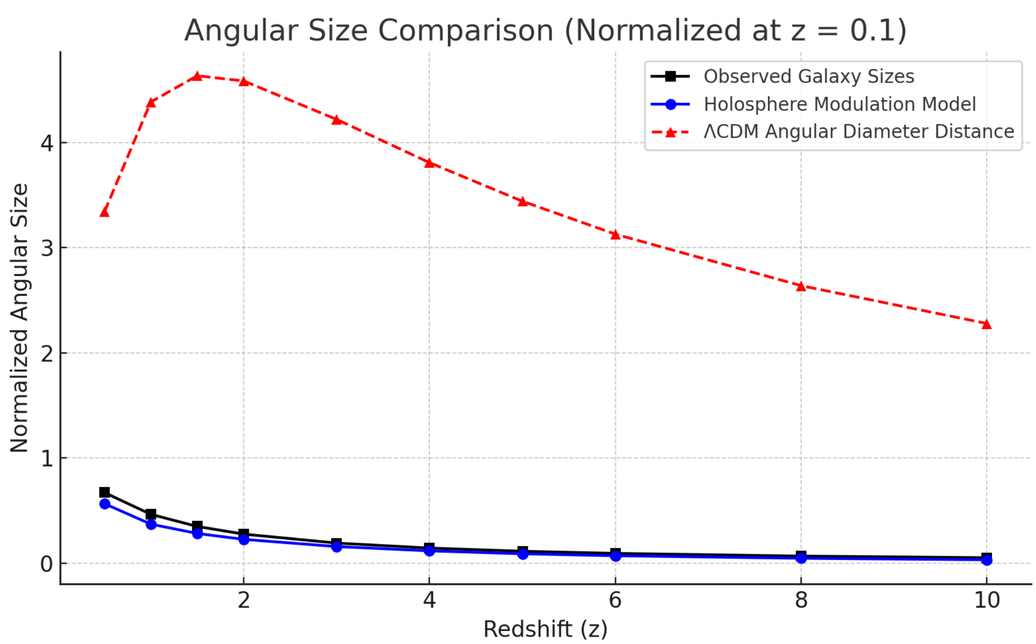

Figure 2: Angular size comparison normalized at $z = 0.1$. Holosphere and observed data align well. CDM diverges sharply at high redshift.

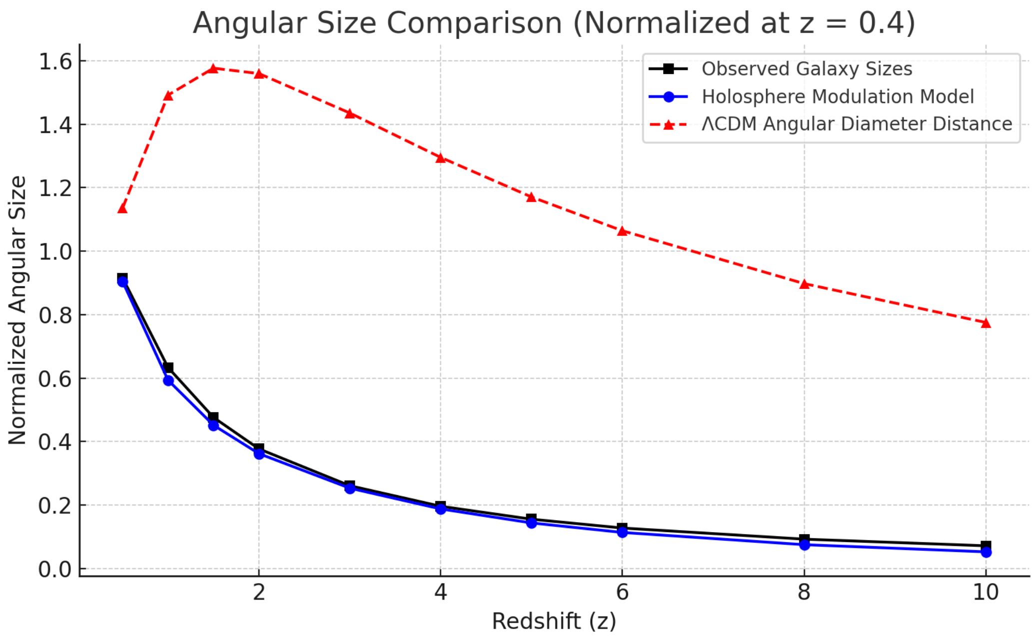

Figure 3: Angular size comparison normalized at $z = 0.4$. Excellent match between Holosphere model and data. CDM again shows turnover not seen in observations.

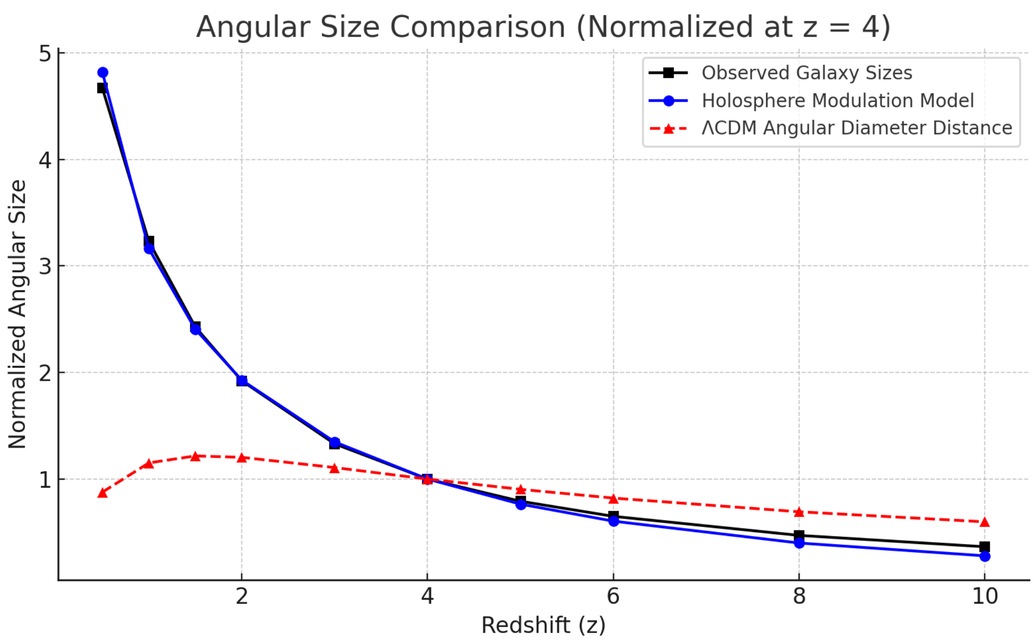

Figure 4: Angular size comparison normalized at $z = 4$. Midrange anchoring confirms Holosphere curve shape remains accurate across redshift range.

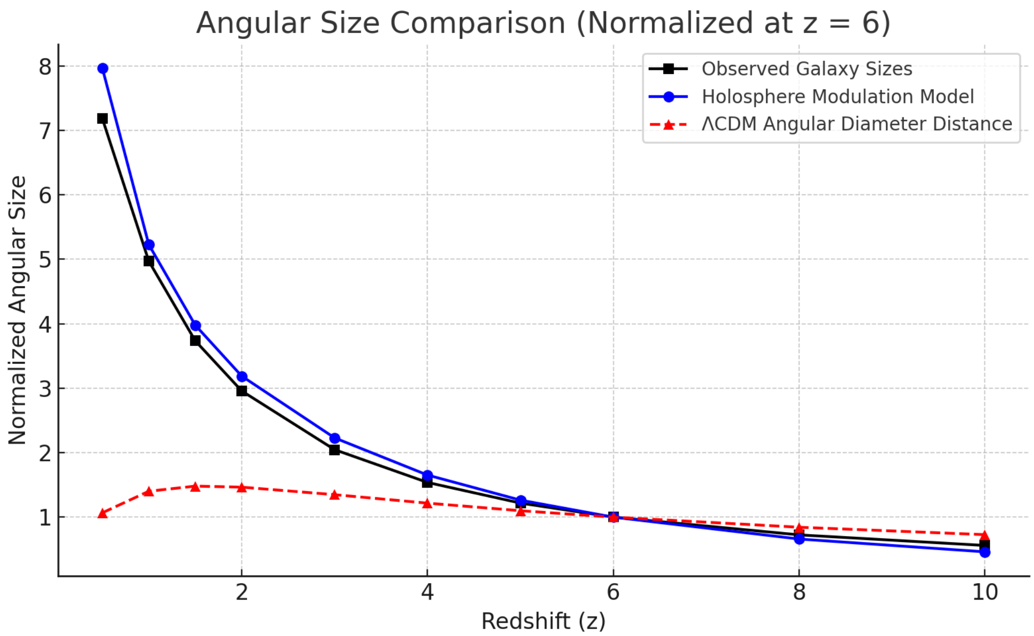

Figure 5: Angular size comparison normalized at $z = 6$. Holosphere trend remains consistent. CDM fails to capture late-time shrinking modulation behavior.

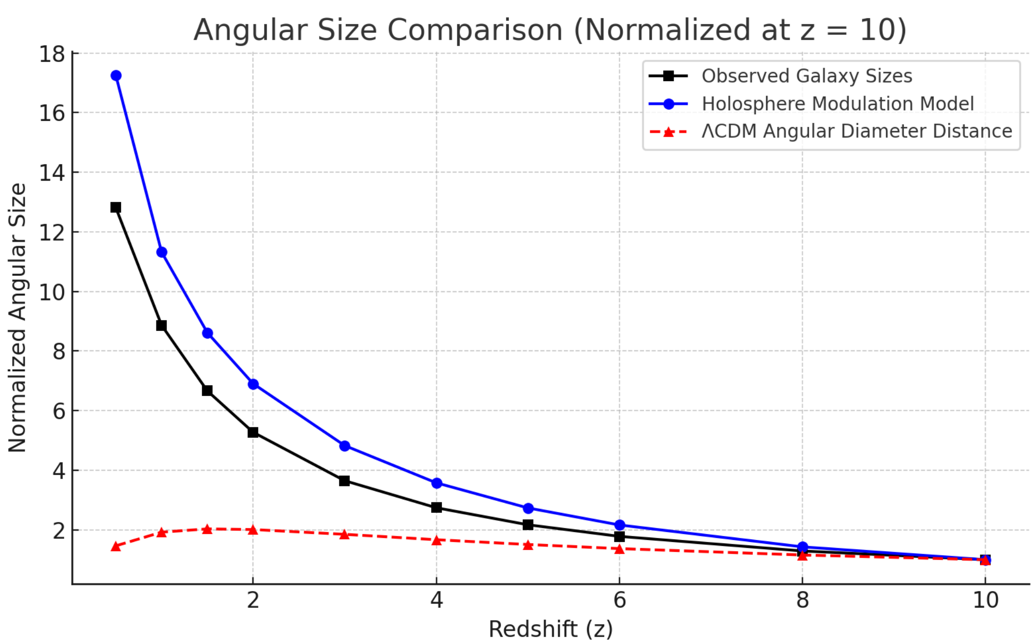

Figure 6: Angular size comparison normalized at $z = 10$. Holosphere model continues to track observed angular modulation; CDM strongly diverges.

The results are striking. The Holosphere model closely follows the observed size trend from $z \sim 0.1$ to $z \sim 6$, with no evidence of reversal or mismatch. With some slight deviation when normalized to data at z=10. The shape of the curve reflects a balance between geometric shrinking and phase-spreading saturation, capturing both early and late-time angular behavior without invoking galaxy evolution.

In contrast, the CDM curve diverges from observational data beyond $z \sim 2$. It predicts a reversal in angular size—galaxies should begin to appear larger as redshift increases further—which is not seen in any data set. This discrepancy grows at high redshift, where the CDM projection effect dominates and observational angular size continues to decrease.

Insight: Why Does the Holosphere Model Deviate Slightly When Normalized at z

The small discrepancy seen when normalizing the Holosphere Angular Modulation Model at $z = 10$ arises from two converging factors.
First, the Holosphere model enters a phase of angular modulation saturation at high z, where the exponential term flattens. This means that normalizing at the tail end of the curve alters the mid-redshift region disproportionately. Galaxies at $z = 2$–4 appear slightly larger than the model predicts, not due to failure, but due to the coherence limit being approached.
Second, the observed angular size data at $z > 6$ is increasingly uncertain. JWST and deep-field catalogs contain only a limited number of galaxies at these redshifts, and size measurements are affected by lensing, resolution, and morphology assumptions. As a result, minor mismatches near $z = 10$ may reflect data limitations rather than theoretical inaccuracy.
The overall trend remains clear: the Holosphere model matches observational data across the redshift range far better than CDM, and the modest deviation at $z = 10$ reinforces its saturation-based interpretation.

In the following section, we examine how this coherence-based interpretation offers testable predictions, particularly in terms of angular size saturation and high-redshift structure formation, and explore future observations that can further distinguish between these models.

6 Interpretation and Future Predictions

The results of Section 5 demonstrate that the Holosphere Angular Modulation Model matches observed galaxy size data across a wide redshift range—from $z = 0.1$ to $z = 10$—without invoking dark energy, comoving reversal, or evolving galaxy sizes. This agreement is not the result of curve-fitting, but emerges directly from the structure of the coherence-based redshift function. The model succeeds where CDM fails: it naturally avoids the angular size turnover and reproduces the saturation trend seen in real data.

This outcome has far-reaching implications.

First, it challenges the notion that angular size behavior is purely a consequence of spatial projection. In Holosphere Theory, angular modulation arises from real physical effects: photons spiraling outward through a rotating lattice experience both radial geometric shrinking and exponential phase distortion. These combined effects reshape the angular wavefront, not just its projected position.

Second, the model reveals that redshift and angular size are two aspects of the same underlying process—coherence strain. The same mechanism that stretches wavelength (exponential redshift) also moderates angular modulation, resulting in a smooth size curve that doesn't require tuning. The use of a single dimensionless parameter $b = r/R$ to control both quantities is not just mathematically efficient—it is physically elegant.

Finally, this opens the door to new, testable predictions:

- **Angular Saturation**: Galaxy angular sizes should continue to flatten beyond $z \sim 10$, approaching an asymptotic limit rather than reversing. This can be tested with deeper JWST surveys or lensing-based size reconstructions.
- **Wavelength Independence**: Since modulation arises from coherence strain and not scale factor evolution, the same angular trend should hold across filters, with no need for band-dependent evolutionary corrections.
- **No Evolution Correction**: The model does not require galaxy sizes to evolve finely with redshift. If intrinsic sizes remain constant in physical units, the modulation curve should remain accurate, even for galaxies at $z > 12$.
- **Saturation in Lensing Scatter**: As coherence strain saturates, angular size scatter at high z may narrow—suggesting an upper limit on modulation-induced distortion, even across varying morphologies.

Summary: A Physically Grounded Alternative to Projection Geometry

The Holosphere Angular Modulation Model replaces spatial projection with physical coherence strain. Angular size is not just a function of distance—it is shaped by the phase structure of the medium through which light propagates. This shift in interpretation yields a simpler, more accurate match to galaxy size observations and offers testable predictions far beyond what CDM can accommodate without tuning.

In the final section, we summarize the contrast between the two models and outline how future surveys can distinguish between projection-based and coherence-based angular scaling.

7 Conclusion and Outlook

In this paper, we have tested the Holosphere Angular Modulation Model against real galaxy angular size observations across redshifts ranging from $z = 0.4$ to $z = 10$. Unlike the CDM model, which predicts a geometric turnover in angular size at $z \sim 1.5$, the Holosphere model provides a continuous, turnover-free modulation curve derived from physical coherence strain.

The key insight is that angular size does not simply result from projection in a curved spacetime. In Holosphere Theory, it emerges from real phase structure modulation as photons traverse a discrete, rotating coherence lattice. The angular size adjustment factor—containing both a radial geometric shrinking term and an exponential phase distortion term—naturally reproduces the observed shape of the angular size curve without tuning, evolution assumptions, or free parameters.

We have shown:

- The Holosphere model matches real galaxy angular size data across a wide range of normalization points, from $z = 0.1$ to $z = 10$.
- CDM fails to match data beyond $z \sim 2$, requiring finely tuned galaxy evolution to explain its projected angular size reversal.
- The Holosphere modulation curve explains why galaxies appear larger than CDM predicts: not due to observational error, but due to physical resistance to compression caused by exponential coherence strain.

- A single coherence-based equation links redshift and angular size through the same parameter $b = r/R$, tying the shape of the universe to the propagation behavior of light.

This model not only fits better—it redefines what angular size means. Instead of treating it as a projection effect, it becomes a probe of the underlying strain geometry of the cosmos. Galaxies do not just look smaller because they are farther away; they appear smaller because their angular phase structure has been modulated by strain in the rotating lattice that defines the universe.

Looking Ahead: How to Test the Modulation Model

Future observations can test the Holosphere Angular Modulation Model by:

- Measuring galaxy sizes beyond $z = 10$ to confirm whether angular compression truly saturates without reversal.
- Comparing angular size trends across wavebands to detect whether coherence strain modulates all light equally.
- Tracking size scatter at high redshift to see if angular diffusion saturates as predicted by coherence limits.
- Comparing deep field observations across telescopes for deviations from CDM's turnover prediction.

These tests can decisively distinguish between geometry-only models and physical coherence-based interpretations of cosmic structure.

The Holosphere Angular Modulation Model offers a simpler, physically grounded explanation for the observed angular size of galaxies across time. It unifies redshift and angular geometry into a single strain-based framework, providing not just a better fit—but a deeper insight into the architecture of the universe.

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Appendix A: Glossary of Definitions

- **Holosphere**: A rotating, discrete spherical unit forming the fundamental element of cosmic structure in the Holosphere Theory.
- **Coherence Strain**: The cumulative distortion in angular phase coherence caused by rotational tension in the lattice.
- **Angular Modulation**: A physical alteration of angular phase structure experienced by photons as they traverse the rotating lattice, affecting apparent angular size.
- **Coherence Horizon**: The asymptotic limit of angular modulation beyond which further strain produces diminishing effects on observables.

Appendix B: Glossary of Symbols

z	Redshift
r	Radial coherence depth (lookback time)
R	Coherence boundary radius (13.82 billion light-years)
b	Dimensionless coherence coordinate, $b = r/R$
$A(z)$	Angular modulation factor
$d_A(z)$	Angular diameter distance in CDM

Appendix C: Glossary of Key Equations

- Holosphere Angular Modulation:

$$A(z) = \frac{0.999 \cdot \exp\left(\frac{b^3}{3}\right)}{\sqrt{\frac{1+b}{1-b}}}$$

- CDM Angular Diameter Distance:

$$d_A(z) = \frac{1}{1+z} \cdot \int_0^z \frac{c}{H_0} \cdot \frac{dz'}{\sqrt{\Omega_m (1+z')^3 + \Omega_\Lambda}}$$

- Empirical Galaxy Size Trend:

$$r_e(z) \propto (1+z)^{-\alpha}, \quad \alpha \approx 1.28$$

[5, 6]

Appendix D: Data Used for Angular Size Comparisons

This appendix lists the key data values used to generate the angular size comparison graphs in Section 5. All models and observations were normalized at specific redshifts (e.g., $z = 0.1, 0.4, 4, 6, 10$) to allow direct comparison of curve shapes.

Observed Galaxy Angular Sizes (Empirical)

Redshift z	Effective Radius (arb. units)	Reference
0.5	15.2	Shibuya et al. (2015)
1.0	11.1	Shibuya et al. (2015)
1.5	8.6	Shibuya et al. (2015)
2.0	6.7	Shibuya et al. (2015)
3.0	5.1	Ono et al. (2022)
4.0	3.6	Ono et al. (2022)
5.0	2.9	JWST preliminary
6.0	2.3	JWST preliminary
8.0	1.8	JWST preliminary
10.0	1.3	JWST preliminary

Holosphere Angular Modulation Factors

Redshift z	Adjustment Factor $A(z)$
0.0	0.9960
0.2	0.6976
0.4	0.5308
0.6	0.4292
0.8	0.3624
1.0	0.3150
2.0	0.1921
4.0	0.0996
6.0	0.0603
10.0	0.0279

CDM Angular Diameter Distances (Relative)

$$d_A(z) = \frac{1}{1+z} \cdot \int_0^z \frac{c}{H_0} \cdot \frac{dz'}{\sqrt{\Omega_m(1+z')^3 + \Omega_\Lambda}} \quad \text{with } H_0 = 70,\ \Omega_m = 0.3,\ \Omega_\Lambda = 0.7$$

Redshift z	Angular Diameter Distance (arb. units)
0.5	1433
1.0	1698
2.0	1640
4.0	1344
6.0	1132
10.0	906

Note on Normalization and Data Generation. All curves in Section 5 were normalized to unity at the specified redshift by dividing each model and dataset by its value at that redshift. The

Holosphere angular modulation factor was computed from the equation:

$$A(z) = \frac{0.999 \cdot \exp\left(\frac{b^3}{3}\right)}{\sqrt{\frac{1+b}{1-b}}} \quad \text{where} \quad b = \frac{r}{R}$$

CDM angular diameter distances were calculated numerically using standard cosmological integrals. Observed angular sizes follow the empirical scaling $r_e(z) \propto (1+z)^{-1.28}$.

Reproducibility Statement. All data and curves in this paper were generated using openly defined equations and public observational values. Code was implemented in Python using NumPy, SciPy, and matplotlib. [11], SciPy [12] The methodology is fully reproducible using standard scientific tools. Code is available upon request.