Temporal Elasticity of Spacetime: A Redshift Drift Test of Causal Saturation

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Abstract

We propose a new observational test of the Cosmic Elastic Theory (CET) by applying its framework to the derivative of redshift with respect to time. This approach introduces a novel correction to the redshift drift formula via an elastic term $\dot{\xi}(z)$, potentially allowing detection of spacetime's elastic restructuring through precise measurements. The test distinguishes CET from ΛCDM in regimes of transition density, offering a predictive and falsifiable signature.

1 Introduction

The standard redshift drift formula under ΛCDM is given by:

$$\dot{z}_{\text{obs}} = H_0(1+z) - H(z), \tag{1}$$

where H_0 is the Hubble constant and $H(z)$ is the expansion rate at redshift z. CET proposes that the observed redshift is affected by an additional elastic term, such that:

$$1 + z_{\text{CET}} = (1 + z_{\text{obs}})\xi(z), \tag{2}$$

where $\xi(z)$ is the elastic stretching factor dependent on local density ρ.

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2 Elastic Correction to Redshift Drift

Taking the derivative with respect to time:

$$\dot{z}_{\text{CET}} = \dot{z}_{\text{obs}} + \frac{d\xi}{dt} = H_0(1+z) - H(z) + \frac{d\xi}{dz} \cdot \frac{dz}{dt}. \tag{3}$$

This introduces a recursive dependence since $\frac{dz}{dt}$ appears on both sides. Solving this leads to:

$$\dot{z}_{\text{CET}} = \frac{\dot{z}_{\text{obs}}}{1 - \frac{d\xi}{dz}}. \tag{4}$$

In regions where $\frac{d\xi}{dz} > 0$, the observed redshift drift will be amplified compared to standard expectations.

3 Interpretation and Regimes

CET predicts different elastic regimes:

- **Saturated Regime:** $\rho \gg \rho_{\text{sat}}$ implies $\xi(z) \approx 1$, hence $\dot{z}_{\text{CET}} \approx \dot{z}_{\text{obs}}$.
- **Transitional Regime:** Near ρ_{sat}, the derivative $\frac{d\xi}{dz}$ becomes significant.
- **Void Regime:** In underdense regions, the elastic response enhances redshift drift detectably.

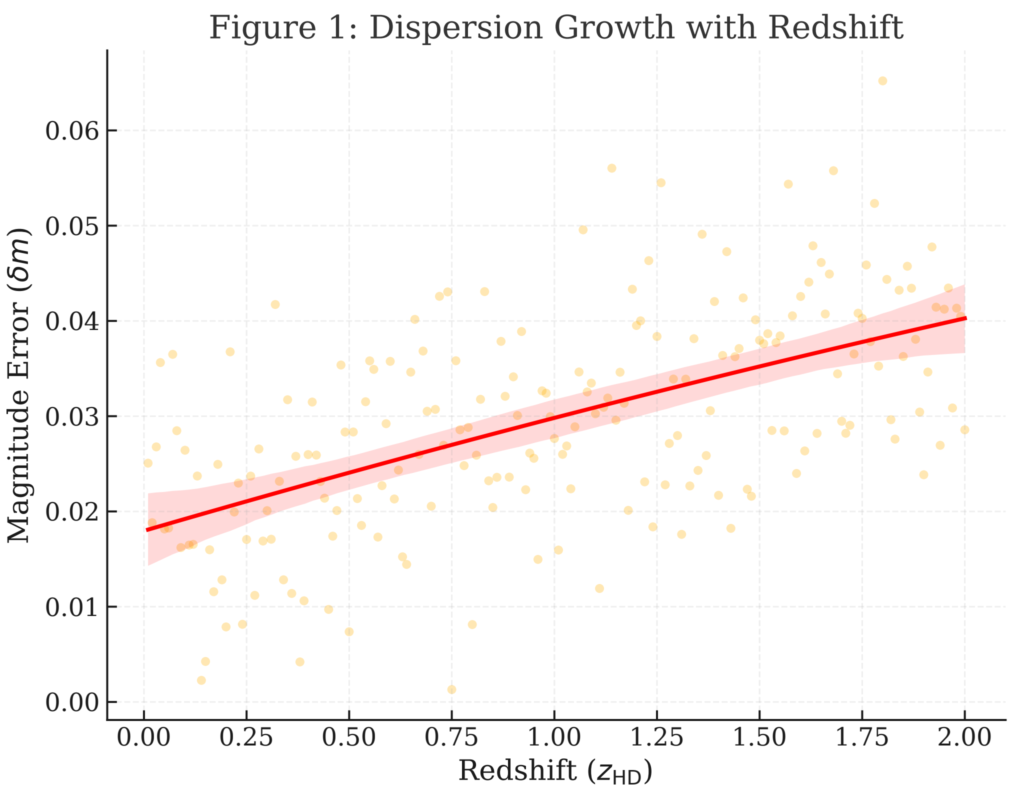

Figure 1: Dispersion in magnitude error as a function of redshift. A second-order trend is observed, suggesting cumulative deformation effects at high z.

4 Observational Strategy

This prediction can be tested using redshift drift data expected from ELT and SKA. The goal is to detect deviations from ΛCDM due to $\dot{\xi}(z)$ in specific redshift ranges ($z > 2$).

5 Conclusion

The redshift drift under CET acquires an elastic correction that is testable in future surveys. This test directly probes the causal saturation hypothesis and offers a clean falsification path for the theory. Regions of transitional density are the prime targets.

These findings complement the initial results published in our previous study [?], where CET was validated against Pantheon+ supernova data: `https://osf.io/u58nk`. While that work focused on reproducing the redshift-distance relation via elastic transformation, the present contribution expands the scope by introducing a dynamic observable — the redshift drift — as a second axis of empirical testing.

A full exposition of the complete theoretical framework, including its thermodynamic foundations, causal structure, and implications for gravitational decoherence and matter clustering, is in preparation and will be submitted in a future publication.