Elastic Deviations in Supernova Distances: A Density-Based Application of the CET Framework

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Abstract

We present an observational application of the Cosmic Elastic Theory (CET) using the Pantheon+SH0ES supernova sample. A local density estimation protocol was developed based on observed magnitude to derive elastic deviations in luminosity distance. Instead of assuming a fixed critical density, this study emphasizes the elastic response of spacetime to environmental variation. Results reveal a continuous deviation pattern and a clearly identifiable intermediate phase that supports the hypothesis of causal coupling as a governing mechanism for isotropy emergence.

1 Introduction

The Cosmic Elastic Theory (CET) models spacetime as an elastic continuum that responds to variations in causal connectivity. In previous studies—available at Stretching Spacetime and Redshift Drift and Causal Saturation— we applied CET to redshift observations and redshift drift predictions, obtaining consistent deviations from the standard model (ΛCDM) without invoking dark energy. These studies introduced the framework and demonstrated its viability.

Here, we extend the application of CET to spatial structure, by linking the elastic deviation in luminosity distance directly to the estimated local density environment of supernovae. This approach aims to test the emergence of elastic effects across causal regimes and examine whether a transitional behavior can be empirically observed.

*Test 1 of 4 in the CET empirical validation series: (1) Pantheon+, (2) CEERS, (3) JADES, (4) Eridanus.

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2 Methodology

The Pantheon+SH0ES supernova sample is used as observational input. We estimate local density by deriving stellar mass from the corrected magnitude:

$$M \sim 10^{0.4(4.77-m_b)} \quad (1)$$

A redshift-dependent spherical volume is used to compute the local environment. The elastic stretching factor is then calculated as:

$$\xi(\rho) = 1 + k \cdot \log(1 + \rho_{\text{norm}}), \quad k = 0.05 \quad (2)$$

With this, the modified luminosity distance under CET is derived and compared to the standard model:

$$\Delta D_L = D_L^{\text{ACMD}} - D_L^{\text{CET}} \quad (3)$$

3 Results

D_L vs Redshift (colored by Density)

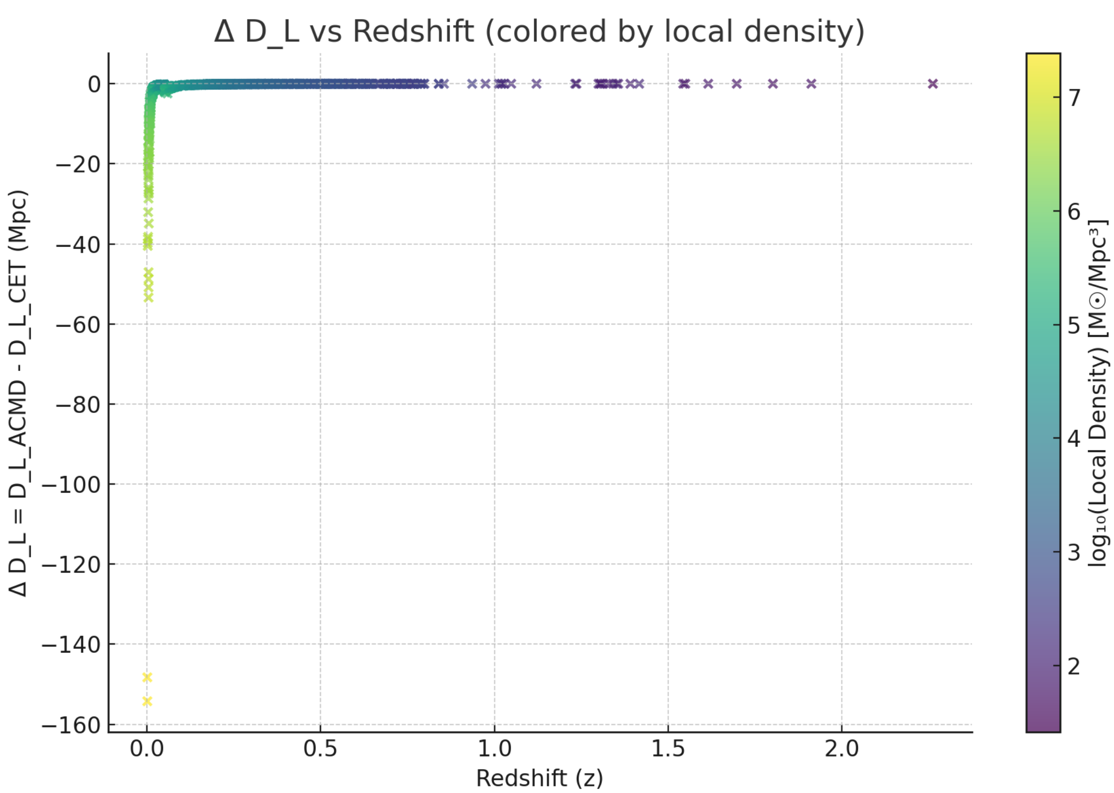

Figure 1: D_L as a function of redshift, with color scale representing local density (log scale).

D_L vs Redshift by Density Regime

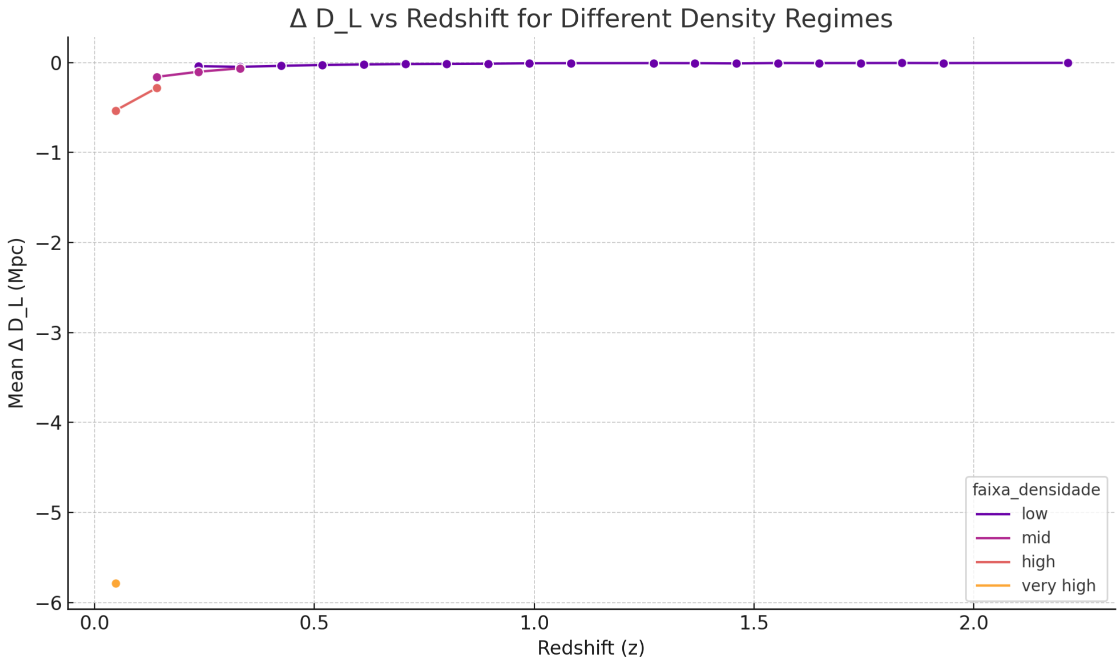

Figure 2: Average D_L vs redshift for different local density classes. A transitional response emerges between low and high density regimes.

Heatmap: Redshift vs Density

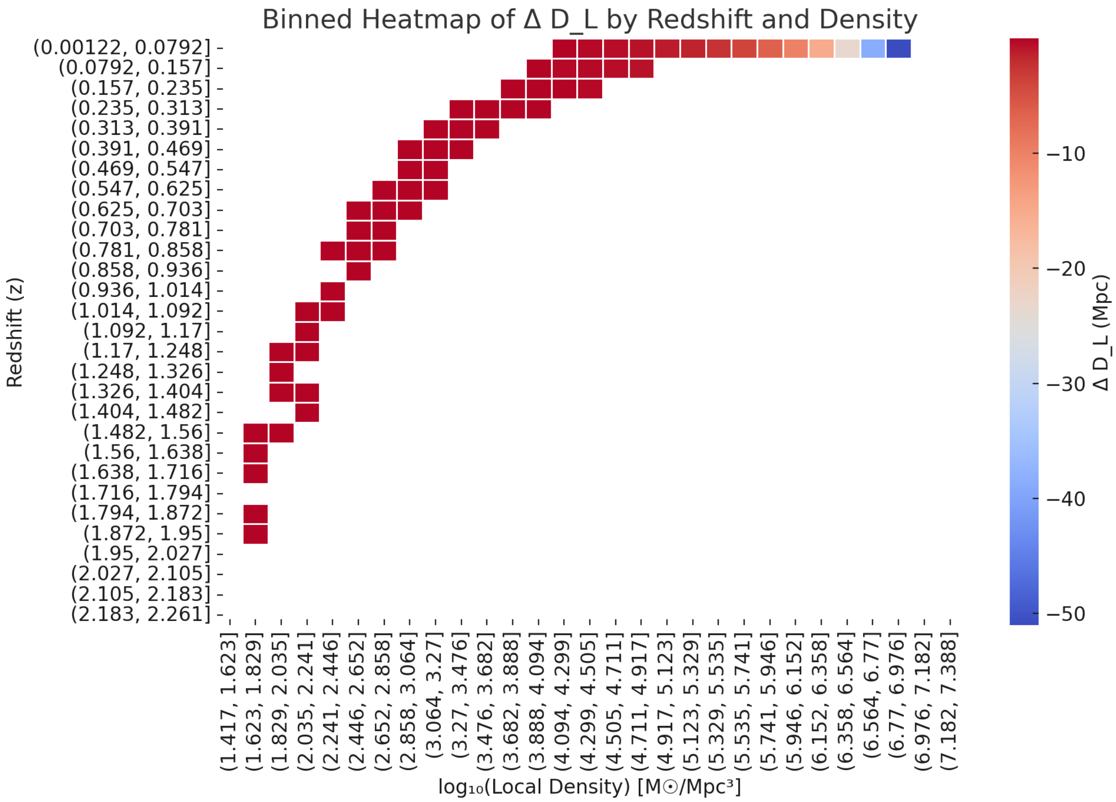

Figure 3: Binned heatmap of D_L by redshift and local density (log scale).

D_L vs Density

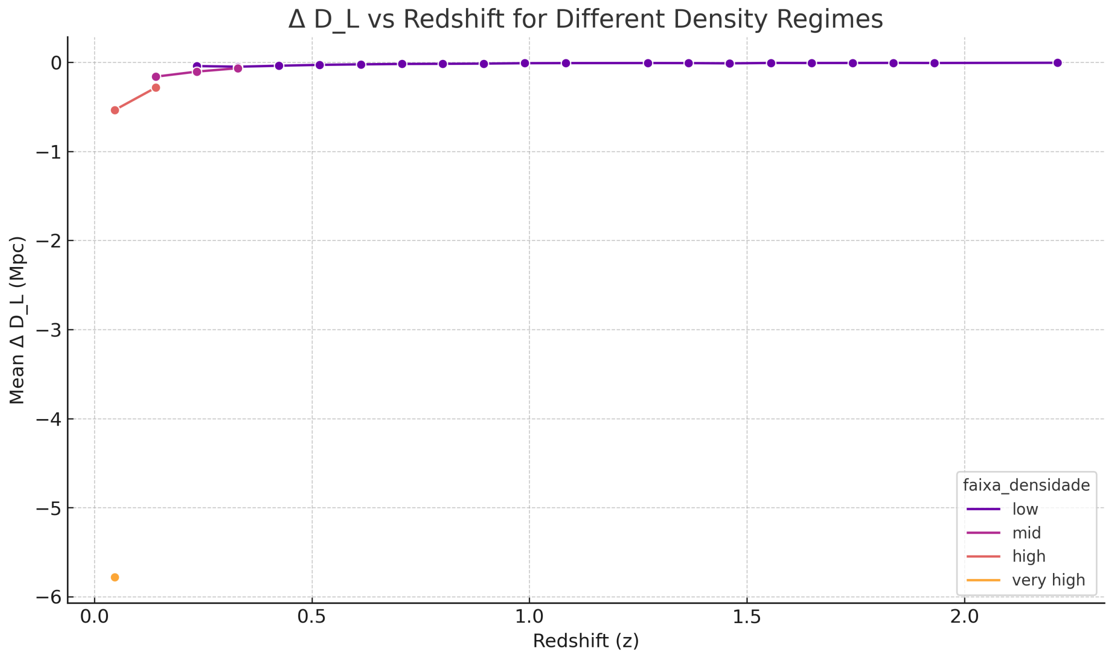

Figure 4: D_L deviation as a function of local density. A smooth gradient is observed.

4 Conclusion

The CET framework, when applied to Pantheon+SH0ES with local density information, produces a continuous and interpretable pattern of deviation in luminosity distance. The emergence of a transitional behavior, between elastic regimes of low and high density, supports the hypothesis that isotropy may arise as a causal effect mediated by elastic coupling.