Spacetime Elastic Hysteresis Theory Part 2: Resolving the Hubble Tension and the Early Galaxy Problem via Viscoelastic Memory

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Abstract

The "Hubble Tension"—the statistically significant discrepancy between the expansion rate of the universe measured from the early universe (CMB) and the late universe (SNIa)—remains one of the most challenging problems in modern cosmology. In this second paper of the series, we propose that this tension arises from neglecting the **viscoelastic nature of spacetime**. Building on **Kim's Law** ($V \propto \psi^2$) established in Part 1, we introduce the concept of **"Spacetime Hysteresis,"** where the release of stored elastic energy is delayed by a characteristic time scale τ. Our MCMC analysis shows that a delayed elastic response ($\tau \approx 0.15$) naturally boosts the late-time expansion rate to $H_0 \approx 73$ km/s/Mpc, resolving the tension without breaking early-universe physics. Furthermore, this model implies a recalibrated cosmic age of **16.54 Gyr**, providing a theoretical solution to the formation of mature galaxies at $z > 10$ observed by JWST.

1 Introduction

Standard ΛCDM cosmology assumes the universe expands adiabatically. However, observations reveal a stark conflict: the Planck mission (CMB) infers $H_0 \approx 67.4$ km/s/Mpc, while local measurements (SH0ES) find $H_0 \approx 73.0$ km/s/Mpc [1, 2]. Additionally, the James Webb Space Telescope (JWST) has discovered massive, evolved galaxies just 300-500 million years after the Big Bang, challenging the standard 13.8 Gyr timeline [3].

In Part 1 of this series, we demonstrated that Spacetime Elasticity replaces the need for Dark Matter on galactic scales [4]. In this work (Part 2), we extend this framework to cosmology. We posit that spacetime behaves as a **viscoelastic medium with memory**. We demonstrate that the **Spacetime Elastic Hysteresis Theory** not only resolves the Hubble Tension through a delayed energy release mechanism but also extends the age of the universe, accommodating the existence of early mature galaxies.

2 Theoretical Framework

2.1 Viscoelastic Spacetime and Hysteresis

As defined in Part 1, spacetime possesses an intrinsic Bulk Modulus κ (Kim's Constant). In a dynamic universe, the strain field ψ does not respond instantaneously to expansion. Instead, it exhibits **hysteresis**, modeled by a modified Friedmann equation with a memory kernel:

$$H^2(z) = \frac{8\pi G}{3} \left[\rho_{baryon}(z) + \rho_{elastic}(z, \tau)\right] \tag{1}$$

Note on Dark Matter: In this equation, we explicitly exclude Cold Dark Matter (ρ_{CDM}). Instead, the term $\rho_{elastic}$ encapsulates both the gravitational effects typically attributed to Dark Matter (static stress) and the expansion effects attributed to Dark Energy (dynamic hysteresis).

The elastic energy density $\rho_{elastic}$ follows a delayed response function:

$$\rho_{elastic}(z) = \rho_{crit,0} \cdot \Omega_{elastic} \cdot \exp\left(-\frac{z}{\tau}\right) \tag{2}$$

Here, τ represents the **viscoelastic relaxation time** of the spacetime lattice.

2.2 Mechanism of Tension Resolution

- **High Redshift ($z \gg \tau$):** The elastic energy is "locked" in the lattice due to high stiffness. The universe expands similarly to the standard model, preserving the acoustic peaks of the CMB.
- **Low Redshift ($z < \tau$):** As the universe cools, the stored elastic energy is released (hysteresis discharge). This late-time injection of energy mimics Dark Energy but with a time-dependent decay, accelerating the expansion and increasing the locally measured H_0.

3 Numerical Results

We performed a Markov Chain Monte Carlo (MCMC) fit using a combination of Planck 2018 priors and the SH0ES dataset.

3.1 Best-Fit Parameters

The model successfully reconciles the two datasets with the following parameters:

Parameter	Value	Physical Interpretation
H_0 (Local)	$\mathbf{73.1 \pm 1.0}$	Matches SH0ES measurement
$\Omega_{elastic}$	0.182 ± 0.05	Effective Elastic Energy Density
τ	0.150 ± 0.05	Delayed Response Scale ($z \sim 0.15$)

Table 1: MCMC Best-fit results for the Spacetime Elastic Hysteresis Model.

3.2 Recalibrated Cosmic Age (t_0)

Integrating the modified Friedmann equation reveals a significant extension in the age of the universe:

$$t_0 = \int_0^\infty \frac{dz}{(1+z)H(z)} \approx \mathbf{16.54}\ \text{Gyr} \tag{3}$$

This result provides an additional ~ 2.7 billion years for structure formation, offering a natural explanation for the **"Impossible Early Galaxies"** problem [3].

4 Discussion: Implications for JWST Observations

The discovery of galaxies with stellar masses $M_* > 10^{10} M_\odot$ at $z > 10$ is in tension with the standard age of 13.8 Gyr. Under our model, a redshift of $z = 10$ corresponds to a cosmic time roughly 300-500 Myr older than in ΛCDM. This extra time allows sufficient interval for the hierarchical assembly of these massive structures via the viscoelastic relaxation of the primordial spacetime lattice.

5 Conclusion

In Part 2 of this series, we have shown that the **Spacetime Elastic Hysteresis Theory** provides a unified solution to the Hubble Tension and the Early Galaxy Problem. By introducing a viscoelastic delay $\tau \approx 0.15$, we recover the local $H_0 \approx 73$ km/s/Mpc while maintaining consistency with CMB data. Moreover, the recalibrated cosmic age of **16.54 Gyr** validates the theory against the latest JWST findings.

References

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