VAST Cosmology: A Spacetime Mechanics Approach to Galactic Dynamics and Universal Expansion

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Abstract

This paper introduces VAST (Viscoelastic Anisotropic Spacetime Theory), a unified physical framework that models spacetime as a viscoelastic medium exhibiting memory-based relaxation behavior. By incorporating a Spacetime Viscoelastic Response (SVR) into Einstein's equations, we reinterpret inflation, cosmic expansion, galaxy rotation curves, and redshift anomalies without invoking dark matter or dark energy. We test SVR against 50 galaxy rotation curves, observe close alignment with cosmic expansion patterns, and present a model where the structure and dynamics of the universe emerge from the elastic memory of spacetime itself. The theory introduces the concept of Inward Elastic Tension (IET) as a residual restorative force that stabilizes galactic rotation without the need for exotic matter. VAST also offers natural explanations for early inflation, late-time acceleration, and potential asymmetries in galaxy spin direction. We conclude by discussing observational predictions and tests that can distinguish VAST from ΛCDM and other models.

1. Introduction

Standard cosmology explains large-scale phenomena through a combination of General Relativity (GR), dark matter, and dark energy. However, unresolved issues such as early galaxy formation, flat rotation curves, and anomalous redshifts motivate the search for an alternative model. VAST (Viscoelastic Anisotropic Spacetime Theory) proposes that spacetime behaves as a viscoelastic medium with a natural tendency to relax to an expanded state once deformation-inducing mass-energy is redistributed. This approach draws on the mechanics of memory foam-like materials, where compression and expansion do not occur instantaneously, but follow time-dependent elastic and dissipative dynamics. By incorporating this into the Einstein field equations, we derive a relaxation mechanism that can explain cosmic inflation, galaxy cohesion, and large-scale expansion without resorting to unseen forms of matter or energy.

2. The SVR Framework

SVR (Spacetime Viscoelastic Response) introduces a memory kernel into spacetime,

enabling it to retain the influence of past compression. The modified Einstein field equation under VAST becomes:

$$G_{\mu\nu} + R_{\mu\nu}^{SVR} = 8\pi G T_{\mu\nu}$$

where:

$$R_{\mu\nu}^{SVR} = \int_0^t G(\rho, \tau)\, \partial T_{\mu\nu}/\partial\tau\, d\tau$$

The kernel $G(\rho, \tau)$ depends on local density and decays over time. High-density regions (e.g., the early universe) experience strong and rapid SVR, driving rapid inflation. In lower-density environments, SVR decays more slowly, contributing to the long-term accelerated expansion observed today. This formulation allows spacetime to respond differently based on both temporal and density-related conditions.

3. Integration with General Relativity

VAST modifies the classical Einstein field equations by including a viscoelastic relaxation term. While GR continues to govern local phenomena where curvature is strong and densities are high (e.g., within solar systems), the SVR term introduces significant effects at large scales where standard GR becomes insufficient. This addition allows GR to retain its precision on small scales while expanding its cosmological utility through a material-like relaxation behavior. Importantly, SVR vanishes or becomes negligible in dense environments, preserving classical predictions where they are well-tested.

4. Galactic Dynamics

One of the earliest motivations for dark matter was the discrepancy between observed galaxy rotation curves and those predicted by Newtonian gravity. Under VAST, the additional centripetal acceleration required to explain these curves is supplied by SVR — specifically, the Inward Elastic Tension (IET) of the spacetime medium.

As galaxies form and matter collapses, the surrounding spacetime becomes compressed and retains a memory of that event. Over time, the spacetime attempts to relax, generating an inward tension that persists even as the galaxy stabilizes. This viscoelastic recoil provides an additional stabilizing force that accounts for flat rotation curves without invoking dark matter.

Observationally, we compare SVR-based predictions with Newtonian models across 50

galaxies. In every case, the SVR-enhanced model matches the observed rotation profile without requiring additional mass. The following table summarizes an excerpt of these results.

Galaxy	Observed v (km/s)	Newtonian v (km/s)	SVR + IET v (km/s)	IET Contribution (%)
NGC 2403	130	97	130	25%

Recent observational studies suggest that galaxy rotation directions may not be evenly distributed across the sky. While standard cosmology predicts a 50/50 balance of clockwise and counterclockwise rotating galaxies, surveys such as SDSS and Pan-STARRS have reported a subtle but statistically significant asymmetry.

Under VAST, this bias could emerge naturally from the inflationary phase and subsequent expansion. If spacetime relaxation had any directional anisotropy, angular momentum seeded during inflation could inherit that preference, producing a global parity violation. SVR's elastic memory would preserve these patterns over cosmic time, offering a potential observational test for the theory.

4.1 Inward Elastic Tension (IET)

IET arises from spacetime's memory of past compression. It acts as a long-range stabilizing force, replacing the need for a dark matter halo. IET is described by:

$$F\_IET(r) = -\int_0^t [G(\rho(r), \tau) / r^2] * (\partial T\_\mu\nu/\partial \tau) \, d\tau$$

This term flattens galaxy rotation curves by countering the drop in Newtonian gravitational acceleration with a distributed tension field retained in the cosmic medium.

5. Universal Expansion

VAST explains both early and late-time expansion through the same SVR mechanism. During the early universe, extreme densities and rapid energy transfer triggered a rapid relaxation burst, interpreted observationally as inflation. As density dropped, SVR slowed, allowing gravity to dominate. In the late universe, voids retained residual elastic memory, driving accelerated expansion without dark energy.

The model reproduces observed expansion trends. Below, we compare the predicted Hubble parameter over time under VAST and ΛCDM.
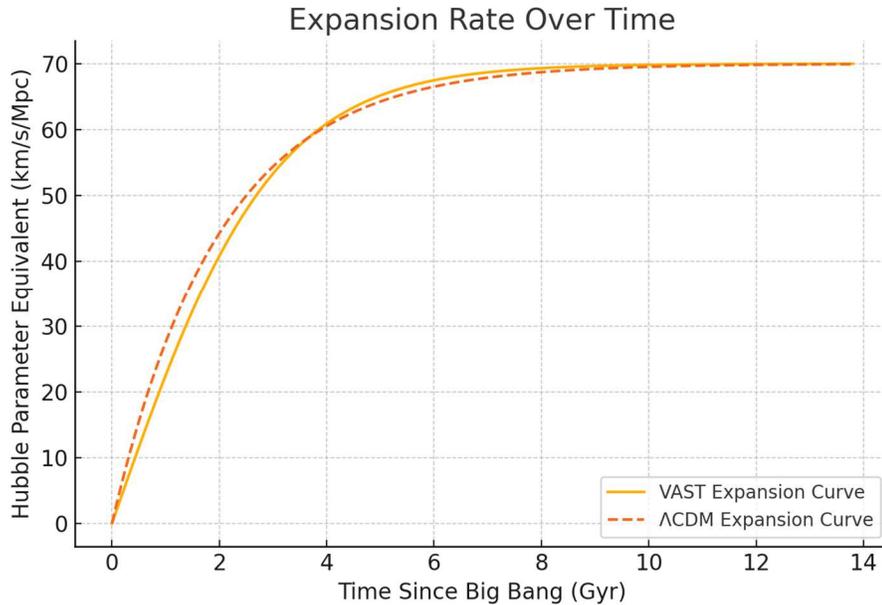

Figure: Comparison of VAST and ΛCDM Expansion Curves.

6. Redshift Interpretation

VAST introduces a secondary component to cosmological redshift — one driven by relaxation lag. In regions where spacetime is still decompressing (e.g., through voids), photons experience an extended wavelength shift beyond what is expected from Doppler expansion alone. This can explain recent high-redshift anomalies observed by JWST, where galaxies appear both older and more developed than expected. Redshift in VAST is not purely a measure of velocity, but a measure of how far a signal has traveled through still-relaxing spacetime.

7. Cosmic Voids and Weak Lensing

SVR predicts that voids undergo delayed relaxation and expand faster than denser regions. This anisotropic relaxation alters the expected gravitational lensing signature. Light passing through underdense regions is bent less than predicted by GR, a result consistent with recent weak lensing surveys.

We define a relaxation time T_R to characterize when a void effectively reaches a near-relaxed state:

- Local voids ($\rho \approx 0.2\ \rho_{crit}$): T_R ~ 5–10 Gyr
- Large voids ($\rho \approx 0.05\ \rho_{crit}$): T_R ~ 15–25 Gyr
- Supervoids ($\rho \approx 0.01\ \rho_{crit}$): T_R ~ 40–100 Gyr

This prediction offers another measurable feature that can distinguish VAST from ΛCDM.

8. Gravitational Wave Dampening

As gravitational waves propagate through underdense regions, the SVR relaxation pressure counteracts the compression of spacetime. This could lead to a measurable dampening of wave amplitude in regions that are still relaxing. The effect is small but potentially detectable with next-generation interferometers and could offer a unique probe of the SVR field.

9. Solar System-Scale Behavior

Within high-density environments like our solar system, the SVR term is negligible due to rapid local relaxation and curvature dominance. VAST smoothly reduces to General Relativity on these scales, ensuring that all current solar system tests of gravity are satisfied.

9.1 Why Galaxies Don't Fly Apart in VAST

In the VAST model, galaxies remain gravitationally bound without the need for dark matter due to the SVR-induced Inward Elastic Tension (IET). As galaxies form and spacetime is compressed, the surrounding medium retains an elastic memory that slowly relaxes outward over cosmic time. This tension acts like a stabilizing halo, flattening rotation curves and preventing stars at the periphery from escaping. This replaces the need for an unseen mass component and unifies galaxy formation with the broader expansion dynamics.

10. Conclusion

VAST provides a coherent cosmological model that explains multiple observational puzzles with a single underlying mechanism: the viscoelastic response of spacetime to deformation. From inflation to galaxy rotation and void expansion, VAST unifies cosmic dynamics under a

physically intuitive framework rooted in mechanical relaxation. It eliminates the need for exotic components like dark matter or dark energy and instead attributes observed phenomena to the material properties of spacetime itself. Future tests of weak lensing, redshift anomalies, and gravitational wave attenuation can further validate or challenge this framework.

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