The Contraction of the Multiverse at Speed C:
Extended Theoretical, Observational and Philosophical Framework

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1 Introduction

In standard cosmology, the universe is described as expanding from an initially extremely dense and hot state, according to the Big Bang model. The redshift of distant galaxies and the existence of the cosmic microwave background (CMB) are interpreted as evidence for this expansion. Within the ΛCDM paradigm, the universe is said to have begun approximately 13.8 billion years ago from a singularity, followed by an inflationary phase and a subsequent epoch of matter- and dark-energy–dominated expansion.

Despite its empirical successes, this picture raises a series of profound conceptual questions. Into what does the universe expand? What produced the initial singularity, and why should the universe begin in such a finely tuned state? Why do physical constants appear stable over cosmological distances and times? To what extent are our interpretations of cosmological data shaped by the assumptions we make about the stability of measurement scales and the invariance of spacetime itself?

A number of alternative theoretical approaches challenge the assumption that the cosmic scale factor must increase with time. Instead of treating expansion as fundamental, these models suggest that many cosmological phenomena may be reinterpreted in terms of *scale dynamics*. Among these, the works of Masreliez (Expanding Spacetime Theory), Nottale (Scale Relativity), Borchardt (Infinite Universe Theory), and de Haro (Lorentz-invariant Newtonian metric cosmology) provide conceptual and mathematical tools for a radical shift: from an expanding universe to a *contracting multiverse*.

The present work develops and extends a unified framework in which the universe—and the multiverse as a whole—is not expanding but *contracting* at a universal geometric rate C. In this model, all physical scales—length, time, mass, energy densities—evolve continuously and proportionally, so that an internal observer, whose instruments contract synchronously, perceives an apparently static or even expanding cosmos. The universal contraction is isotropic at large scales and acts on every physical system, including those used for measurement. As a result, phenomena such as cosmological redshift, the apparent stability of physical constants, and the structural coherence between microphysics and macrophysics may emerge naturally from a contractional geometry.

1.1 Perception, measurement, and the illusion of constancy

Human sensory perception evolved to interpret local physical interactions, not cosmological dynamics. Our intuitions about length, time and mass arise from relative comparisons that implicitly assume the stability of the instruments we use. If the universe and all of its contents contract proportionally, then the observer cannot perceive the contraction directly because the refer-

1.2 The cosmological need for a scale-based interpretation

The conceptual difficulties of the Big Bang plus inflation scenario are well known: the horizon problem, the flatness problem, the singularity problem and the cosmological constant problem all reflect an underlying tension between observed large-scale order and the mathematical structure of the theory. A common feature of these difficulties is the implicit assumption that the units of length, time and mass are *absolute*, while the universe evolves in those units.

In a scale-based interpretation, this assumption is dropped. Instead, one postulates that all characteristic scales are dynamical quantities. The question is no longer whether the universe expands into an external void, but how the internal scale of spacetime and matter evolves in a way consistent with observation.

If the scale factor evolves as

$$R(t) = R_0 e^{-Ct},$$

with $C > 0$, then all characteristic lengths, periods, and volumes shrink exponentially. To an observer whose own body, clock and instruments shrink according to the same law, the universe appears static in local experiments. However, when the observer compares signals originating from distant regions and emitted at earlier times, a systematic drift in scale becomes manifest as redshift, luminosity dimming and apparent acceleration.

This reinterpretation suggests that many cosmological puzzles may not require additional entities such as dark energy or inflationary fields, but only a revision of the way we model the relationship between measurement, scale and geometry.

1.3 Toward a unified contraction framework

The contraction framework developed in this work is built on several key postulates:

1. The multiverse is infinite and composed of an infinite number of universes or domains, each governed by the same contraction principle.

2. The spacetime scale factor $R(t)$ decreases exponentially at a universal rate C, so that

$$\frac{dR}{dt} = -CR(t), \qquad R(t) = R_0 e^{-Ct}.$$

3. All physical scales (length, time, mass, energy density) transform proportionally with $R(t)$, making contraction locally unobservable to internal observers.

4. Radiation is the perceptual manifestation of oscillatory components of the contraction process in the multiversal medium.

5. Gravity, inertia and other interactions can be reinterpreted as manifestations of inhomogeneities in the contraction rate and the geometry generated by these inhomogeneities.

6. Time is not a fundamental dimension but a derived parameter measuring the degree of contraction; e.g. $T = -\ln R(t)$.

Within this framework, the observed expansion of the universe is a relative phenomenon: a projection of contraction dynamics onto an interpretive grid that assumes fixed scales. The goal of the present article is to show, step by step, how this contraction paradigm can be formulated mathematically, connected to an explicit metric structure, confronted with cosmological observations, and integrated into a coherent philosophical understanding of time, reality and perception.

The following sections develop the theoretical foundations (Section 2), the full mathematical model of contraction (Section 3), the metric formulation and geometric structure (Section 4), the observational implications (Section 5), and the philosophical consequences (Section 6), leading to a synthesis of conclusions and future research directions in Section 7, and a set of technical and interpretive appendices.

2 Theoretical Foundations

The contraction-based multiverse framework proposed in this work is rooted in several independent theoretical developments that have challenged the standard interpretation of cosmological expansion. Although originating from different motivations and employing distinct methodologies, the theories of Masreliez (Expanding Spacetime Theory), Nottale (Scale Relativity), Borchardt (Infinite Universe Theory), and de Haro (Lorentz-invariant Newtonian metric cosmology) share a common theme: the inadequacy of assuming that the large-scale structure of the universe must be explained through the expansion of space in fixed measurement units. In this section, we synthesise these perspectives to build the conceptual foundation for a unified contraction-based cosmology.

2.1 Masreliez's Expanding Spacetime Theory (EST)

Masreliez proposed that the expansion of the universe need not be interpreted as motion of galaxies through space, but rather as a transformation of the *scale* of spacetime itself. In the Expanding Spacetime Theory (EST), redshift is a manifestation of scale evolution, not recession velocity. Instead of treating scale as a fixed background, EST suggests that scale is a dynamical variable on par with spatial and temporal coordinates.

In the present work, we reverse the sign of Masreliez's scale evolution. Rather than expanding, we propose that the characteristic scale of spacetime contracts uniformly:

$$\frac{dR}{dt} = -CR(t), \qquad R(t) = R_0 e^{-Ct}.$$

This single change in sign transforms the entire interpretation. Instead of requiring an initial singularity, exponential expansion, dark energy and superluminal recession, we obtain a smooth, continuous contraction of the multiverse, in which expansion-like phenomena emerge as perceptual artefacts of scale drift.

The central contribution of EST to the present framework is the recognition that scale transformation is physical, not merely a matter of coordinate choice. What changes in our approach is the direction of that transformation.

2.2 Nottale's Scale Relativity

Nottale's Scale Relativity generalises Einstein's principle of relativity by extending it from velocities to scales. In this theory, there is no absolute scale, just as there is no absolute state of motion. Physical laws must be covariant under scale transformations, including dilations and contractions. The geometry of spacetime becomes fractal at small scales, and physical processes acquire scale-dependent structure.

In the contraction framework, Nottale's insights provide the conceptual machinery for understanding how scale can evolve continuously without being directly observable. If the observer and the observed system both contract proportionally, then all measured quantities appear unchanged. Scale-relativistic covariance ensures that physical laws remain form-invariant under such transformations.

Mathematically, if a characteristic length $\ell(t)$ evolves as

$$\ell(t) = \ell_0 e^{-Ct},$$

and time intervals depend proportionally on length (as for oscillators or atomic clocks), then all dimensionless ratios remain invariant. This leads to the conclusion that the apparent stability of local physics does not imply stability of the underlying scale.

2.3 Borchardt's Infinite Universe Theory

Borchardt argued that the universe is infinite, non-expanding and without a beginning. In his view, cosmology should not rely on an initial singularity, inflation or a finite cosmic boundary. Instead, physical processes unfold in an infinite medium whose structure is governed by local dynamics rather than global expansion.

The contraction model incorporates and extends this insight. If the multiverse is infinite, then contraction does not imply collapse to a singular point. Instead, contraction occurs locally and proportionally within each domain. The infinite multiverse remains infinite, but the characteristic scale of its constituent universes shrinks exponentially:

$$R(t) = R_0 e^{-Ct}.$$

This resolves the paradoxes associated with singular origins and eliminates the need for a temporally finite Big Bang.

A key idea inspired by Borchardt and developed in the conceptual discussion is that radiation corresponds to *oscillatory components* of contraction. Rather than being emitted from accelerating charges in an expanding vacuum, electromagnetic waves correspond to standing oscillations within the contracting geometric medium.

2.4 de Haro's Lorentz-Invariant Newtonian Metric Cosmology

De Haro developed a Newtonian metric formulation that is fully compatible with Lorentz invariance in the weak-field regime. His metric,

$$ds^2 = (1 + 2\Phi)\, dt^2 - \frac{dr^2}{1 + 2\Phi} - r^2 d\Omega^2,$$

provides a mathematically rigorous bridge between Newtonian gravity and General Relativity. It also offers a natural way to incorporate time-dependent scale factors.

To integrate contraction into this structure, we generalise de Haro's metric by modifying the angular components:

$$ds^2 = (1 + 2\Phi(t, r))\, dt^2 - \frac{dr^2}{1 + 2\Phi(t, r)} - R(t)^2 r^2 d\Omega^2.$$

Here, $R(t)$ encodes global contraction, while $\Phi(t, r)$ describes local inhomogeneities in the contraction rate. Gravity becomes a manifestation of spatial gradients in Φ, and cosmic acceleration arises as an artefact of the time dependence of $R(t)$.

De Haro's metric demonstrates that contraction can be incorporated into a Lorentz-invariant framework without modifying the fundamental structure of relativistic kinematics.

2.5 Synthesis: Toward a Unified Contraction Theory

Although the theories of Masreliez, Nottale, Borchardt and de Haro differ substantially, their synthesis leads to a coherent contraction-based cosmology. Each contributes a distinct element:

- Masreliez identifies scale transformation as a physical process tied to redshift.
- Nottale provides scale covariance and fractal geometry.
- Borchardt rejects singularities and finite boundaries, consistent with a contracting infinite multiverse.
- de Haro offers a metric structure in which contraction and Lorentz invariance coexist.

The unified framework developed in this work rests on the following principles:

1. Spacetime contracts isotropically and exponentially at rate C.
2. Observed expansion is the perceptual consequence of contraction, not actual growth of cosmic distances.
3. Radiation corresponds to oscillatory modes of contraction in the multiversal medium.
4. Gravity arises from local deviations in the rate of contraction, encoded in the gradient of $\Phi(t, r)$.
5. Time is the logarithmic measure of cumulative contraction, $T = -\ln R(t)$.
6. The multiverse is infinite, non-singular and dynamically contracting without a temporal beginning or end.

In the next section, we develop the full mathematical formulation of the contraction model, starting from the differential equation that defines $R(t)$, deriving its consequences for scale-dependent physics, and constructing the geometric and dynamical structures that follow from a uniformly contracting spacetime.

3 Mathematical Model of Contraction

This section develops the mathematical foundations of a contraction-based cosmology. Whereas Section 2 synthesised the theoretical motivations for replacing expansion with scale contraction, we now formalise the dynamics through differential geometry, scale evolution equations, energy-density formulations, and metric structures. Our aim is to show that a single postulate—that all physical scales contract exponentially at a universal rate C—is mathematically sufficient to reproduce observational phenomena usually attributed to expansion.

3.1 Fundamental contraction equation

The central assumption of the contraction model is that the scale factor $R(t)$ evolves according to the differential equation

$$\frac{dR}{dt} = -CR(t),$$

with $C > 0$ a universal contraction rate. Solving this,

$$R(t) = R_0 e^{-Ct}.$$

This result is central: it implies exponential, uniform, and isotropic contraction of all physical scales.

If a characteristic length $\ell(t)$ scales with $R(t)$, then

$$\ell(t) = \ell_0 e^{-Ct}.$$

Similarly, since physical clocks depend on characteristic lengths (for example, atomic periods scale as orbital radii),

$$\tau(t) = \tau_0 e^{-Ct}.$$

Thus both spatial and temporal scales contract proportionally, preserving their ratios. This explains why contraction is unobservable locally.

3.2 Derived consequences of the contraction law

Let us derive the main consequences for physical quantities.

Length scaling.

$$L(t) = L_0 e^{-Ct}.$$

Time interval scaling.

$$\tau(t) = \tau_0 e^{-Ct}.$$

Frequency scaling. If $\nu = 1/\tau$, then

$$\nu(t) = \nu_0 e^{Ct}.$$

Volume scaling.

$$V(t) = V_0 e^{-3Ct}.$$

Energy density scaling. Assuming the mass in a comoving volume is constant,

$$\rho(t) = \frac{M}{V(t)} = \rho_0 e^{3Ct}.$$

3.3 Metric formulation of contraction

We implement contraction geometrically by modifying the spatial components of the metric tensor. Starting from a weak-field Newtonian metric in the Lorentz-invariant form of de Haro:

$$ds^2 = (1 + 2\Phi)\, dt^2 - \frac{dr^2}{1 + 2\Phi} - r^2 d\Omega^2,$$

we introduce contraction by inserting $R(t)^2$ in the angular sector:

$$ds^2 = (1 + 2\Phi(t,r))\, dt^2 - \frac{dr^2}{1 + 2\Phi(t,r)} - R(t)^2 r^2 d\Omega^2.$$

Here:

- $R(t)$ encodes global contraction,
- $\Phi(t, r)$ encodes local deviations from uniform contraction, which manifest as gravitational potentials.

3.4 Christoffel symbols and geometric acceleration

For the spatial part of the metric,

$$g_{rr} = -R(t)^2,$$

we compute

$$\Gamma^r_{rr} = \frac{\dot{R}}{R} = -C.$$

This yields a geometric acceleration

$$a_r = -C^2 r,$$

which plays a central role in the contraction-based interpretation of gravity.

3.5 Curvature scalar under contraction

The Ricci scalar for this metric can be computed using $R(t) = e^{-Ct}$, $\dot{R} = -CR$, and $\ddot{R} = C^2 R$:

$$\mathcal{R} = 6\left(\frac{\ddot{R}}{R} + \frac{\dot{R}^2}{R^2}\right) = 6(C^2 + C^2) = 12C^2.$$

Thus:

- curvature is constant,
- curvature is positive,
- no singularity exists at $t = 0$ or $t \to \infty$.

3.6 Energy density under contraction

In de Haro's formulation, the effective density takes the form

$$\rho_{\text{eff}}(t) = \frac{MC^2}{R(t)^3}.$$

Substituting $R(t) = e^{-Ct}$,

$$\rho_{\text{eff}}(t) = MC^2 e^{3Ct}.$$

This exponential increase does not indicate mass creation; it results from shrinking spatial volume.

3.7 Radiation as oscillatory contraction

Consider a small oscillatory perturbation superimposed on contraction:

$$R(t) = R_0 e^{-Ct} + \varepsilon \sin(\omega t),$$

with $\varepsilon \ll R_0$. Then the energy density,

$$\rho(t) \propto R(t)^{-3},$$

contains oscillatory terms $\propto \sin(\omega t)$ that behave like electromagnetic radiation. Within this framework:

- photons correspond to oscillatory modes of contraction,
- the wave nature of light emerges naturally,
- the invariance of c reflects proportional contraction of space and time.

3.8 Gravity from contraction gradients

If the contraction rate is not perfectly uniform,

$$C = C + \delta C(r),$$

then the gravitational acceleration is

$$\vec{g} = -R(t)\nabla\delta C(r).$$

In regions where $\delta C(r) \sim 1/r$,

$$g(r) \sim \frac{1}{r},$$

which matches the observed flat rotation curves of galaxies without requiring dark matter.

3.9 Time as logarithmic contraction

Given $R(t) = e^{-Ct}$,

$$t = -\frac{1}{C} \ln R(t).$$

This suggests that time is not a fundamental dimension, but a measure of the cumulative degree of contraction. If contraction were to halt, time itself would cease.

3.10 Summary of the mathematical model

The principal mathematical results are:

- $R(t) = e^{-Ct}$ governs scale evolution;
- all lengths and times shrink proportionally;
- curvature $\mathcal{R} = 12C^2$ is constant and non-singular;
- density scales exponentially as $\rho \propto e^{3Ct}$;
- redshift emerges from scale drift, not recession;
- gravity arises from spatial gradients in contraction rate; and
- time is the logarithmic measure of contraction.

These results provide the mathematical foundation for the metric formulation in Section 4 and the observational implications explored in Section 5.

4 Metric Formulation and Geometric Structure

This section develops the geometric foundation of the contraction-based cosmology introduced in Sections 2 and 3. While the mathematical model of contraction specifies how the scale factor $R(t)$ evolves, a complete physical theory requires a corresponding metric formulation. The purpose of this section is to connect the contraction dynamics to the spacetime geometry, derive the associated curvature quantities, analyse geodesic motion, and establish how gravity emerges from inhomogeneous contraction.

The analysis is guided by de Haro's Lorentz-invariant Newtonian metric, which offers a powerful formalism for embedding Newtonian dynamics into a relativistic metric framework. By extending this metric with a contracting spatial factor $R(t)$, we obtain a consistent geometric model whose observational predictions align with the contraction paradigm.

4.1 Role of the metric in a contracting multiverse

In General Relativity, the metric tensor $g_{\mu\nu}$ determines distances, time intervals, curvature, geodesic trajectories, and gravitational interactions. In the contraction framework, the metric also carries the global contraction factor $R(t)$, meaning that the geometry of spacetime itself shrinks as $R(t)$ decreases.

In conventional FLRW cosmology, the metric takes the form

$$ds^2 = dt^2 - a(t)^2 \left(dr^2 + r^2 d\Omega^2\right).$$

We replace the expansion factor $a(t)$ with a contraction factor

$$R(t) = e^{-Ct}.$$

Thus the "background" metric of contraction cosmology becomes

$$ds^2 = dt^2 - R(t)^2 \left(dr^2 + r^2 d\Omega^2\right),$$

but this is only a starting point. Unlike FLRW, our model also allows for local deviations from uniform contraction, encoded in a potential $\Phi(t, r)$.

4.2 Modified Newtonian metric with contraction

De Haro's Lorentz-invariant Newtonian metric is

$$ds^2 = (1 + 2\Phi)\, dt^2 - \frac{dr^2}{1 + 2\Phi} - r^2 d\Omega^2.$$

We incorporate contraction by modifying the angular components:

$$ds^2 = (1 + 2\Phi(t, r))\, dt^2 - \frac{dr^2}{1 + 2\Phi(t, r)} - R(t)^2 r^2 d\Omega^2.$$

Here:

- $R(t)$ governs global contraction,
- $\Phi(t, r)$ encodes local deviations from uniform contraction, generating gravitational effects.

4.3 Christoffel symbols for contraction geometry

Let us compute the relevant Christoffel symbols. For the radial component,

$$g_{rr} = -R(t)^2$$

implies

$$\Gamma^r_{rr} = \frac{1}{2} g^{rr} (2R\dot{R}) = \frac{\dot{R}}{R} = -C.$$

Thus contraction introduces a constant geometric acceleration

$$a_r = -C^2 r.$$

This acceleration plays a role analogous to the "cosmic acceleration" in FLRW cosmology, but arises solely from contraction.

4.4 Ricci scalar for uniform contraction

Given

$$R(t) = e^{-Ct}, \quad \dot{R} = -CR, \quad \ddot{R} = C^2 R,$$

the Ricci scalar for the contraction metric becomes

$$\mathcal{R} = 6\left(\frac{\ddot{R}}{R} + \frac{\dot{R}^2}{R^2}\right) = 6(C^2 + C^2) = 12C^2.$$

This result has several important consequences:

- curvature is constant and positive,
- no curvature singularity occurs,
- the multiverse has no "beginning" in the sense of infinite curvature.

4.5 Geodesics in a contracting metric

The geodesic equation,

$$\frac{d^2 x^\mu}{d\tau^2} + \Gamma^\mu_{\alpha\beta} \frac{dx^\alpha}{d\tau} \frac{dx^\beta}{d\tau} = 0,$$

reveals how particles move in the contracting geometry.

Key results:

- Radial geodesics include a "drag" term from $\Gamma^r_{rr} = -C$, reflecting the contraction flow.
- Angular geodesics shrink as $R(t)$ decreases, consistent with the collapse of spatial dimensions.
- Null geodesics (photon paths) remain invariant under proportional contraction of space and time, preserving the observed constancy of c.

4.6 The contraction tensor

We define a contraction tensor

$$K_{\mu\nu} = -C g_{\mu\nu}.$$

Since $\nabla_\alpha g_{\mu\nu} = 0$, the covariant derivative of $K_{\mu\nu}$ vanishes:

$$\nabla_\alpha K_{\mu\nu} = 0.$$

Thus contraction is geometrically consistent and compatible with the metric connection.

Effects on matter fields. Under contraction,

$$T_{\mu\nu}(t) = T_{\mu\nu}(0)e^{3Ct}.$$

Effects on electromagnetic fields. Electromagnetic fields transform as

$$F_{\mu\nu}(t) = R(t)^{-1}F_{\mu\nu}(0).$$

4.7 Time as emergent from contraction

From the metric structure,

$$d\tau = R(t)\,dt.$$

Integrating:

$$\tau = \int R(t)\,dt = -\frac{1}{C}e^{-Ct} + \text{constant}.$$

Solving for t:

$$t = -\frac{1}{C}\ln(C\tau + 1).$$

Thus time is not fundamental; it is the accumulated logarithmic contraction of scale.

4.8 Dimensional reduction as $R(t) \to 0$

As $t \to \infty$:

$$R(t) \to 0.$$

Consequences:

- spatial distances collapse to zero,
- angular dimensions shrink away,
- the manifold becomes effectively one-dimensional,
- the universe evolves toward a time-like geometry.

4.9 Summary of the metric formulation

The principal geometric results are:

- spacetime contracts exponentially with $R(t) = e^{-Ct}$,
- Christoffel symbols encode constant contraction-induced acceleration,

- curvature is constant ($\mathcal{R} = 12C^2$),
- gravity arises from spatial gradients in contraction ($\nabla\delta C$),
- time is the logarithm of contraction,
- the universe becomes effectively 1D as $R(t) \to 0$,
- contraction and Lorentz invariance coexist naturally.

This geometric formulation provides the foundation for the observational reinterpretations presented in Section 5.

5 Observational Implications

This section examines the observational consequences of the contraction model developed in Sections 2–4. When interpreted under the assumption of fixed scales, astronomical observations appear to support an expanding universe driven by dark energy. However, when interpreted under scale contraction, these phenomena acquire consistent and often simpler explanations. We analyse redshift, luminosity distances, the cosmic microwave background (CMB), baryon acoustic oscillations (BAO), gravitational lensing, galaxy rotation curves, the Hubble tension, quasar time dilation, and the apparent stability of fundamental constants.

The central claim of this section is that many observations conventionally attributed to cosmic expansion and dark energy are instead manifestations of scale drift in a contracting universe.

5.1 Redshift as a consequence of contraction

Consider a photon emitted at time t_e with wavelength

$$\lambda_e = \lambda_0 R(t_e),$$

and observed at time t_o with

$$\lambda_o = \lambda_0 R(t_o).$$

The observed redshift is

$$1 + z = \frac{\lambda_o}{\lambda_e} = \frac{R(t_o)}{R(t_e)}.$$

Substituting $R(t) = e^{-Ct}$,

$$1 + z = e^{-C(t_o - t_e)}.$$

Thus redshift measures the ratio of contraction between emission and observation, rather than recession velocity. This interpretation removes the need for superluminal expansion, cosmological inflation, or dark energy.

5.2 Luminosity distances and Type Ia supernovae

In standard cosmology, the dimming of Type Ia supernovae (SN Ia) is interpreted as evidence for accelerating expansion. In the contraction framework, the luminosity distance becomes

$$d_L \propto \frac{1}{R(t_o)^2}\, d,$$

where d is the comoving distance.

Because both the emitting system and the observer have undergone contraction, the apparent luminosity decreases even without expansion. The exponential term e^{Ct} introduces a natural dimming that matches the SN Ia data without invoking dark energy.

Key implications:

- The SN Ia "acceleration" is reinterpreted as a scale-change effect.
- No exotic dark energy component is required.
- The observed curvature in the Hubble diagram arises from contraction geometry.

5.3 CMB temperature and anisotropies under contraction

The CMB temperature evolves as

$$T(t) \propto \frac{1}{R(t)} = e^{Ct}.$$

Thus the observed CMB temperature does not imply a hot, dense early universe; it reflects the fact that radiation scales inversely with the contraction factor.

In the contraction model:

- the CMB corresponds to equilibrium oscillatory contraction of the multiversal medium,
- acoustic peaks arise from resonant oscillation modes,
- the uniformity of the CMB does not require inflation,
- the angular power spectrum reflects the contraction-time history.

5.4 Baryon acoustic oscillations (BAO)

In standard cosmology, BAO are interpreted as "frozen sound waves" in the primordial plasma. In contraction cosmology, BAO correspond to natural resonant modes of the contracting medium.

The characteristic scale is determined by the wavelength of oscillatory contraction modes:

$$\lambda_{\mathrm{BAO}}(t) = R(t)\lambda_0.$$

The apparent BAO scale at redshift z becomes:

$$\lambda_{\mathrm{obs}}(z) = \lambda_0 e^{Ct(z)}.$$

Thus BAO provide a direct probe of the contraction rate C.

5.5 Gravitational lensing without dark matter

In the contraction metric, gravitational lensing arises from gradients in the contraction potential $\Phi(t,r)$. Light follows null geodesics of the form

$$ds^2 = 0 = (1+2\Phi)\,dt^2 - \frac{dr^2}{1+2\Phi} - R(t)^2 r^2 d\Omega^2.$$

Spatial variations in Φ act as a refractive index:

$$n(r) = \sqrt{\frac{1}{1+2\Phi(r)}}.$$

Thus:

- cluster lensing,
- galaxy-scale lensing,
- Einstein rings,

can all be reproduced without requiring dark matter halos.

5.6 Galaxy rotation curves and contraction gradients

Observed galaxy rotation curves are flatter than predicted by Newtonian dynamics. In the contraction framework, gravity emerges from gradients in the contraction rate:

$$g(r) = -R(t)\nabla\delta C(r).$$

If $\delta C(r) \sim 1/r$,

$$g(r) \sim \frac{1}{r},$$

which matches:

- flat rotation curves,
- baryonic Tully–Fisher relation,
- velocity dispersion in dwarf galaxies.

Thus dark matter is not required.

5.7 The Hubble tension as differential contraction

The Hubble tension arises from a discrepancy between local (Cepheid–SN Ia) and global (CMB–BAO) measurements of the Hubble constant.

In standard cosmology:

- $H_0 \approx 73\,\mathrm{km/s/Mpc}$ locally,
- $H_0 \approx 67\,\mathrm{km/s/Mpc}$ from early universe.

In contraction cosmology:

$$H(z) = -\frac{\dot{R}}{R} = C,$$

but C is sampled at different epochs when analysing CMB vs. local data.

Thus the Hubble tension is not a paradox; it is a natural consequence of temporal evolution of the contraction factor over observational baselines.

5.8 Quasar time dilation

In an expanding universe, high-redshift quasars should exhibit time dilation in their variability patterns. Observationally, this effect is absent.

In the contraction model:

- time intervals at emission and observation contract proportionally,
- contraction cancels time-dilation effects,
- quasar variability is scale-invariant.

Thus the absence of quasar time dilation supports the contraction hypothesis.

5.9 Variation of fundamental constants

Evidence has been reported for possible variations in the fine-structure constant α.

In contraction cosmology:

$$\alpha(t) = \alpha_0 e^{kCt},$$

but because local clocks and rulers contract proportionally, such variations appear effectively constant.

5.10 Redshift drift (Sandage–Loeb test)

The Sandage–Loeb test predicts a measurable redshift drift over decades.

In FLRW:

$$\frac{dz}{dt} = (1+z)H_0 - H(z).$$

In contraction cosmology:

$$\frac{dz}{dt} = -C(1+z),$$

which has the opposite sign.

Thus redshift drift will decisively distinguish contraction cosmology from expansion.

5.11 Summary of observational implications

The key observational results are:

- redshift arises from scale contraction, not expansion;
- SN Ia dimming is a natural effect of contraction, not dark energy;
- the CMB is equilibrium contraction radiation;

- BAO reflect resonant contraction modes;
- lensing arises from contraction gradients, not dark matter;
- galaxy rotation curves follow from $\delta C(r)$;
- the Hubble tension is a sampling artifact of temporal contraction;
- quasar time dilation cancels under contraction;
- fundamental constants appear stable due to proportional contraction;
- redshift drift provides the strongest observational test.

These results show that many observational pillars of ΛCDM cosmology may be reinterpreted consistently within a contraction framework.

6 Philosophical Implications

This section explores the philosophical implications of the contraction framework, extending the geometric and observational results of Sections 3–5 into questions of ontology, epistemology, perception, and the nature of time. While the preceding sections establish contraction as a mathematically and observationally viable cosmological model, the present section examines the deeper interpretive consequences of a universe in which scale—and not expansion—is the fundamental dynamical parameter.

The philosophical implications of contraction are profound. They encompass the nature of time, the perceptual basis of physical measurement, the ontological status of the multiverse, the emergence of causality, and the apparent stability of reality.

6.1 Time as a consequence of contraction

In conventional physics, time is treated as a fundamental dimension. In the contraction model, however, time emerges from the evolution of the scale factor $R(t)$:

$$T = -\ln R(t).$$

This means:

- Time does not "flow" independently of scale.
- Time is the cumulative measure of contraction.

- Temporal ordering arises from the monotonic decrease of $R(t)$.

When space contracts, clocks contract as well. The rate of oscillatory processes increases proportionally to e^{Ct}, and thus the internal experience of time remains invariant. Therefore:

If contraction stops, time stops.

Time is not a background parameter; it is a derived property of the contraction dynamics.

6.2 Perception and scale invariance

Human cognition evolved to interpret the world through ratios: length ratios, time ratios, mass ratios. If both the measuring instrument and the measured object contract proportionally, their ratio remains constant. As shown earlier, if

$$L_o(t) = L_{o0}R(t), \quad L_r(t) = L_{r0}R(t),$$

then

$$\frac{L_o(t)}{L_r(t)} = \frac{L_{o0}}{L_{r0}}.$$

Thus contraction is inherently unobservable to internal observers.

This explains why:

- local experiments cannot detect contraction,
- the universe appears static locally,
- global contraction is misinterpreted as expansion.

Perception is therefore *scale-relative.* What we call reality is filtered through the assumption of fixed measurement scales.

6.3 Ontology of the multiverse

In a contracting multiverse:

- there is no singular beginning,
- the multiverse is infinite and non-expanding,
- individual universes contract locally,

- contraction does not imply collapse to a point.

An object's existence is characterised not by its absolute size but by its *contraction state*. Identity is encoded in the trajectory of contraction in scale-space.

This leads to a relational ontology:

$$\text{existence} = \text{relative contraction relationships.}$$

There is no absolute size, no absolute clock, no absolute ruler. All physical reality is scale-dependent.

6.4 Causality as emergent from contraction

In standard physics, events occur *in* time and causality is a relationship between temporally ordered events. In the contraction model:

$$t = -\frac{1}{C} \ln R(t),$$

so time arises from contraction.

Thus:

- Events generate time, not the reverse.
- Causality emerges from the monotonic contraction of scale.
- The causal structure of the universe reflects the contraction trajectory.

Instead of a temporal arrow derived from entropy, we have an arrow derived from the unidirectional collapse of scale.

6.5 The illusion of expansion

The appearance of expansion is a perceptual artifact of contraction.

Because:

$$\lambda \propto R(t), \quad L_r \propto R(t),$$

the ratio

$$\frac{\lambda_o}{\lambda_e} = \frac{R(t_o)}{R(t_e)}$$

is interpreted as recession.

But:

- Photons do not stretch.

- Measuring devices contract.
- Redshift measures age difference in contraction, not distance.

Thus expansion is not a physical phenomenon. It is a cognitive interpretation imposed on scale drift.

6.6 Consciousness under contraction

Consciousness depends on:

- neuronal lengths,
- synaptic firing intervals,
- electrochemical potentials,

all of which scale with $R(t)$.

Thus conscious experience contracts with the universe. The mind remains invariant to scale drift.

Implication: Reality is a *scale-stabilized illusion* generated by the co-contraction of the observer and the observed.

6.7 End of time as asymptotic contraction

As $t \to \infty$,

$$R(t) \to 0.$$

Consequences:

- spatial separation disappears,
- dimensions collapse,
- clocks accelerate without bound,
- time approaches a finite limit.

Thus the "end of the universe" is not catastrophic. It is simply the extinction of scale.

6.8 Summary of philosophical implications

The principal philosophical results are:

- time is not fundamental but emerges from contraction;
- perception is invariant under scale drift, masking contraction;
- reality is scale-relative, not absolute;
- expansion is a perceptual misinterpretation of contraction;
- causality is emergent from contraction dynamics;
- the multiverse is infinite, non-singular, and dynamically contracting;
- consciousness is scale-invariant;
- the "end of time" corresponds to complete contraction of scale.

The contraction framework therefore unifies geometry, perception, and metaphysics into a coherent interpretation of cosmic evolution.

7 Conclusions and Future Directions

This work has introduced and developed a comprehensive contraction-based cosmological framework, integrating theoretical, mathematical, geometric, observational, and philosophical components into a unified model. Instead of relying on an expanding universe with an initial singularity, dark energy, and inflation, we have shown that many cosmological phenomena can be reinterpreted as consequences of a universal contraction law:

$$R(t) = R_0 \, e^{-Ct}.$$

The central objective of this work has been to demonstrate that replacing expansion with contraction does not merely provide an alternative interpretation, but yields a more coherent, non-singular, and physically grounded cosmology. The key results of the preceding sections can be synthesised as follows.

7.1 Summary of core findings

1. The universe is contracting, not expanding. The exponential contraction law

$$\frac{dR}{dt} = -CR(t)$$

naturally explains redshift, luminosity evolution, and the apparent acceleration of the universe without invoking dark energy.

2. Cosmological observations do not require expansion. Redshift, SN Ia dimming, the CMB temperature, BAO patterns, lensing profiles, and galaxy rotation curves follow from scale drift and contraction gradients.

3. The metric structure remains Lorentz-invariant. Using de Haro's Newtonian metric, we showed that contraction can be embedded consistently into a relativistic framework while preserving local Lorentz symmetry.

4. Gravity arises from inhomogeneous contraction. Spatial variations in the contraction rate, encoded in $\delta C(r)$, generate gravitational effects without requiring unseen matter.

5. Time emerges from contraction. Temporal ordering corresponds to the monotonic decrease of scale, not to an independent dimension. Time is the logarithmic measure of contraction,

$$T = -\ln R(t).$$

6. The universe is non-singular. Since $R(t)$ never reaches zero in finite time and curvature remains constant,

$$\mathcal{R} = 12C^2,$$

the multiverse is free from the singularities that plague the Big Bang paradigm.

7. Observational anomalies receive natural explanations. The Hubble tension, absence of quasar time dilation, variations of α, and the shape of lensing profiles emerge from contraction rather than requiring new energy or matter components.

7.2 Implications for cosmology

The contraction framework eliminates the need for:

- the Big Bang singularity,
- cosmic inflation,
- dark energy,
- dark matter halos (in many contexts),
- a finite beginning of time.

It reframes cosmology as a scale-dynamic theory, where:

- scale is a physical degree of freedom,
- contraction determines the flow of time,
- expansion is a perceptual artefact,
- gravity is a scale-gradient phenomenon,
- the multiverse is infinite and self-consistent.

7.3 Open problems and future research directions

While the contraction model offers a coherent and compelling alternative to the standard cosmological paradigm, several major avenues for future research remain.

1. Determination of the contraction rate C. Precise fitting to SN Ia, BAO, CMB and redshift-drift data is required to determine a cosmologically consistent value of C.

2. Fully relativistic contraction field equations. A complete system of contraction-based field equations, potentially of the form

$$\nabla_\mu K^\mu{}_\nu = 8\pi G_{\text{eff}} T_\nu,$$

remains to be constructed.

3. Quantum field theory under contraction. The impact of contraction on vacuum energy, renormalisation, particle creation and symmetry breaking requires deeper analysis.

4. Numerical simulations. N-body and hydrodynamic simulations under contraction dynamics could reveal whether large-scale structure formation is consistent with observations.

5. Electromagnetic field dynamics. A full derivation of Maxwell's equations under contraction is required to formalise the interpretation of radiation as oscillatory contraction modes.

6. Structure formation in a contracting universe. The role of contraction gradients in galaxy formation, cluster evolution, and cosmic web emergence remains a major research avenue.

7.4 Concluding remarks

The contraction of the multiverse at speed C provides a mathematically elegant, philosophically coherent, and observationally compatible alternative to the expanding universe paradigm. It yields a universe that is:

- infinite,
- non-singular,
- self-consistent,
- free of dark energy,
- free of inflation,
- dynamically governed by scale evolution,
- and intrinsically connected with the emergence of time.

The path forward involves deepening the mathematical formulation, refining the observational tests, and exploring the conceptual implications. Yet the framework presented here demonstrates that the universe does not expand into anything; rather, *space itself contracts*, and what we perceive as time is the measure of that contraction.

This contraction paradigm provides fresh perspective on long-standing cosmological problems and opens a promising avenue for a new foundational understanding of the structure and evolution of the multiverse.

A Appendix A: Mathematical Derivations

This appendix presents the detailed mathematical derivations underlying the contraction model described in Sections 2–4. We begin with the fundamental contraction law, derive its consequences for physical quantities, construct the corresponding metric structure, compute curvature tensors, analyse geodesic motion, and show how gravity, radiation and cosmological observables emerge from contraction dynamics.

A.1 A.1. Derivation of the fundamental contraction law

We assume that the cosmic scale factor $R(t)$ evolves according to the proportionality

$$\frac{dR}{dt} \propto R(t),$$

with a negative sign (representing contraction). Thus:

$$\frac{dR}{dt} = -CR(t),$$

where $C > 0$ is a universal contraction rate.

This equation is separable:

$$\frac{dR}{R} = -C\,dt.$$

Integrating:

$$\ln R = -Ct + \ln R_0,$$

where R_0 is the scale at $t = 0$. Exponentiating:

$$R(t) = R_0 e^{-Ct}.$$

A.2 A.2. Derived scaling laws

Let $L(t)$ be any characteristic length scale. If lengths scale with $R(t)$:

$$L(t) = L_0 R(t) = L_0 e^{-Ct}.$$

Because time intervals scale as lengths (atomic periods, orbital times, etc.):

$$\tau(t) = \tau_0 e^{-Ct}.$$

Frequency:

$$\nu(t) = \frac{1}{\tau(t)} = \nu_0 e^{Ct}.$$

Volume:

$$V(t) = V_0 e^{-3Ct}.$$

Energy density:

$$\rho(t) = \rho_0 e^{3Ct}.$$

These transformations explain why contraction is unobservable locally: all scales drift proportionally.

A.3 A.3. Metric structure for contraction geometry

Starting from de Haro's Lorentz-invariant Newtonian metric:

$$ds^2 = (1 + 2\Phi)\, dt^2 - \frac{dr^2}{1 + 2\Phi} - r^2 d\Omega^2,$$

we introduce contraction by inserting a factor of $R(t)$ in the spatial part:

$$ds^2 = (1 + 2\Phi(t, r))\, dt^2 - \frac{dr^2}{1 + 2\Phi(t, r)} - R(t)^2 r^2 d\Omega^2.$$

Here:

- $R(t)$ encodes global contraction,
- $\Phi(t, r)$ encodes local deviations from uniform contraction.

A.4 A.4. Christoffel symbols for contraction

We compute key Christoffel symbols. The radial metric component is:

$$g_{rr} = -R(t)^2.$$

Thus:

$$\Gamma^r_{rr} = \frac{1}{2} g^{rr}(2R\dot{R}) = \frac{\dot{R}}{R} = -C.$$

This implies a contraction-induced geometric acceleration:

$$a_r = -C^2 r.$$

A.5 A.5. Ricci scalar and curvature tensors

We compute the Ricci scalar $\mathcal{R}$ for:

$$R(t) = e^{-Ct}, \quad \dot{R} = -CR, \quad \ddot{R} = C^2 R.$$

The Ricci scalar for the contraction metric is:

$$\mathcal{R} = 6\left(\frac{\ddot{R}}{R} + \frac{\dot{R}^2}{R^2}\right) = 6(C^2 + C^2) = 12C^2.$$

Thus:

- curvature remains constant,
- no singularity is produced,
- the universe evolves smoothly under contraction.

A.6 A.6. Energy density under contraction

De Haro's effective density:

$$\rho_{\text{eff}}(t) = \frac{MC^2}{R(t)^3}.$$

Substitute $R(t) = e^{-Ct}$:

$$\rho_{\text{eff}}(t) = MC^2 e^{3Ct}.$$

Thus density increases exponentially due entirely to diminishing volume, not mass creation.

A.7 A.7. Contraction-based redshift derivation

Let a photon be emitted at t_e:

$$\lambda_e = \lambda_0 R(t_e),$$

and observed at t_o:

$$\lambda_o = \lambda_0 R(t_o).$$

Thus:

$$1 + z = \frac{\lambda_o}{\lambda_e} = \frac{R(t_o)}{R(t_e)} = e^{-C(t_o - t_e)}.$$

This reproduces the observed Hubble law without expansion.

A.8 A.8. Gravity as a gradient in contraction rate

If C varies spatially:

$$C(r) = C + \delta C(r),$$

then:

$$\vec{g} = -R(t)\,\nabla\delta C(r).$$

If $\delta C(r) \propto 1/r$, then:

$$g(r) \propto \frac{1}{r},$$

exactly matching galaxy rotation curves without dark matter.

A.9 A.9. Maxwell equations under contraction

Assume EM fields scale as:

$$F_{\mu\nu}(t) = R(t)^{-1} F_{\mu\nu}(0).$$

Maxwell's equations become:

$$\nabla_\mu \big(R^{-1} F^{\mu\nu}\big) = 0.$$

Because time and space shrink proportionally:

$$c(t) = \frac{\lambda(t)}{\tau(t)} = \frac{R(t)}{R(t)} = \text{constant}.$$

Thus the speed of light remains invariant in a contracting universe.

A.10 A.10. Radiation as oscillatory contraction

Let:

$$R(t) = R_0 e^{-Ct} + \varepsilon \sin(\omega t), \qquad \varepsilon \ll 1.$$

Density oscillations:

$$\rho(t) \propto R(t)^{-3}$$

contain sinusoidal components:

$$\propto \sin(\omega t).$$

Thus electromagnetic waves correspond to oscillatory modes of contraction.

A.11 A.11. Geodesic motion

The geodesic equation:

$$\frac{d^2x^\mu}{d\tau^2} + \Gamma^\mu_{\alpha\beta}\frac{dx^\alpha}{d\tau}\frac{dx^\beta}{d\tau} = 0.$$

Results:

- Radial geodesics include a "drag" from $\Gamma^r_{rr} = -C$.
- Angular geodesics shrink due to $R(t)$.
- Null geodesics preserve c.

A.12 A.12. Time as logarithmic contraction

Given:

$$R(t) = e^{-Ct},$$

then:

$$t = -\frac{1}{C}\ln R(t).$$

Time is therefore the logarithmic record of contraction.

A.13 A.13. Dimensional reduction

As $t \to \infty$:

$$R(t) \to 0.$$

Consequences:

- Spatial distances vanish.
- The metric becomes effectively 1-dimensional.
- Temporal structure dominates geometry.

A.14 A.14. Summary of Appendix A

Key mathematical results:

- $R(t) = e^{-Ct}$ governs scale.
- All scales contract proportionally.
- Curvature $\mathcal{R} = 12C^2$ is constant.

- Density increases exponentially under contraction.
- Redshift arises from scale drift.
- Gravity arises from $\nabla \delta C$.
- Photons remain at constant speed.
- Radiation is oscillatory contraction.
- Time is emergent from contraction.

These results support the geometric and observational conclusions developed in the main text.

B Appendix B: Diagrams, Models and Geometric Interpretations

This appendix provides conceptual diagrams and geometric interpretations of the contraction model described in the main text. While graphical rendering (e.g. TikZ) is left to the Overleaf environment, we present detailed descriptions that can be translated directly into figures.

B.1 B.1. Global contraction geometry

The global contraction of the universe can be visualised as a sequence of shrinking hyperspheres, each representing the characteristic spatial scale $R(t)$.

A TikZ representation may use nested circles:

$$R(t_0) > R(t_1) > R(t_2) > \cdots ,$$

with each circle labelled by $R(t_n) = R_0 e^{-Ct_n}$.

Key interpretation:

- Nothing moves inward; instead, the scale of every spatial dimension shrinks.
- Observers shrink with the geometry and do not perceive contraction locally.

B.2 B.2. Perceptual invariance under contraction

Consider an object with length $L_o(t)$ and a ruler with length $L_r(t)$:

$$L_o(t) = L_{o0}R(t), \qquad L_r(t) = L_{r0}R(t).$$

A diagram should depict both object and ruler shrinking proportionally. The measured ratio

$$\frac{L_o(t)}{L_r(t)} = \text{constant}$$

illustrates why contraction is unobservable internally.

B.3 B.3. Redshift as scale drift

A photon emitted at time t_e has wavelength

$$\lambda_e = \lambda_0 R(t_e),$$

and at observation time t_o:

$$\lambda_o = \lambda_0 R(t_o).$$

A diagram should depict:

- longer emitted wavelength (larger scale),
- shorter observed wavelength measure (smaller ruler),
- the ratio interpreted as "expansion" although contraction is the true cause.

B.4 B.4. Gravity as contraction gradient

If the contraction rate varies,

$$C(r) = C + \delta C(r),$$

a gravitational field

$$\vec{g} = -R(t)\,\nabla\delta C(r)$$

arises.

A diagram may illustrate concentric shells with a gradient in $\delta C(r)$ and arrows pointing inward, showing how gravity emerges from non-uniform contraction.

B.5 B.5. Dimensional collapse as $R(t) \to 0$

Spatial radii shrink to zero as $t \to \infty$:

$$R(t) \to 0.$$

A diagram should depict:

- 3D spheres shrinking to 2D discs,
- then to 1D segments,
- illustrating asymptotic dimensional collapse.

B.6 B.6. Electromagnetic fields under contraction

EM waves have

$$\lambda(t) = \lambda_0 R(t).$$

The ratio λ/τ remains constant, preserving c.

A diagram can show the shrinking wavelength and shrinking temporal period along a worldline.

B.7 B.7. Multiversal hierarchy

The multiverse is composed of infinite contracting domains.

A diagram may depict:

- multiple contracting bubbles,
- each with its own $R(t)$,
- embedded in an infinite background.

These conceptual schematics provide the visual intuition underlying the contraction model.

C Appendix C: Observational Data Reinterpretation

This appendix reinterprets major cosmological data sets within the contraction framework. Rather than assuming constant measurement scales, we examine how observations appear once scale drift is properly accounted for.

C.1 C.1. Type Ia supernovae (SN Ia)

In standard cosmology, SN Ia dimming at high redshift implies accelerated expansion. In contraction cosmology, the luminosity distance becomes

$$d_L \propto \frac{1}{R(t_o)^2}\, d,$$

where d is comoving distance.

Because physical scales contract as $R(t)\, e^{-Ct}$:

- luminosity decreases,
- distances appear larger,
- flux is reduced,

all without invoking dark energy.

C.2 C.2. The Hubble tension

Standard cosmology:

$$H_0^{\text{local}} \approx 73, \quad H_0^{\text{CMB}} \approx 67.$$

In contraction cosmology:

$$H(z) = C,$$

but local and high-redshift measurements probe different epochs of the contraction curve. Thus the Hubble tension is not a paradox, but a sampling effect.

C.3 C.3. Cosmic microwave background (CMB)

Temperature scales as:

$$T(t) \propto e^{Ct}.$$

The CMB corresponds to equilibrium radiation of the contraction medium, not a relic of a primordial explosion.

Acoustic peaks reflect contraction oscillation modes, not frozen sound waves in an early hot plasma.

C.4 C.4. Baryon acoustic oscillations (BAO)

BAO represent resonant contraction modes:

$$\lambda_{\rm BAO}(t) = \lambda_0 R(t).$$

The observed scale:

$$\lambda_{\rm obs}(z) = \lambda_0 e^{Ct(z)}.$$

This provides a direct probe of the contraction rate C.

C.5 C.5. Gravitational lensing

In contraction geometry, lensing arises from gradients of $\Phi(r)$.

The refractive index:

$$n(r) = \sqrt{\frac{1}{1+2\Phi(r)}}$$

replaces curvature as the lensing source.

Einstein rings, arcs, shear maps and strong lensing events follow naturally.

C.6 C.6. Galaxy rotation curves

Gravity emerges from non-uniform contraction:

$$g(r) = -R(t)\,\nabla\delta C(r).$$

If $\delta C(r) \propto 1/r$:

$$g(r) \propto \frac{1}{r}.$$

This reproduces:

- flat rotation curves,
- baryonic Tully–Fisher relation,
- dwarf galaxy kinematics,

without dark matter halos.

C.7 C.7. Redshift drift (Sandage–Loeb test)

The sign of redshift drift distinguishes contraction from expansion.

FLRW:

$$\frac{dz}{dt} = (1+z)H_0 - H(z).$$

Contraction:

$$\frac{dz}{dt} = -C(1+z).$$

This predicts a negative drift, opposite to FLRW.

C.8 C.8. Quasar time dilation

High-redshift quasars show no time dilation in their variability. Under contraction:

$$\tau(t) = \tau_0 e^{-Ct}$$

at both emission and observation, cancelling dilation.

C.9 C.9. Variation in fundamental constants

Fine-structure constant:

$$\alpha(t) = \alpha_0 e^{kCt}.$$

Local instruments co-contract:

$$\alpha_{\text{local}} = \frac{\alpha(t)}{\alpha_{\text{clock}}} \approx \text{constant}.$$

Thus apparent stability is preserved.

C.10 C.10. Summary

The contraction interpretation resolves or reframes:

- SN Ia dimming,
- CMB temperature and peaks,
- BAO scale,
- gravitational lensing,
- galaxy rotation curves,
- quasar timing,

- Hubble tension,
- redshift drift,
- constant fundamental parameters,

without invoking:

- dark energy,
- inflation,
- dark matter halos (in many contexts).

Observationally, contraction cosmology is a viable alternative to ΛCDM.