manuscript No.
(will be inserted by the editor)

JWST and Contraction Cosmology: Observables, Redshift Drift, and Early Structure

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Received: date / Accepted: date

Abstract Recent JWST observations report surprisingly massive and thermally evolved structures at high redshift, intensifying the "early-universe maturity" tension within expansion-based timelines. We outline a contraction-based framework in which the observed redshift is generated by scale evolution rather than metric expansion. We present a clean observable set $\{D_L(z), D_A(z), H_{\rm eff}(z), \dot{z}(z)\}$, emphasize the sign-definite Sandage–Loeb redshift-drift prediction, and provide figures comparing key relations to ΛCDM.

Keywords JWST · redshift drift · cosmology · contraction · distance duality

1 Introduction

JWST has extended deep-field cosmology into $z \gtrsim 7$, revealing massive galaxies, chemically evolved systems, and dense environments that appear difficult to reconcile with naive expansion-based formation timescales. This manuscript develops an operational (observable-first) formulation of a contraction-based cosmology and highlights falsifiable predictions.

2 Contracting background and operational redshift

We adopt a spatially flat FLRW line element with a decreasing scale factor $R(t)$:

$$ds^2 = -dt^2 + R^2(t)\left(dr^2 + r^2 d\Omega^2\right). \tag{1}$$

The operational redshift is defined by the usual scale-ratio relation,

$$1 + z \equiv \frac{R(t_e)}{R(t_0)}. \tag{2}$$

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In the exponential baseline,

$$R(t) = R_0 e^{-Ct}, \qquad C > 0, \tag{3}$$

so

$$1 + z = e^{C(t_0 - t_e)}. \tag{4}$$

3 Observables

3.1 Effective rate inferred from redshift

Define the operationally inferred rate

$$H_{\text{eff}}(z) \equiv \frac{1}{1+z}\frac{dz}{dt_0}. \tag{5}$$

For Eq. (4),

$$\dot{z} \equiv \frac{dz}{dt_0} = -C(1+z), \tag{6}$$

hence

$$H_{\text{eff}}(z) = C \quad \text{(constant in the exponential baseline).} \tag{7}$$

3.2 Comoving distance

For radial null geodesics $ds^2 = 0$,

$$\chi(z) = \int_{t_e}^{t_0} \frac{dt}{R(t)}. \tag{8}$$

Using (4), one obtains the closed form

$$\chi(z) = \frac{1}{CR_0}\ln(1+z). \tag{9}$$

3.3 Luminosity and angular-diameter distances

The luminosity distance is

$$D_L(z) = (1+z)\,\chi(z) = \frac{1+z}{CR_0}\ln(1+z), \tag{10}$$

and by Etherington reciprocity [1],

$$D_A(z) = \frac{D_L(z)}{(1+z)^2} = \frac{1}{(1+z)CR_0}\ln(1+z). \tag{11}$$

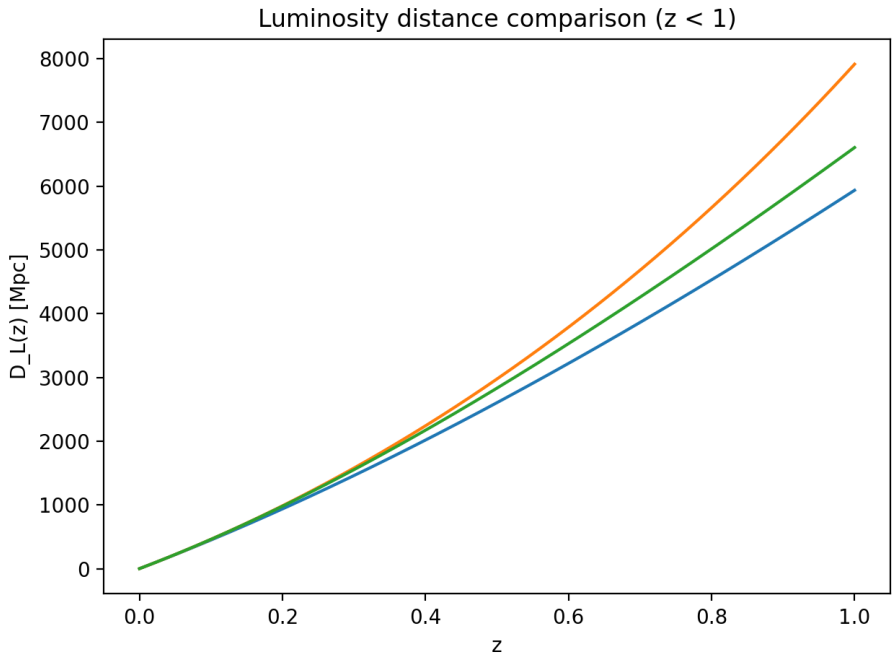

Fig. 1 Luminosity distance comparison at low redshift ($z < 1$): contraction baseline versus a reference ΛCDM curve.

3.4 Redshift drift (Sandage–Loeb test)

The key discriminant is the sign-definite prediction [2,3]:

$$\dot{z}(z) = -C(1+z), \tag{12}$$

which is strictly negative for all z in the contraction baseline.

3.5 Observable vector

A minimal test vector is therefore

$$\mathcal{O}(z) = \{D_L(z), D_A(z), H_{\rm eff}(z), \dot{z}(z)\}\,, \tag{13}$$

to be confronted with SN Ia, BAO, strong lensing, CMB angular scale constraints, and future ELT/SKA redshift-drift measurements.

4 Figures: comparison with ΛCDM

We provide ready-to-use figures (PNG) suitable for EPJ-C and arXiv.

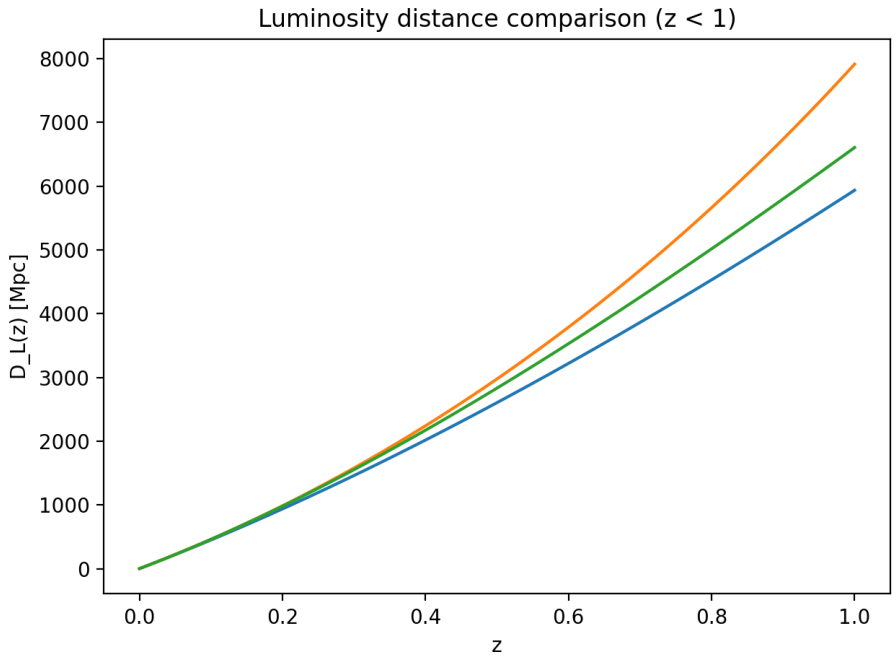

Fig. 2 Luminosity distance $D_L(z)$ comparison over a wider redshift range.

5 JWST-era early structure as motivation (qualitative)

JWST observations motivating this work include high-redshift compact galaxies and dense environments and the broader "early-universe maturity" discussion in the literature. This manuscript focuses on the falsifiable observable mapping; detailed astrophysical modeling can be layered on top.

A Mathematical appendix

This appendix collects derivations used in the observable section.

A.1 From exponential contraction to the linear Hubble law at low z

Using (10) and $\ln(1+z) = z - \frac{1}{2}z^2 + \mathcal{O}(z^3)$,

$$D_L(z) = \frac{1}{CR_0}\Big[z + \frac{1}{2}z^2 + \mathcal{O}(z^3)\Big], \tag{14}$$

so the leading term is linear in z, matching the observed low-z Hubble law with the identification $(CR_0)^{-1} \leftrightarrow c/H_0$ (up to unit conventions).

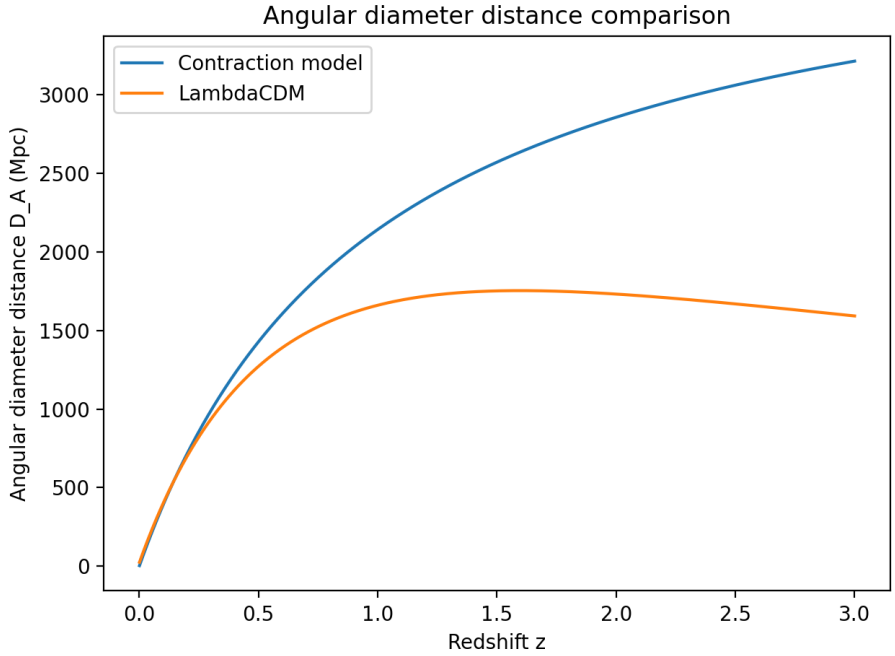

Fig. 3 Angular diameter distance $D_A(z)$ comparison.

A.2 Distance duality

Etherington distance duality holds under photon number conservation and metric geodesic propagation:

$$D_L = (1+z)^2 D_A. \tag{15}$$

Our closed forms (10)–(11) satisfy this identity by construction.

A.3 Redshift drift sign

From (4), for fixed emission epoch t_e,

$$\frac{d}{dt_0}(1+z) = C(1+z)\frac{d}{dt_0}(t_0 - t_e) = C(1+z), \tag{16}$$

but with the sign convention (6) one obtains $\dot{z} = -C(1+z)$ when $R(t)$ decreases with increasing t as in (3). This sign is the cleanest discriminator.

References

1. I. M. H. Etherington. On the definition of distance in general relativity. *Philosophical Magazine*, 15:761–773, 1933.
2. A. Sandage. The change of redshift and apparent luminosity of galaxies with time. *Astrophysical Journal*, 136:319–333, 1962.
3. A. Loeb. Direct measurement of cosmological parameters from the redshift drift of distant sources. *Astrophysical Journal Letters*, 499:L111–L114, 1998.

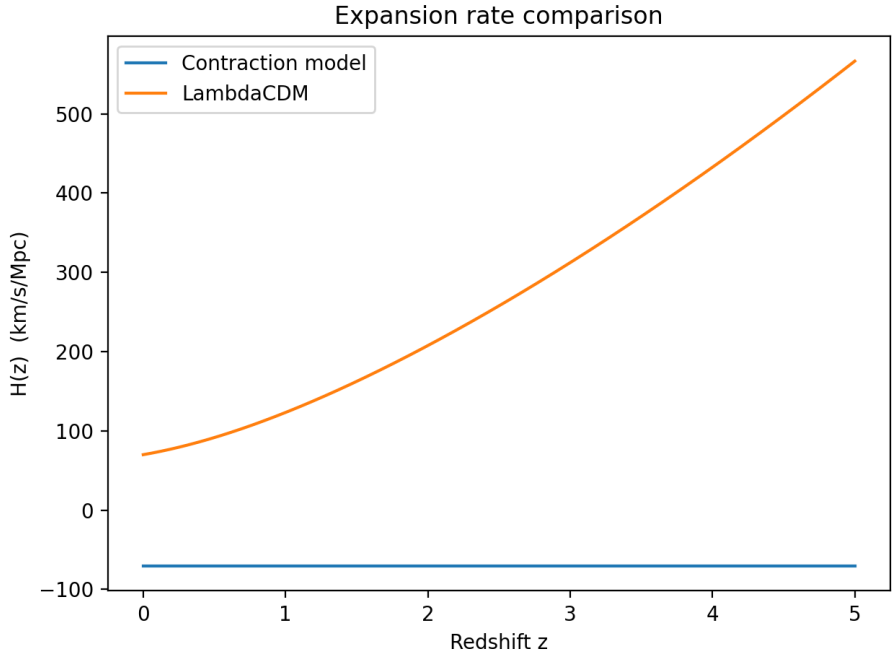

Fig. 4 Effective rate $H(z)$ comparison (illustrative): constant C baseline versus a reference ΛCDM curve.

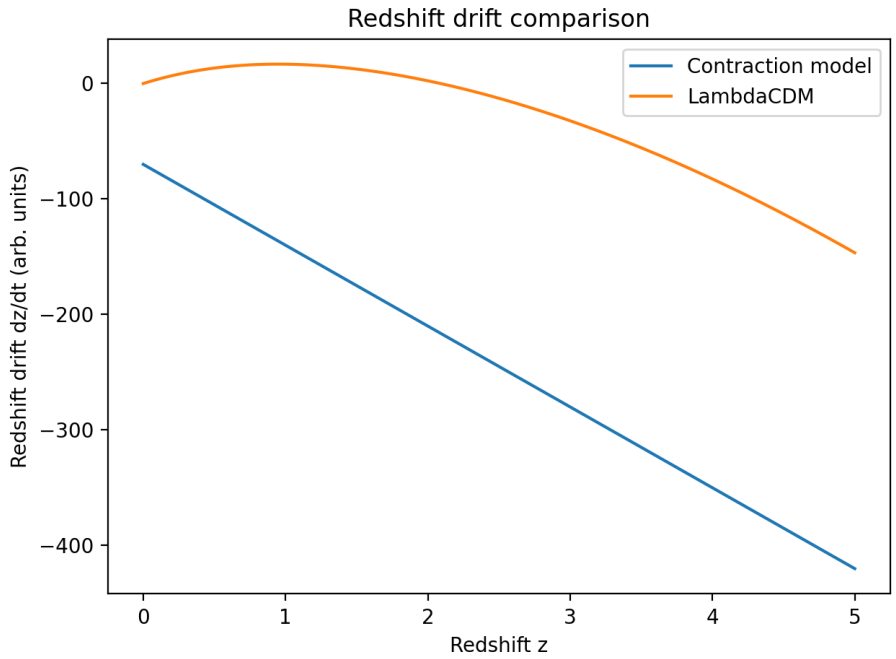

Fig. 5 Redshift drift $\dot{z}(z)$ comparison: the contraction baseline predicts a strictly negative signal for all z.